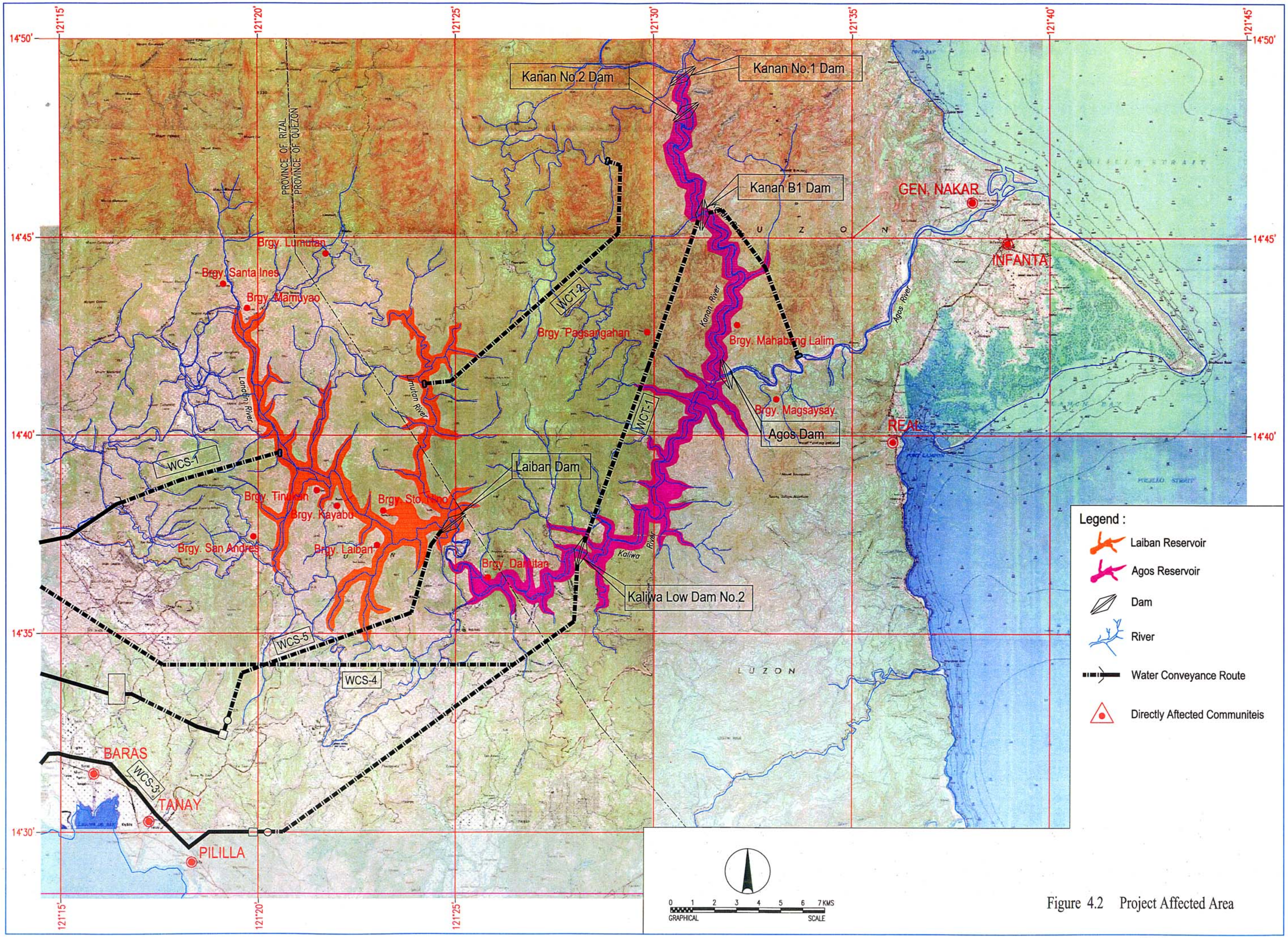



Figure 4.2 Project Affected Area

# CHAPTER V WATER RESOURCES DEVELOPMENT PLAN IN THE AGOS RIVER BASIN

## 5.1 Basic Framework of Plan Formulation

### 5.1.1 General

The Agos River Basin is only a river basin left undeveloped in the area surrounding Metro Manila, which can meet the future water demands over a long term as discussed in the foregoing Chapter I.

To date, many studies have been carried out in connection with the water resources development in the Agos River Basin. The purpose of most of the past studies was placed on the formulation of hydropower development projects with the exception of the Manila Water Supply III Project (MWSP III), which was formulated in the late 1970' for the main purpose of water supply to Metro Manila. The MWSP III proposed the Laiban Dam project as the first step development in the Ago River basin, associated with water conveyance facilities connecting the Laiban Dam reservoir and Metro Manila.

The present Master Plan Study has reviewed carefully each of the previous studies and also conducted supplemental scheme identification studies to work out comprehensive water resources development plans in the Agos River Basin. The Study placed the first priority on the development for water supply to Metro Manila which can suffice the water demand of the MWSS's service area up to the year 2025, the target year of the Study.

The distance from water source sites in the Agos River Basin to Metro Manila is as long as 24 to 39 km varying by scheme. The waterway conveyance scheme constitutes a vital element in terms of its large share to the total project cost. Hence, it is essential to evaluate the economic viability of the water resources development scheme(s) in conjunction with the waterway conveyance scheme. From this viewpoint, this Study attempted to identify alternative development scenarios combined with water source development scheme and water conveyance scheme.

### 5.1.2 Development Scale for Meeting Water Demand up to Year 2025

(1) Present Condition of Demand-Supply Balance

As presented in the foregoing Section 2.5, water demand of the MWSS's service area is projected as tabulated below:

**Water Demand Projection (MLD)**

| Year | 2000 | 2005 | 2010 | 2015 | 2020 | 2025 | 2030 | 2040 |
|---|---|---|---|---|---|---|---|---|
| Daily average demand | 3,663 | 3,783 | 4,250 | 5,033 | 5,866 | 6,980 | 7,973 | 10,401 |
| Day peak demand | (4,400) | 4,577 | 5,143 | 6,090 | 7,097 | 8,466 | 9,647 | 12,585 |

Note: (1) Water demand projected for period of 2025 onward is approximate

(2) Day peak demand factor is assumed as 1.21. Figure in ( ) for 2000 is estimated potential day peak demand.

It is estimated that the total available water quantity at the existing water sources consisting of Angat Dam and groundwater is approximately 3,700 MLD on a daily average basis, which is almost equal to the actual water demand in 2000 (3,663 MLD) as shown in the table above. The present supply capacity of the existing water production/conveyance facilities is 4,090 MLD on a daily peak basis (4,000 MLD from Angat system and 90 MLD from groundwater).

On one hand, the present potential daily peak demand is presumed to be as large as 4,400 MLD, if a day peak factor of 1.21 is applied to the daily average demand (3,663 MLDx1.21=4,400 MLD). If this is correct, the present potential day peak demand in Metro Manila seems to be much larger than the existing water supply capacity as evidenced by rationing of water supply imposed so often. A severe water shortage is foreseen to take place in the very near future, unless new water sources are developed urgently.

(2) Interim Schemes

The earliest possible commissioning of the water supply scheme of the Agos River Basin is foreseen to be around year 2010. This Study assumes that demand up to 2010 should be met by other water source development schemes to be commissioned prior to the Agos Scheme, called the "Interim Schemes".

The interim schemes presently contemplated by MWSS and two water companies, as at middle of 2001, include 300 MLD Bulk Water Supply Project (Laguna Lake Development Project), 50 MLD Wawa River Development Project and Angat Augmentation Project (Expansion of 350 MLD in daily peak supply capacity), giving a total of 700 MLD.

(3) Development Scale of New Water Resources

In determining the development scale of the Agos water resources toward year 2025, the following two aspects were considered:

(a) With the completion of these interim schemes (700 MLD in total), the supply capacity becomes 4,790 MLD. This affords the daily average supply of about 3,960 MLD, if a day peak factor of 1.21 is assumed (4,790 MLD/1.21=3,960 MLD). Under this condition, new water sources of about 3,020 MLD in terms of daily supply quantity will need to be exploited in the Agos River Basin in order to meet the water demand in 2025 (6,980 MLD-3,960 MLD=3,020 MLD).

(b) It is more desirable if the day peak water demand up to 2010 could fully be met by more input of Interim Schemes. The Interim Schemes required for this is 1,050 MLD in total in day peak capacity (5,143 MLD-4,090 MLD=1,053 MLD), making the total daily average supply capacity to be 4,250 MLD in 2010. In this case, water to be exploited in the Agos River Basin until 2025 comes to 2,730 MLD (6,980 MLD-4,250 MLD) in terms of daily average quantity.

Taking into account the two figures derived above, the Study conservatively plans that the target development scale in the Agos River Basin would be 3,000 MLD on a daily average basis. This corresponds to the figure derived in (a) above, representing the case that all the presently planned interim schemes (700 MLD) would be realized before 2010. The development scale of 3,000 MLD assumes about 10 % allowance for the figure of (b) above. This allowance covers the uncertainty of achieving the Interim Schemes of 1,050 MLD and also the uncertainty involved in the projection of future water demand, especially the achievement of NRW reduction.

### 5.1.3 Formulation of Water Resources Development Plans in the Agos River Basin

Water resources development plans were formulated through review of previous studies and also by map studies and site reconnaissance survey conducted this time. The map study attempted the identification of additional dam schemes. As the result, however, it was found that all the potential damsites had been identified in the previous studies and there seemed no additional dam schemes worthy of inclusion in the Study.

The map study, however, identified new alternative run-of- river schemes (see below) and also examined new alternative water conveyance routes (see Chapter VI).

The previous studies have identified the following five (5) potential water source development sites:

- i) Laiban Dam on the Kaliwa River,
- ii) Kaliwa Low Dam on the Kaliwa River,
- iii) Kanan Dam on the Kanan River (either Kanan No.1 Dam or Kanan No.2 Dam which are mutually exclusive)
- iv) Kanan B1 Dam on the Kanan River (also mutually exclusive with Kanan No.1 Dam/Kanan No.2 Dam), and
- v) Agos Dam on the Agos mainstream.

In addition to the above sites, the Study identified the following two run-of-river type development sites:

- i) Kanan Low Dam on the Kanan River and
- ii) Laiban Low Dam on the Kaliwa River (its location is the same as that of "(i) Laiban Dam" above, but the development type is modified from high dam to low dam for run-of-river type development).

The above potential water source development sites are shown in Figure 5.1.

The water resources development schemes in the Agos River Basin that can satisfy the water demand of the MWSS's service area up to 2025 (3,000 MLD of daily average water volume to be newly exploited) are formulated in accordance with the following principles:

i) The optimum development scale of reservoir schemes is determined at the scale of minimizing the unit water cost per reservoir water yield. In case the development scale so determined has a lesser yield than 3000 MLD, it is combined with other schemes so that the combined schemes are able to supply the daily average water of 3,000 MLD.

ii) In case the water exploitable at the source is in excess of the water supply required for Metro Manila (3,000 MLD), the excess water will be used for hydropower generation as long as the multipurpose development is viable (e.g. in the case of Agos Dam). Also in case the effective head is exploitable for hydropower generation on the water conveyance route to Metro Manila and tarnsbasin tunnel, a powerhouse is proposed at its downstream end.

iii) In the case the optimized water source development scale is larger than 3,000 MLD and it is proposed chiefly for water supply purpose, such source development potential will be exploited and used for water supply to the maximum extent of the proposed scale (e.g. Kanan No.2 Dam in Development Scenario A). In this case, the development plans are formulated to meet the water demands beyond year 2025. Instead, the benefit of water supply for such extended period will be duly evaluated in the comparative study.

## 5.2 Background and Development Concepts of Water Source Development Schemes in the Agos River Basin

### 5.2.1 Laiban Dam on the Kaliwa River

The Laiban Dam scheme has been optimized through previous studies; Manila Water Supply Project III (MWSP III), and the detailed design already prepared. Hence, there is no significant need for examining alternative plans of different development scale. This Study deals with the Laiban scheme as per proposed in the existing detailed design prepared under the MWSP III. The detailed background of the MWSP III studies is described in Part-E of Volume III.

### 5.2.2 Kanan No.2 Dam on the Kanan River

The past studies identified three (3) reservoir type schemes on the Kanan River, namely Kanan No.1 Dam, Kanan No.2 Dam, and Kanan B1 Dam. Since these three dams are mutually exclusive due to their locations at elevations between 130-150 m, the most optimum scheme has to be selected. The detail of comparison of these schemes from technical aspect is described in Part-E of Volume III.

Comparison of unit water cost per reservoir water yield indicated that the Kanan No.2 Dam is the most optimum scheme (see Section 5.3 hereinafter). Hence, this Study adopted the Kanan No.2 Dam as a dam scheme on the Kanan River.

The Kanan No.2 dam was studied in the feasibility study of MWSP III in 1997. The MWSP III study proposed that Kanan No.2 Dam should come up on development stream next to the Laiban Dam scheme for water supply to Metro

Manila. The Kanan No.2 Dam is proposed virtually as a scheme to augment the capacity of water supply from Laiban Dam, diverting the Kanan water to the Laiban reservoir through a Kanan-Laiban interbasin tunnel. Water yield rate was estimated at 36.7 $m^3$/sec (3,170 MLD) with a reservoir of FSL 295 m. The previous MWSP III study proposed a 160-m high dam of earth-core rockfill construction at a preliminary design level.

### 5.2.3 Agos Dam on Agos Mainstream

The 1981 JICA study formulated a hydropower single-purpose scheme for this site, on the condition that the majority of upstream water would be transferred outside the basin for water supply to Metro Manila. The previous study identified that an optimum development would be to create a reservoir having FSL 165 m.

This Study plans the Agos Dam to be developed as a multipurpose scheme for water supply and hydropower development.

### 5.2.4 Kaliwa Low Dam on the Kaliwa River

#### (1) Previous Study

This scheme was originally proposed by a MWSS in-house consultant and has been studied by a consulting firm (EDCOP). EDCOP completed a pre-feasibility study in May 2001. The concept of the plan is initially to divert the Kaliwa natural runoff (8.6 $m^3$/sec, corresponding to 90 % discharge during dry months as estimated by EDCOP) at Kaliwa Low Dam, and subsequently augment the water transfer capacity by exploiting water from the Agos storage reservoir. The EDCOP study estimated that 6,740 MLD (78 $m^3$/sec) could be exploited at the Agos reservoir with FSL 159 m.

#### (2) Development Concepts of Kaliwa Low Dam

Following the development concept proposed in the previous study, the Kaliwa Low Dam scheme is regarded as the first stage development ahead of the subsequent development of the Agos Dam. The main purpose of this first stage project is to transfer the Kaliwa runoff water for Metro Manila at the earliest possible time, since the Agos Dam will require a longer lead time of about 11 years before it is commissioned.

#### (3) Location of Kaliwa Low Dam Site

Figure 5.1 shows two alternative sites for Kaliwa Low Dam, Kaliwa Low Dam No.1 site and No.2 site in the order from upstream. These two alternative Low Dam sites were reconnoitered and compared by the Study Team so as to determine the most favorable dam site from the technical viewpoint as discussed below.

Low Dam No.1 site is located some 300 m downstream of the confluence with the Limananin Creek, where the riverbed elevation is around EL. 110 m. Geology at the dam site is acceptable for building a low dam. However, the following factors do not favor this site as a waterway intake site:

- There is a large volume of sand/gravel accumulation at 300 m upstream from the damsite, which is the accumulation of riverbed materials washed out from Kaliwa upstream reaches through a narrow rapid gorge in the Daraitan limestone area. This sand/gravel deposit is supposed to move downstream in the flood season and fill up the pond area to be created by the Kaliwa Low Dam No.1.
- Existence of the rapids, some 400-m upstream of the Kaliwa Low Dam No.1, is also an adverse factor in a view that the pond is confined in the area downstream of the rapids, resulting in reduced pond capacity for sediment deposition.

Another concern for the No.1 site is the possibility of distribution of faults in the vicinity, although it is not a critical factor for discarding this damsite.

The Kaliwa Low Dam No.2 site is identical to ‘Kaliwa Downstream Dam Site’ surveyed in the course of the MWSP III study in 1979. It seems that the site has no problem for constructing a low dam. Geological condition is acceptable for construction of a low dam.

The above stated factors show that the Kaliwa Low Dam No.2 site is superior to the Kaliwa No.1 site from the geological aspect. Therefore, the Kaliwa Low Dam No.2 site was selected as the proposed Kaliwa Low Dam site.

### 5.2.5 Laiban Low Dam on the Kaliwa River

The Laiban Low Dam, as a run-of-river scheme, is conceived to be developed instead of Laiban High Dam proposed in the MWSP III (Laiban Dam + Kanan No.2 Dam).

The Study examined potential sites for Laiban Low Dam. It was initially thought that future development potential of Laiban High Dam should be retained as far as possible. In this case, the Laiban Low Dam should be built at a location downstream of the Laiban High Dam site.

However, there is no suitable site found for the Laiban Low Dam in the reach downstream of the Laiban High Dam site (see Par-E of Volume III). As the result, the Laiban Low Dam site was selected at the location that is identical with the Laiban High Dam site proposed in the MWSP III.

### 5.2.6 Kanan Low Dam on the Kanan River

The Kanan Low Dam scheme is identified in this Study as a run-of-river scheme on the Kanan River. The proposed Kanan Low Dam site is located at the middle reach of the Kanan River, about 8.0 km downstream of the proposed Kanan No.2 damsite.

The low dam scheme contemplates to exploit the comparatively abundant dry season flow of the Kanan River and to convey the water to the Kaliwa Low Dam through a Kanan-Kaliwa interbasin tunnel.

## 5.3 Optimization of Reservoir Type Schemes

### 5.3.1 Selection of Optimum Full Supply Water Level (FSL)

As stated above, the Study examined five storage dams: Kanan No.1 Dam, Kanan No.2 Dam, Kanan B1 Dam, Agos Dam and Laiban Dam. The Study adopted the FSL and dam height of the Laiban Dam as per optimized in the previous MWSP III study. Optimum FSL of the other four dams was evaluated by comparing a unit water cost index represented by construction cost divided by $m^3$/sec of exploitable water. The results of the comparison study are shown in Figure 5.2 and summarized below:

**Optimum FSL of Four Dams**

| Dam | Optimized FSL (EL. m) | Estimated Construction Cost of Dam (US$ Mill.) | Reservoir Water Yield ($m^3$/sec) | Cost per Water Yield (US$ Mill. per $m^3$/sec) | FSL Proposed in Previous Study (for reference) |
|---|---|---|---|---|---|
| Kanan No.1 | EL.300 | 219.1 | 25.1 | 8.7 | EL.300 m |
| Kanan No.2 | EL.310 | 233.1 | 38.3 | 6.1 | EL.295 m/* |
| Kanan B1 | El. 195 | 114.8 | 9.7 | 11.8 | El. 180 m |
| Agos | El. 175 | 436.0 | 81.1 | 5.4 | |
| | El. 165 | 349.6 | 59.2 | 5.9 | El. 165 m |
| | El. 159 | 331.0 | 49.7 | 6.7 | |

Note: 1. Unit Water Cost =Dam Construction Cost (Base Cost)/Exploitable Water in $m^3$/sec
2. /*; The maximum storage level of the Kanan No.2 Dam is set at El. 310m in Volume 2B, Drawings, MWSP III, 1979, which is identical to the optimized FSL in this Study.

As indicated above, FSL of each dam is optimized at elevations slightly different from the one proposed in the previous studies. This is mainly due to difference in hydrological data used in the current study.

Kanan No.1 Dam and Kanan No.2 Dam are mutually exclusive as stated earlier. Both of these dams generally show more favorable unit cost index with an increase of dam height as shown in Figure 5.2. On the other hand, the maximum FSL levels of Kanan No.1 and No.2 dams are limited topographically to El. 300 m and El. 310 m, respectively. Hence, the optimal FSL of both dams are set at the topographical maximum levels.

Figure 5.2 indicates that unit water cost evaluated for the Kanan No.1 Dam with FSL 300 m is higher than that of Kanan No.2 Dam with FSL 310 m. This suggests that Kanan No.2 Dam should be taken up for further planning study. Accordingly, Kanan No.1 Dam was ruled out at this study stage.

Kanan B1 Dam, also mutually exclusive with both the Kanan No.2 Dam and Agos Dam, was also discarded in view of higher cost index value.

Cost index of the Agos Dam is lowest in the case of FSL 175 m as shown in Figure 5.2, which is however not adopted since it will submerge Barangay Daraitan, core village in the area, and also the Laiban Dam site. The present Master Plan Study adopts the FSL of Agos Dam to be EL. 159 m in order to minimize the resettlement requirement, thus minimizing the anticipated social problems. This selection was the trade-off between the economic benefits and socio-environmental benefits.

5.3.2 Selection of Dam Type

The Study attempted to select the most economical dam type for the Kanan No.2 Dam and Agos Dam.

The ELC study in 1990 examined the viability of Agos hydropower project for the case of adoption of Roller Compacted Concrete Dam (RCCD), instead of Earth Core Rockfill Dam (ECRD) proposed in the former 1981 JICA study. In the ELC study, the shear strength of 5 $kg/cm^2$ was adopted for the foundation rock of Agos Dam and assessed the minimum safety factor of some 1.0 against sliding of dam. On the other hand, the Japanese dam design code specifies that the safety factor of more than 4.0 for sliding needs to be secured for concrete gravity dam.

The stability analysis carried out in this Study clarified that it is very difficult to secure a safety factor of more than 4 for the dam with a height of more than 160m, even in the case of adopting such a typical section as having moderate upstream and downstream slopes of 1:0.1 and 1:0.8, respectively. As the result, the RCCD is discarded and the optimal dam type is determined to be either Concrete Face Rockfill Dam (CFRD) or ECRD.

Construction cost of the dam was assessed for two different types of dam: i.e. CFRD and ECRD. The result is summarized below (see Part-E of Volume III for detail).

**Cost Comparison of Dam Types for Kanan No.2 Dam and Agos Dam**

| Dam | Estimated Construction Cost : (Base Cost) (US$ Million equiv.) | |
|---|---|---|
| | CFRD | ECRD |
| Kanan No.2 Dam | 230.6 | 258.6 |
| Agos Dam | 331.0 | 332.8 |

Note: Comparison was made for the dam of a height selected through evaluation of optimum FSL (see Subsection 5.3.1 above)

The cost comparison revealed that CFRD is more economical for both the Kanan No.2 and Agos Dam. With regard to Agos Dam, on the other hand, CFRD and ECRD are competitive from the cost viewpoint. This requires more detailed cost comparison in the successive feasibility study. From technical aspect, CFRD seems more advantageous than ECRD for the reason of shorter construction period, since the dam embankment works in CFRD can be continued even during the wet season, thereby enabling the earlier completion of the proposed project.

## 5.4 Formulation of Alternative Development Scenarios

5.4.1 Water Balance Study

The water balance study was carried out to estimate the exploitable water at each of the proposed water source development site in the Agos River Basin using the long-term monthly runoff data assessed in the foregoing Section 3.2.

The exploitable water is estimated for each stage of the development of a new water source scheme. In the case there exists a reservoir scheme on the upstream reach, the long-term inflow data at the downstream water source development site are derived to be a sum of the discharge released from the upstream reservoir and the runoff from the catchment area of the downstream source site.

The exploitable water quantities were assessed based on the following concepts:

(1) Reservoir Type Scheme

In the case of a reservoir type scheme having the capability of seasonal flow regulation, the exploitable water is derived to be the discharge that can be yielded by the proposed reservoir constantly even in the draughty year occurring once in 10 years out of the total hydrological records. The exploitable water so assessed represents the water availability with a dependability of 97-98 % for the whole hydrological data period.

To estimate the exploitable water, the reservoir operation study was performed based on the long-term inflow data taking into account evaporation loss from the reservoir surface as well as river maintenance flow to be constantly released downstream. The release of river maintenance flow is planned to be 10% of 80% discharge assessed on a flow duration curve at the scheme site.

(2) Run-of-River Type Scheme

A 90% discharge at the water source site is adopted as the exploitable discharge in the case of the run-of-river development. This reduced criterion was applied in consideration that the run-of river schemes proposed in this Study are planned to supply water only for a relatively short period of 2 to 3 years until a reservoir scheme is put in service subsequently.

### 5.4.2 Exploitable Water Resources at Each Water Source Development Site

As the result of the water balance study mentioned above, exploitable water resources at each site have been evaluated as summarized below:

**Exploitable Water Resources at Each Water Source Development Site**

| Name of Development Schemes | Reservoir Water Level (EL. m) | | Exploitable Water | | Figures Proposed in Previous Study |
|---|---|---|---|---|---|
| | FSL | MOL | (MLD) | ($m^3$/sec) | |
| Reservoir Scheme: | | | | | |
| - Laiban Dam | 270 | 237 | 1,830 | 21.2 | 1,900 MLD at FSL 270 |
| - Kanan No.2 Dam | 310 | 278 | 3,310 | 38.3 | 3,170 MLD at FSL 295 /* |
| | 310 | 225 | 3,770 | 43.6 | |
| - Agos Dam | 159 | 133 | 5,210 | 60.3 | 6,740 MLD at FSL 159 |
| Run-of-River Scheme: | | | | | |
| - Kaliwa Low Dam | - | | 550 | 6.4 | 8.6 $m^3$/sec in EDCOP Study |
| - Laiban Low Dam | - | | 340 | 3.9 | - |
| - Kanan Low Dam | | | 770 | 8.9 | |

Note: /* The crest elevation of the Kanan No.2 Dam is set at El. 320m in Volume 2B, Drawings, MWSP III, 1979.

Of the above, exploitable water at Laiban Dam was assessed to be 1,830 MLD (21.2 $m^3$/sec) in the hydrological analysis in this Study (see Part-C of Volume III). The same was estimated at 1,900 MLD in the 1979 MWSP III study. Of the two figures, the subsequent studies will adopt the figure of 1,830 MLD as the exploitable water of Laiban Dam taking into consideration the relatively minor difference between the both estimates.

### 5.4.3 Formulation of Alternative Development Scenarios

Out of the above six (6) schemes, only Agos Dam and Kanan No.2 Dam can yield the water of more than 3,000 MLD, the development need for meeting water demand of Metro Manila towards year 2025. Hence, for the other schemes, the Study elaborated to formulate the water resource development plans by means of combining some of the six (6) water source schemes. Consequently, the combination of eight (8) water source development plans shown in Table 5.1 have been proposed as the plans meeting the water demand up to the year 2025.

As described in Chapter VI, three water transfer routes were selected for water transfer to Metro manila. The proposed waterways are Laiban-Taytay Waterway, Laiban-Angono Waterway, and Kaliwa-Angono Waterway, respectively.

This Study worked out a total of eight (8) alternative development scenarios by combining six (6) water source development schemes and three (3) water transfer schemes. The eight (8) development scenarios, Development Scenarios A to H, are tabulated below:

**Combination of Water Source Development Schemes and Water Transfer Schemes for Alternative Development Scenarios Conceived**

| Develop. Scenario | Stage of Develop. | Schemes Involved in Each Development Scenario | |
|---|---|---|---|
| | | Water Source Development Scheme | Associated Waterway (w/w) Scheme |
| A | 1st | A-1) Laiban Dam | 1st w/w: Laiban-Taytay |
| | 2nd | A-2) Kanan No.2 Dam with Kanan-Laiban Tunnel | 2nd w/w: - do - |
| B | 1st | B-1) Kaliwa Low Dam | 1st w/w: Kaliwa-Angono |
| | 2nd | B-2) Agos Dam | 2nd w/w: - do - |
| C | 1st<br>2nd | C-1) & C-2) Agos Dam (w/o Kaliwa Low Dam) | 1st w/w: Kaliwa-Angono<br>2nd w/w: - do - |
| D | 1st | D-1) Kaliwa Low Dam | 1st w/w: Kaliwa-Angono |
| | 2nd | D-2) Kanan No.2 Dam with Kanan-Laiban Tunnel | 2nd w/w: - do - |
| E | 1st | E-1) Kaliwa Low Dam | 1st w/w: Kaliwa-Angono |
| | 2nd | E-2-1) Kanan Low Dam with Kanan-Kaliwa Tunnel | |
| | | E-2-2) Kanan No.2 Dam | 2nd w/w: Kaliwa-Angono |
| F | 1st | F-1) Laiban Dam | 1st w/w: Laiban-Taytay |
| | 2nd | F-2) Agos Dam | 2nd w/w: Kaliwa-Angono |
| G | 1st | G-1) Kaliwa Low Dam | 1st w/w: Kaliwa-Angono |
| | 2nd | G-2-1) Laiban Dam | |
| | | G-2-2) Agos Dam | 2nd w/w: - do - |
| H | 1st | H-1) Laiban Low Dam | 1st w/w: Laiban-Angono |
| | 2nd | H-2-1) Kanan No.2 Dam with Kanan-Laiban Tunnel | |
| | | H-2-2) - | 2nd w/w: - do - |

Note: The future development plans for each of the eight development scenarios that are presented in the succeeding Section 5.6 are not shown in the table above.

Proposed development framework in each of the eight (8) development scenarios is as presented in Table 5.1 and the general layout of all of the schemes are shown in Figure 5.3.

Figures 5.4 to 5.11 depict the general layout and profile of the Development Scenarios A to H, respectively.

## 5.5 Main Features of Eight (8) Alternative Development Scenarios to Meet Water Demands of Metro Manila until Year 2025

The proposed Development Scenarios are comprised of the schemes classified as the 'First Stage Development' and 'Second Stage Development' in Table 5.1. The schemes listed in Table 5.1 as 'Future Development' are discussed in Section 5.6 below.

### 5.5.1 Alternative Development Scenario A (Laiban Dam + Kanan No.2 Dam)

(1) Plan A-1: Laiban Dam as the First Stage

Development Scenario A is identical to the development plans proposed in the MWSP III. Figure 5.4 shows the general layout and profile of the Development Scenario A.

In the Plan A-1, the Laiban Dam with the first Laiban-Taytay waterway is planned to be constructed to convey the daily average water volume of 1,830 MLD that would be exploited at the Laiban Dam.

(2) Plan A-2: Kanan No.2 Dam as the Second Stage

The Plan A-2 contemplates that the water conveyance from the Laiban Dam is augmented by water diversion from the Kanan River through the provision of Kanan No.2 Dam with Kanan-Laiban transfer tunnel and the second Laiban-Taytay waterway. The total daily average water volume conveyed at this stage becomes 5,140 MLD.

### 5.5.2 Alternative Development Scenario B (Kaliwa Low Dam + Agos Dam)

(1) Plan B-1: Kaliwa Low Dam as the First Stage

In the Development Scenario B shown in Figure 5.5, the Kaliwa Low Dam scheme is proposed as the first stage development to enable earliest water supply for Metro Manila. The plan envisages the subsequent development of Agos Dam.

Kaliwa Low Dam is constructed as a temporary structure for use for about 3 years. Specific considerations given to the planning of the Kaliwa Low Dam are described in Part-E of Volume III.

(2) Plan B-2: Agos Dam as the Second Stage

After the completion of the Agos Dam, the Agos Dam will function as the sole water source for water supply to Metro Manila. Out of the exploitable water of 60.2 $m^3$/sec (equivalent to 5,210 MLD), this Study contemplates to convey a daily average water volume of 3,000 MLD to Metro Manila for meeting the water demand up to 2025. The remaining water in excess of the water supply for Metro

Manila is planned to use for hydropower generation with a powerhouse provided at the toe of the Agos Dam. The second Kaliwa-Angono waterway will be constructed at the final stage of this Plan B-2. At this stage, another powerhouse is built at the downstream end of Tunnel No.1.

### 5.5.3 Alternative Development Scenario C (Agos Dam without Kaliwa Low Dam)

Plan C-1&2: Agos Dam in Two Development Stages:

The Development Scenario C shown in Figure 5.6 is a minor variation of the Development Scenario B mentioned above. Plan C-1 envisages the implementation of only the Agos Dam, without advance implementation of the Kaliwa Low Dam.

Two waterways are built eventually: 1st waterway together with the construction of Agos Dam in the 1st stage (Plan C-1) and 2nd waterway taking additional water from Agos Dam in the 2nd Stage (Plan C-2), each 1,500 MLD, giving the total supply of 3,000 MLD in daily average quantity.

Note: The difference between the Scenarios B and C is whether the scheme includes the Kaliwa Low Dam or not. In Scenario B, the Kaliwa Low Dam is constructed as a pre-investment scheme of the Agos Dam development. Subsequent comparative study will examine whether the extra investment incurred due to advance implementation of the Kaliwa Low Dam scheme could be offset by the benefits of advanced water supply to Metro Manila by 2 years.

### 5.5.4 Alternative Development Scenario D (Kaliwa Low Dam + Kanan No.2 Dam)

(1) Plan D-1: Kaliwa Low Dam as the First Stage

Figure 5.7 shows the general layout and profile of the Development Scenario D.

The concept of Plan D-1 is identical to that described for Plan B-1 above. The Kaliwa Low Dam scheme is regarded as the first stage with development of the Kanan No.2 Dam to be constructed subsequently. The difference from the Plan B-1 is that the Kaliwa Low Dam is built as a permanent structure. No hydropower plant is envisaged in this Plan D-1.

In the First Stage period when water is taken from the Kaliwa natural runoff, the Intake discharge is 6.4 $m^3$/sec (550 MLD), which is the same as planned for the Kaliwa Low Dam in Scenario B.

(2) Plan D-2: Kanan No.2 Dam as the Second Stage

The scheme itself is identical to Plan A-2. All water exploited at the Kanan No.2 reservoir will be diverted to the Limutan River, upstream of the proposed Laiban Damsite. No power plant is installed at the end of Kanan-Kaliwa transbasin tunnel in consideration of the possibility of future development of the Laiban Dam. While, the power plant with an installed capacity of 5.2 MW is exploitable at the downstream end of Tunnel No.1.

With the development of Kanan No.2 Dam at FSL 310 m and MOL 278 m, it is expected that a 38.3 $m^3$/sec (3,310 MLD) of water will be exploited at a dependability of 97-98 %. On one hand, water availability at Kaliwa Low Dam with 97-98 % dependability is 3.4 $m^3$/sec (290 MLD). Total water supply capacity at the second stage is thus 3,600 MLD, which is more than enough for meeting the water supply demand for planning horizon up to year 2025. The 2nd conveyance waterway to Metro Manila will be built at the final stage of this Plan D-2.

### 5.5.5 Alternative Development Scenario E (Kaliwa Low Dam + Kanan Low Dam + Kanan No.2 Dam)

(1) Plan E-1: Kaliwa Low Dam as the First Stage

Figure 5.8 shows the general layout and profile of the Development Scenario E. First stage development of this scenario (Plan E-1) is identical to Plan D-1 of the Development Scenario D. The 1st conveyance waterway to Metro Manila will be constructed at this stage. Supply quantity at this stage is 550 MLD in daily average quantity, taking the Kaliwa natural runoff of 90 % dependability.

(2) Plan E-2: Kanan Low Dam (Plan E-2-1) and Kanan No.2 Dam (Plan E-2-2) as the Second Stage

Development concept of this Scenario is to construct a low diversion dam on the Kanan middle reach and transfer the Kanan natural runoff to the Kaliwa Low Dam (Plan E-2-1) through a Kanan-Kaliwa transbasin tunnel of about 16.5 km long. Similar to the case of Kaliwa Low Dam, design intake discharge at the Kanan Low Dam is planned to be 90% dependable discharge, which is assessed as 8.9 $m^3$/sec (770 MLD). This water is conveyed to the 1st conveyance waterway through the Kaliwa Low Dam intake. Thus, the total flow of the 1st waterway at the Plan E-2-1 stage is 1,320 MLD (550 MLD + 770 MLD) in daily average quantity.

Moreover, Kanan No.2 Dam needs to be constructed in order to yield water to meet the demand up to year 2025. In the case of water transfer to Laiban Dam (Scenarios A and D), a relatively high MOL (EL.278 m) has to be designed due to the transfer intake at a higher elevation located in the upstream reach. In the case of this Development Scenario E, Kanan No.2 reservoir can be designed to have a lower MOL of EL.225 m. The reservoir will yield 3,770 MLD (43.6 $m^3$/sec) in daily average quantity.

Kanan-Kaliwa transbasin tunnel will have a capacity of 3,770 MLD (43.6 $m^3$/sec), and should be built under Plan E-2-1 stage, ahead of the construction of the Kanan No.2 Dam.

At the Plan E-2-2 stage, the 2nd waterway to Metro Manila will be constructed. Total daily average flow by two tunnels is 4,060 MLD (290 MLD from Kaliwa runoff (see Subsection 5.5.4) + 3,770 MLD from Kanan No.2 reservoir). Water transfer of 770 MLD initially planned for the Kanan Low Dam is regarded to be a part of the Kanan reservoir yield of 3,770 MLD.

This alternative scenario was taken up to examine the possible merit of water source development without constructing dams in the initial stages, although a dam (Kanan No.2 Dam) will be required eventually in the ultimate stage (Plan E-2-2).

### 5.5.6 Alternative Development Scenario F (Laiban Dam + Agos Dam)

(1) Plan F-1: Laiban Dam as the First Stage

The Plan F-1 of the Development Scenario F shown in Figure 5.9 is virtually same as Plan A-1 described above. Water stored in the Laiban reservoir will be conveyed to Metro Manila through a Laiban-Taytay Waterway.

(2) Plan F-2: Agos Dam as the Second Stage

This plan is identical to Plan C-1 described above. Water conveyed from the Agos Dam is planned as 1,500 MLD. For the Plan F-2, water is conveyed to the Metro Manila area through a Kaliwa-Angono Waterway.

### 5.5.7 Alternative Development Scenario G (Kaliwa Low Dam + Laiban Dam + Agos Dam)

(1) Plan G-1: Kaliwa Low Dam as the First Stage

This Scenario is a variation of Scenario B and the general layout and profile is shown in Figure 5.10. The Scenario envisages constructing initially Kaliwa Low Dam with Kaliwa-Angono 1st Waterway (Plan G-1). The Kaliwa Low Dam is constructed as a temporary structure, which is submerged by the Agos Dam in the second stage (G-2-2).

(2) Plan G-2: Laiban Dam (Plan G-2-1) and Agos Dam (G-2-2) as the Second Stage

In the second stage, Laiban High Dam (Plan G-2-1) is first constructed for augmentation of the intake discharge of Kaliwa Low Dam constructed in the first stage. In the Plan G-2-1, Laiban Dam will have a lower Minimum Operating Level (MOL) at El. 230m (EL. 237m in the Development Scenarios A and F) and release water through a powerhouse built at the toe of Laiban Dam.

Since the reservoir yield of Laiban Dam (1,930 MLD with MOL 230 m) is not enough for meeting water demand up to year 2025, Agos Dam with 2nd Waterway is required at the ultimate stage (Plan G-2-2). Water conveyance is made through the Kaliwa-Angono waterway, which is identical to that of the Scenario B.

### 5.5.8 Alternative Development Scenario H (Laiban Low Dam + Kanan No.2 Dam)

(1) Plan H-1: Laiban Low Dam as the First Stage

The proposed layout and profile of the Development Scenario H are shown in Figure 5.11. This Development Scenario H is a variation of Scenario D. It envisages constructing Laiban Low Dam with 1st Waterway at the initial stage (Plan H-1).

As shown in Figure 5.11, the Laiban Low Dam is proposed at the same site as the Laiban High Dam. This requires the future development potential of the High Dam to be abandoned.

The elevation of conveyance waterway (around EL.195m at intake site) is much higher than the case of Scenario B (EL. 115m) and hence the waterway cannot take the same route as that of Development Scenario B. This required aligning the waterway on a different route with a water treatment plant at different location as explained in succeeding Chapter VI. Owing to topographical constraints, the waterway tunnel will pass at relatively shallow depths along thin ridges, where there may be geological difficulties. At the end of the tunnel, a powerhouse is planned to be provided. The waterway for the Laiban Low Dam is called Laiban-Angono waterway.

(2) Plan H-2: Kanan No.2 Dam as the Second Stage

After the Laiban Low dam, Kanan No.2 Dam will be commissioned as the permanent source of water supply. Kanan No. 2 Dam will transfer 3,310 MLD (daily average) of water to the Low Dam intake and, in addition, 1/10-year probable low flow of 140 MLD from the Kaliwa basin is available at the Laiban Low Dam site. This available water, 3,450 MLD in total, is more than enough to meet water demand up to year 2025.

## 5.6 Future Developments in Each Development Scenario

The plans listed as 'Future Development' in Table 5.1 are categorized as the schemes to be developed separately from the water supply plan mentioned in Section 5.5 above. Brief outline of the schemes in this category is described below (see Part-E of Volume III for detail).

### 5.6.1 Plan A-3: Additional Development Plan (Agos Dam)

Water supply for Metro Manila towards year 2025 can be met by development of Laiban Dam as the first stage and Kanan No.2 Dam (with a Kanan-Laiban transbasin water transfer) as the second stage. There still remain water resources that could be developed mainly for hydropower generation. The following three schemes are envisaged:

(i) Agos Dam as Hydropower Single-Purpose Scheme (Plan A-3-1)

(ii) Kanan-B1 Dam as Hydropower Single-Purpose Scheme (Plan A-3-2)

(ii) Kanan No.2 Dam with a Hydropower Plant just Downstream of the Dam (Plan A-3-3)

Comparing the above three schemes from technical viewpoints, the Study concluded that only the Agos Dam scheme (Plan A-3-1) would be worthy of taking up for further consideration. Other two schemes (Plans A-3-2 and A-3-3) are ruled out from further study under this Development Scenario A. (See Par-E of Volume III for detail of comparative study)

It is noted that Agos Dam so constructed can also be source of water supply for future water demand. Nevertheless, if Laiban Dam and Kanan No.2 Dam are implemented, it can meet the water demand up to around year 2040. Hence, this Study will propose the Agos Dam to be a hydropower scheme if implemented in the future.

### 5.6.2 Plan B-3: Additional Development Plan (Laiban Dam and Kanan No.2 Dam)

(1) Laiban Dam for Future Water Supply Development (Plan B-3-1)

Concept of development is identical to Alternative Development Scenario A-1. Need for the development of Laiban Dam for the Metro Manila water supply depends on the growth of water demand for the period of year 2025 onward. An alternative would be to abstract additional water from the Agos reservoir at the expense of reduction of power generation.

The comparison of the two plans will be based on an assessment which plans would yield a larger net benefit. In case the additional supply from the Agos reservoir is preferred, the development of Laiban Dam will be mainly for hydropower generation at toe of the dam as well as for augmentation of Agos reservoir yield.

In the case of additional water supply from the Agos reservoir, however, a problem may be the difficulty of aligning the 3rd conveyance waterway line and also the larger cost requirement for conveyance waterway than that from the Laiban Dam. This suggests that the potential of Laiban Dam should better be retained for water supply purpose for meeting demand for year 2025 onward.

(2) Kanan No.2 Dam for Hydropower Generation (Plan B-3-2)

In this case, Kanan No.2 Dam will be developed as a hydropower single-purpose scheme. With Agos reservoir as the after-bay pondage, the power plant can be designed as a peaking plant. Need of the implementation depends entirely on the attractiveness of the scheme for hydropower development. Simultaneously, the dam will contribute to augmentation of the Agos reservoir water yield.

Access to the site in this case is along the left bank of the Kanan River via Agos Dam.

### 5.6.3 Plan C-3: Development Plan of 3rd Stage Onward

The development scenario of the 3rd stage onward is same as the Plan B-3 of Scenario B, which is described in Subsection 5.6.2 above.

### 5.6.4 Plan D-3: Development Plan of 3rd Stage Onward

As a future development, Laiban Dam can be built in this Scenario D. The proposed features of the Laiban Dam are identical to those described for Plan B-3-1 above. Agos Dam will not be included in the plan, since Kaliwa Low Dam is built as a permanent structure.

### 5.6.5 Plan E-3: Development Plan of 3rd Stage Onward

As a future development, Laiban Dam can be built also in this Development Scenario E. Proposed features of the Laiban Dam are identical to those described for Plan B-3-1 above. Agos Dam will not be included in the plan, since Kaliwa Low Dam is built as a permanent structure.

### 5.6.6 Plan F-3: Development Plan of 3rd Stage Onward

As a future development, Kanan No.2 Dam can be built also in this Development Scenario F. Proposed features of the Kanan No.2 Dam are identical to those described for Plan B-3-2 above.

### 5.6.7 Plan G-3: Development Plan of 3rd Stage Onward

As well as the Plan F-3, Kanan No.2 Dam can be built also in this Development Scenario G as a future development. Proposed features of the Kanan No.2 Dam are identical to those described for Plan B-3-2 above.

### 5.6.8 Plan H-3: Development Plan of 3rd Stage Onward

As a future development, Agos Dam can be built also in this Development Scenario H. Proposed features of the Agos Dam are identical to those described for Plan B-3-2 above.

## 5.7 Hydropower Development Potentials in Each Development Scenario

Each development scenarios examined in Sections 5.5 and 5.6 above contains the possibility of hydropower development.

In principle, this Study has taken up the hydropower schemes with an installed capacity of more than 5 MW as the promising ones. The results of the studies on hydropower development are detailed in Chapter E4 of Part-E of Volume III and summarized in Table 5.2 in this Chapter.

## Table 5.1 Summary of Alternative Development Scenarios

| Develop. Scenario | Development Plans to Meet the Water Demand up to Year 2025 | | Future Development |
|---|---|---|---|
| | First Stage Development | Second Stage Development | |
| Scenario A | A-1: Laiban Dam with Laiban-Taytay Water Transfer (1st waterway) – 1,830 MLD | A-2: Kanan No.2 Dam with Kanan-Laiban Interbasin Tunnel & Laiban-Taytay Water Transfer (2nd waterway) – 3,310 MLD (5,110 MLD in total) | A-3-1: Agos Dam (for hydropower & additional water supply if required in future) |
| Scenario B | B-1: Kaliwa Low Dam with Kaliwa-Angono Water Transfer (1st waterway) – 550 MLD | B-2-1: Agos Dam – net additional 950 MLD by impoundment of Agos reservoir<br>B-2-1: Construction of Kaliwa-Angono 2nd Waterway – 1,500 MLD (3,000 MLD in total) | B-3-1: Laiban Dam (for additional water supply for 2026 onward & hydropower)<br>B-3-2: Kanan No.2 Dam (for hydro-power & Agos reservoir yield augmentation) |
| Scenario C | C-1: Agos Dam with Kaliwa-Angono Water Transfer(1st waterway) – 1,500 MLD | C-2: Kaliwa-Angono Water Transfer (2nd waterway) – 1,500 MLD (3,000 MLD in total) | C-3-1: Same as B-3-1 (Laiban Dam)<br>C-3-2: Same as B-3-2 (Kanan No.2 Dam) |
| Scenario D | D-1: Same as B-1 (Kaliwa Low Dam with Kaliwa-Angono Water Transfer (1st waterway) – 550 MLD) | D-2-1: Kanan No.2 Dam with Kanan-Laiban Tunnel – net additional 950 MLD<br>D-2-2 : Kaliwa-Angono 2nd waterway – 2,100 MLD (3,600 MLD in total) | D-3: Same as B-3-1 (Laiban Dam for hydropower)<br>Note: No Agos dam in this case |
| Scenario E | E-1: Same as B-1 (Kaliwa Low Dam with Kaliwa-Angono Water Transfer (1st waterway) – 550 MLD) | E-2-1: Kanan Low Dam with Kanan-Kaliwa Interbasin Tunnel –770 MLD<br>E-2-2: Kanan No.2 Dam – net additional 180 MLD<br>E-2-3: Kaliwa-Angono 2nd Waterway – 2,560 MLD (4,060 MLD in total) | E-3: Same as B-3-1 (Laiban Dam for hydropower)<br>Note: No Agos dam in this case |
| Scenario F | F-1:Same as A-1 (Laiban Dam with Laiban-Taytay Water Transfer (1st waterway) – 1,830 MLD) | F-2: Same as C-1 (Agos Dam with Kaliwa-Angono Water Transfer (1st waterway) – 1,500 MLD (3,330 MLD in total) | F-3-1:Same as B-3-2 (Kanan No.2 Dam)<br>Note: Agos Dam can be used for additional water supply for 2026 onward, if so required |
| Scenario G | G-1:Same as B-1 (Kaliwa Low Dam with Kaliwa-Angono Water Transfer (1st waterway) – 550 MLD) | G-2-1: Laiban Dam with Kaliwa-Angono 1st Water Waterway– net additional 1,380 MLD<br>G-2-2: Agos Dam with Kaliwa-Angono 2nd Water Waterway– 1,500 MLD (3,430 MLD in total) | G-3-1:Same as B-3-2 (Kanan No.2 Dam) |
| Scenario H | H-1: Laiban Dam with Laiban-Angono Water Transfer (1st waterway) – 340 MLD | H-2-1: Kanan No.2 Dam with Kanan-Laiban Interbasin Tunnel– net additional 1,160 MLD<br>H-2-2: Construction of Laiban-Angono 2nd Water Waterway– 1,920 MLD (3,420 MLD in total) | F-3-1:Same as B-2-1 (Agos Dam) |

Note: At this Study stage, only schemes listed for First and Second Stage Development are subject to comparative study in selecting priority development scenario. Schemes shown in column of 'Future Development' above will be separately evaluated.

## Table 5.2 Summary of Hydropower Output of Alternative Development Scenarios (1/2)

| Scenario | Scheme/Power Station | | Water Supply (Daily Average) (MLD) | Power Output: Installed Capacity (MW) | Power Output: 95% Guranteed (MW) | Energy Output: Primary (GWh) | Energy Output: Secondary (GWh) | Energy Output: Total (GWh) | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| **Schemes in Conjunction with Water Supply Schemes: (Plan X-1 & 2 Series)** | | | | | | | | | |
| A | A-1 | Laiban Dam w/1st Waterway | | | | | | | |
| | | Pantay P/S 1st Stage | 1,830 | 22.6 | 17.8 | 179.0 | - | 179.0 | Base load power |
| | A-2 | Kanan No.2 Dam w/2nd Waterway | | | | | | | |
| | | Pantay P/S 1st & 2nd Stage | 5,110 | 54.1 | 40.6 | 417.9 | - | 417.9 | Base load power |
| | | | (1,830+3,280) | | | | | | |
| B | B-1 | Kaliwa Low Dam w/1st Waterway | 550/0 | - | - | - | - | - | No power due to low head |
| | B-2-1 | Agos Dam | | | | | | | |
| | | Agos P/S (at toe of Dam) | (1,500) | 85.6 | 80.1 | 185.8 | 313.2 | 499.0 | Peak load power |
| | | | (3,000) | 85.6 | 71.3 | 178.0 | 240.9 | 418.9 | Peak load power |
| | B-2-2 | 2nd Waterway | | | | | | | |
| | | Abuyod P/S | 3,000 | 12.5 | 7.0 | 98.6 | - | 98.6 | Base load power |
| C | C-1 | Agos Dam w/1st Waterway | | | | | | | |
| | | Abuyod P/S | 1,500 | 6.2 | 3.4 | 48.7 | - | 48.7 | Base load power |
| | | Agos P/S (at toe of Dam) | | 85.6 | 80.1 | 185.8 | 313.2 | 499.0 | Peak load power |
| | C-2 | Agos Dam w/2nd Waterway | | | | | | | |
| | | Abuyod P/S | 3,000 | 12.5 | 7.0 | 98.6 | - | 98.6 | Base load power |
| | | | (1,500+1,500) | | | | | | |
| | | Agos P/S (at toe of Dam) | | 85.6 | 71.3 | 178.0 | 240.9 | 418.9 | Peak load power |
| D | D-1 | Kaliwa Low Dam w/1st Waterway | 550/290 | - | - | - | - | - | No power due to low head |
| | D-2 | Kanan No.2 Dam w/2nd Waterway | | | | | | | |
| | | Abuyod P/S | 3,600 | 5.2 | 4.3 | 43.0 | - | 43.0 | Base load power |
| | | | (1,500+2,100) | | | | | | |
| E | E-1 | Kaliwa Low Dam w/1st Waterway | 550/290 | - | - | - | - | - | No power due to low head |
| | E-2-1 | Kanan Low Dam | 770/0 | - | - | - | - | - | No power due to low head |
| | E-2-2 | Kanan No.2 Dam w/2nd Waterway | | | | | | | |
| | | Kanan No.2 P/S (at toe of Dam) | 3,770 | 51.5 | 33.4 | 401.3 | - | 401.3 | Base load power |
| | | Abuyod P/S | 4,060 | 6.1 | 5.6 | 50.7 | - | 50.7 | Base load power |
| F | F-1 | Laiban Dam w/1st Waterway | | | | | | | |
| | | Pantay P/S | 1,830 | 22.6 | 17.8 | 179.0 | - | 179.0 | Base load power |
| | F-2 | Agos Dam w/2nd Waterway | | | | | | | |
| | | Abuyod P/S | 1,500 | 6.2 | 3.8 | 49.2 | - | 49.2 | Base load power |
| | | Agos P/S (at toe of Dam) | | 91.3 | 78.2 | 190.1 | 236.5 | 426.6 | Peak load power |
| G | G-1 | Kaliwa Low Dam w/1st Waterway | 550/0 | - | - | - | - | - | No power due to low head |
| | G-2-1 | Laiban Dam | | | | | | | |
| | | Laiban P/S (at toe of Dam) | (1,930) | 17.6 | 11.9 | 132.1 | - | 132.1 | Before Agos Dam, Base load |
| | G-2-2 | Agos Dam w/ 2nd Waterway | | | | | | | |
| | | Laiban P/S (at toe of Dam) | (1,930) | 69.6 | 46.9 | 130.0 | 6.2 | 136.2 | After Agos Dam, Peak load |
| | | Abuyod P/S | 3,430 | 11.4 | 5.9 | 88.9 | - | 88.9 | Base load power |
| | | | (1,930+1,500) | | | | | | |
| | | Agos P/S (at toe of Dam) | | 87.5 | 75.0 | 182.9 | 230.9 | 413.8 | Peak load power |
| H | H-1 | Laiban Low Dam w/1st Waterway | 340/140 | - | - | - | - | - | No power due to low head |
| | H-2 | Kanan No.2 Dam w/2nd Waterway | | | | | | | |
| | | Limutan P/S (at Outlet of Kanan-Laiban Transbasin Tunnel) | (3,310) | 12.3 | 5.0 | 87.1 | - | 87.1 | Base load power |
| | | Balimbing P/S | 3,420 | 22.4 | 22.4 | 196.1 | - | 196.1 | Base load power |
| | | | (140+3,280) | | | | | | |

Note: Base Load Power: 24-hour operation in conjunction with water supply
Peak Load Power: Peaking operation (tentatively assumed to be 6-hour peaking operation a day )

## Table 5.2 Summary of Hydropower Output of Alternative Development Scenarios (2/2)

| Scenario | Scheme/Power Station | | Water Supply (Daily Average) (MLD) | Power Output Installed Capacity (MW) | Power Output 95% Guranteed (MW) | Energy Output Primary (GWh) | Energy Output Secondary (GWh) | Energy Output Total (GWh) | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| **Schemes Independent from Water Supply Schemes: (Plan X-3 Series)** | | | | | | | | | |
| A | A-3 | Agos Dam | | | | | | | |
| | | Agos P/S (at toe of Agos Dam) | - | 104.7 | 94.4 | 229.9 | 144.9 | 374.8 | Peak load power |
| B | B-3-1 | Laiban Dam | | | | | | | |
| | | Laiban P/S (at toe of Dam) | - | 69.6 | 46.9 | 130.0 | 6.2 | 136.2 | Peak load power |
| | B-3-2 | Kanan No.2 Dam | | | | | | | |
| | | Kanan No.2 P/S (at toe of Dam) | - | 209.5 | 135.3 | 406.4 | 97.2 | 503.6 | Peak load power |
| C | C-3-1 | Laiban Dam | | | | | | | |
| | | Laiban P/S (at toe of Dam) | - | 69.6 | 46.9 | 130.0 | 6.2 | 136.2 | Peak load power |
| | C-3-2 | Kanan No.2 Dam | | | | | | | |
| | | Kanan No.2 P/S (at toe of Dam) | - | 209.5 | 135.3 | 406.4 | 97.2 | 503.6 | Peak load power |
| D | D-3 | Laiban Dam | | | | | | | |
| | | Laiban P/S (at toe of Dam) | - | 188.5 | 119.5 | 345.0 | 6.0 | 351.0 | Peak load power |
| E | E-3 | Laiban Dam | | | | | | | |
| | | Laiban P/S (at toe of Dam) | - | 69.6 | 46.9 | 130.0 | 6.2 | 136.2 | Peak load power |
| F | F-3 | Kanan No.2 Dam | | | | | | | |
| | | Kanan No.2 P/S (at toe of Dam) | - | 209.5 | 135.3 | 406.4 | 97.2 | 503.6 | Peak load power |
| G | G-3 | Kanan No.2 Dam | | | | | | | |
| | | Kanan No.2 P/S (at toe of Dam) | - | 209.5 | 135.3 | 406.4 | 97.2 | 503.6 | Peak load power |
| H | H-3 | Agos Dam | | | | | | | |
| | | Agos P/S (at toe of Agos Dam) | - | 111.5 | 93.7 | 228.6 | 138.4 | 367.0 | Peak load power |

Note: Peak Load Power: Peaking operation (tentatively assumed to be 6-hour peaking operation a day )

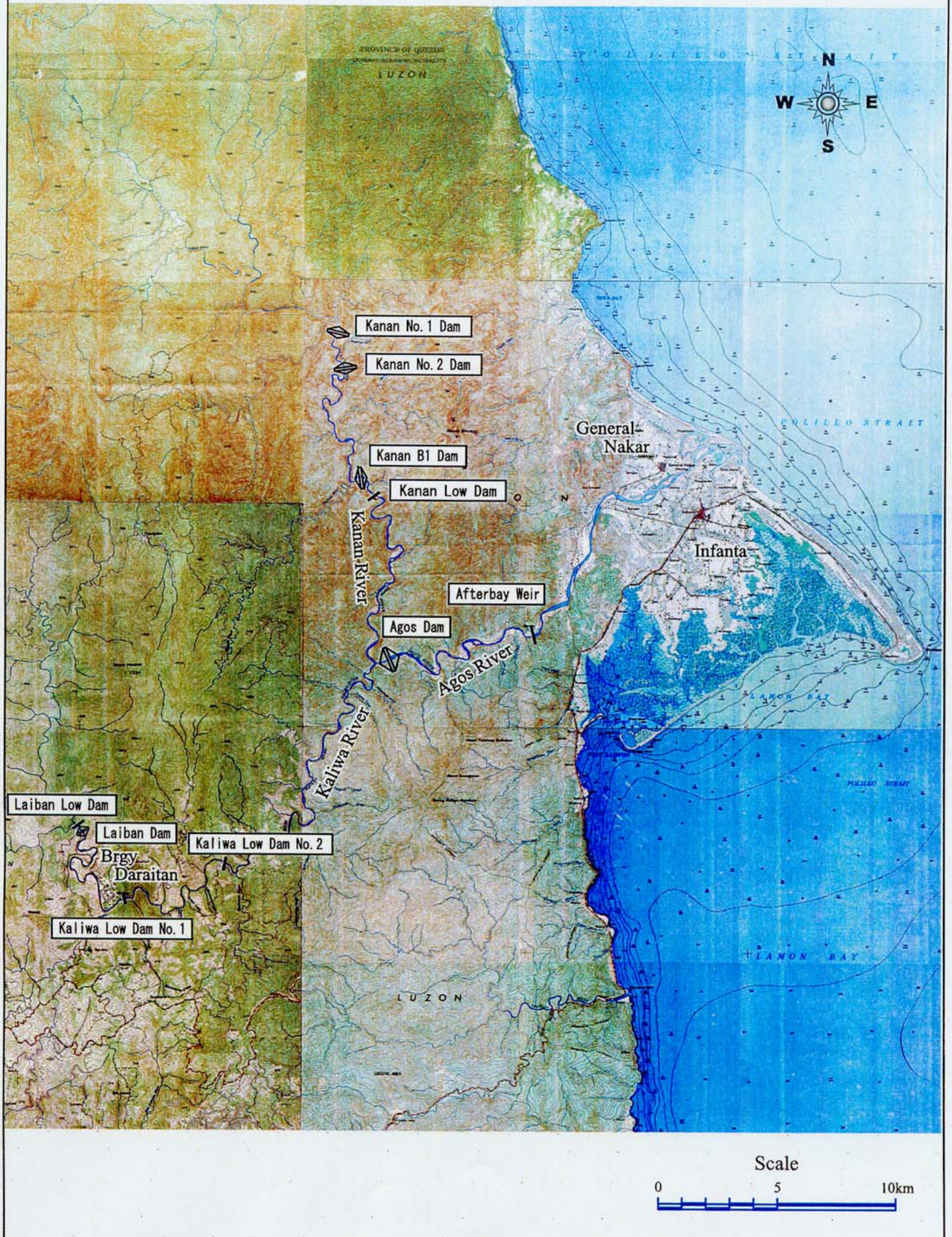
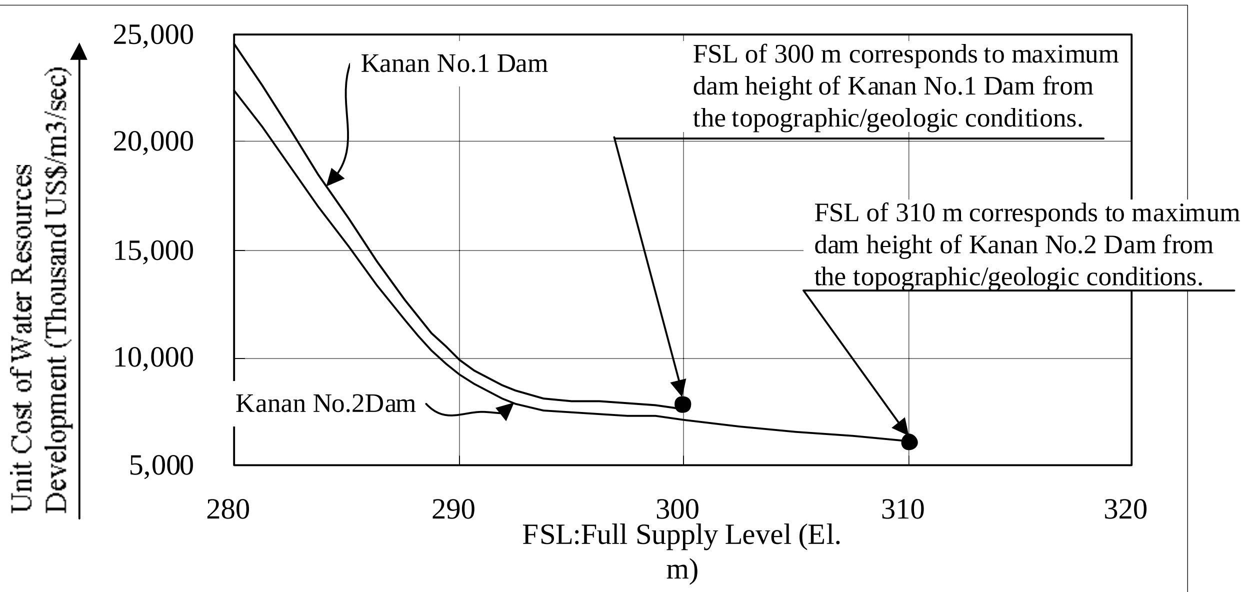
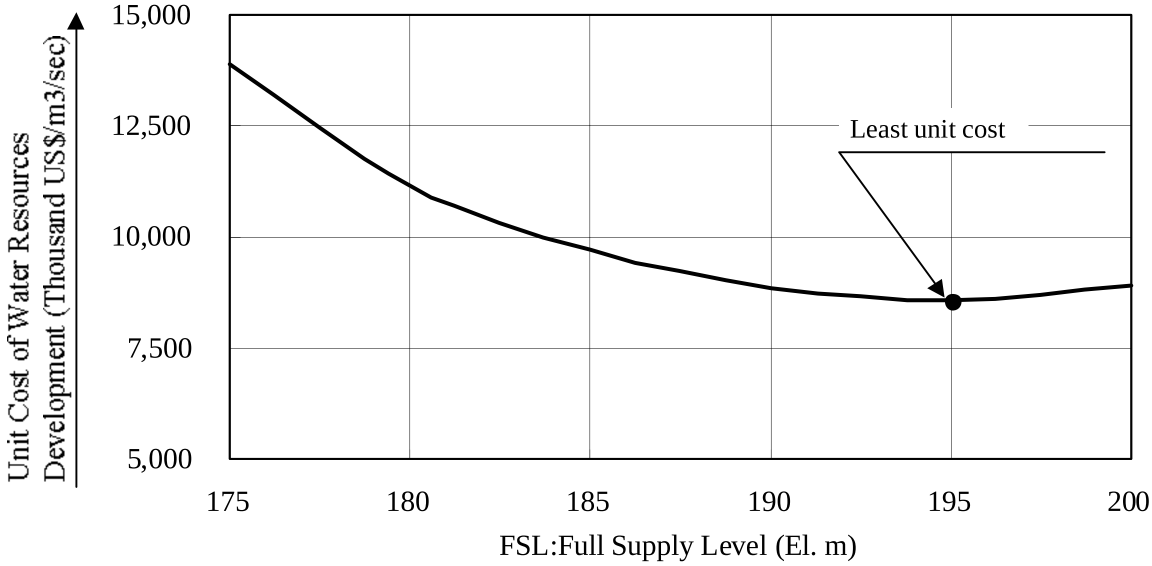


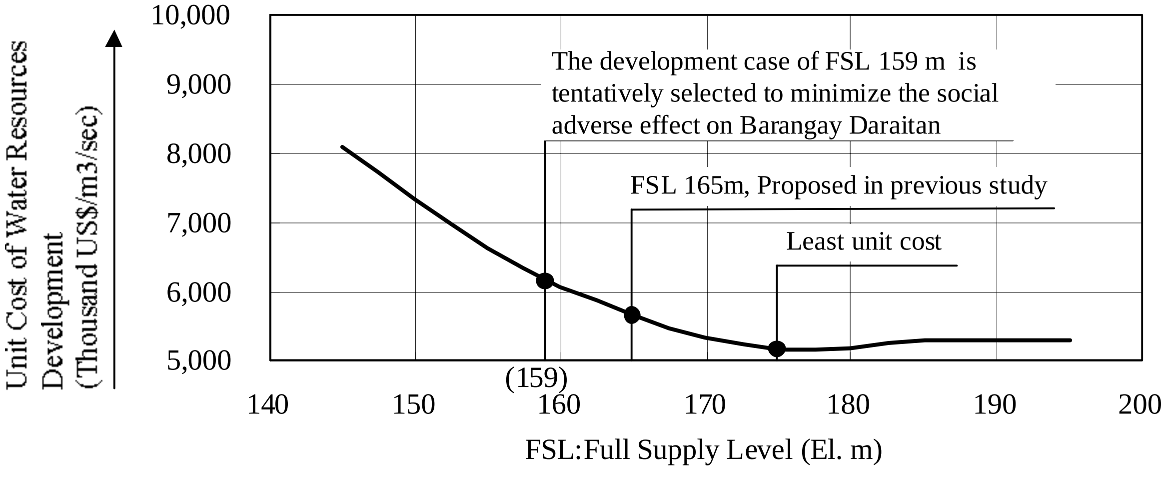

Figure 5.1
Proposed Dam Development Sites in the Agos River Basin




**Kanan No.1 and No.2 Dams**




**Kanan B1 Dam**




**Agos Dam**

**Figure 5.2 Comparison of Unit Cost of Water Resources Development for Dams Planned in the Agos River Basin**

Summary of Development Scenarios

| Scenario | 1st Stage Development | 2nd Stage Development | Future Development |
|---|---|---|---|
| A | A-1 Laiban Dam with Laiban-Taytay 1st Waterway | A-2 Kanan No.2 Dam with Kanan-Laiban Tunnel and Laiban-Taytay 2nd Waterway | A-3 Agos Dam (for hydropower) |
| B | B-1 Kaliwa Low Dam with Kaliwa-Angono 1st Waterway | B-2-1 Agos Dam/Resesvoir<br>B-2-2 Kaliwa-Angono 2nd Waterway | B-3-1 Laiban Dam (for hydropower)<br>B-3-2 Kanan No.2 Dam (for hydropower) |
| C | C-1 Agos Dam with Kaliwa-Angono 1st Waterway<br>Note: Without Kaliwa Low Dam | C-2 Same as B-2-2 (Kaliwa-Angono 2nd Waterway) | C-3-1 Same as B-3-1 (Laiban Dam)<br>C-3-2 Same as B-3-2 (Kanan No.2 Dam) |
| D | D-1 Same as B-1 (Kaliwa Low Dam with Kaliwa-Angono 1st Waterway) | D-2-1 Kanan No.2 Dam with Kanan-Laiban Tunnel<br>D-2-2 Kaliwa-Angono 2nd Waterway | D-3 Same as B-3-1 (Laiban Dam) |
| E | E-1 Same as B-1 (kaliwa Low Dam with Kaliwa-Angono 1st Waterway) | E-2-1 Kanan Low Dam with Kanan-Kaliwa Tunnel<br>E-2-2 Kanan No.2 Dam<br>E-2-3 Kaliwa-Angono 2nd Waterway) | E-3 Same as B-3-1 (Laiban Dam) |
| F | F-1 Same as A-1 (Laiban Dam with Laiban-Taytay Waterway) | F-2 Same as C-1 (Agos Dam with Kaliwa-Angono Waterway) | F-3 Same as B-3-2 (Kanan No.2 Dam) |
| G | G-1 Same as B-1 (kaliwa Low Dam with Kaliwa-Angono 1st Waterway) | G-2-1 Laiban Dam<br>G-2-2 Agos Dam with Kaliwa-Angono 2nd Waterway | G-3 Same as B-3-2 (Kanan No.2 Dam) |
| H | H-1 Laiban Low Dam with Laiban-Angono 1st Waterway | H-2-1 Kanan No.2 Dam with Kanan-Laiban Tunnel and Laiban-Angono 1st Waterway<br>H-2-2 Construction of Laiban-Angono 2nd Waterway | H-3 Same as B-2-1 (Agos Dam) |

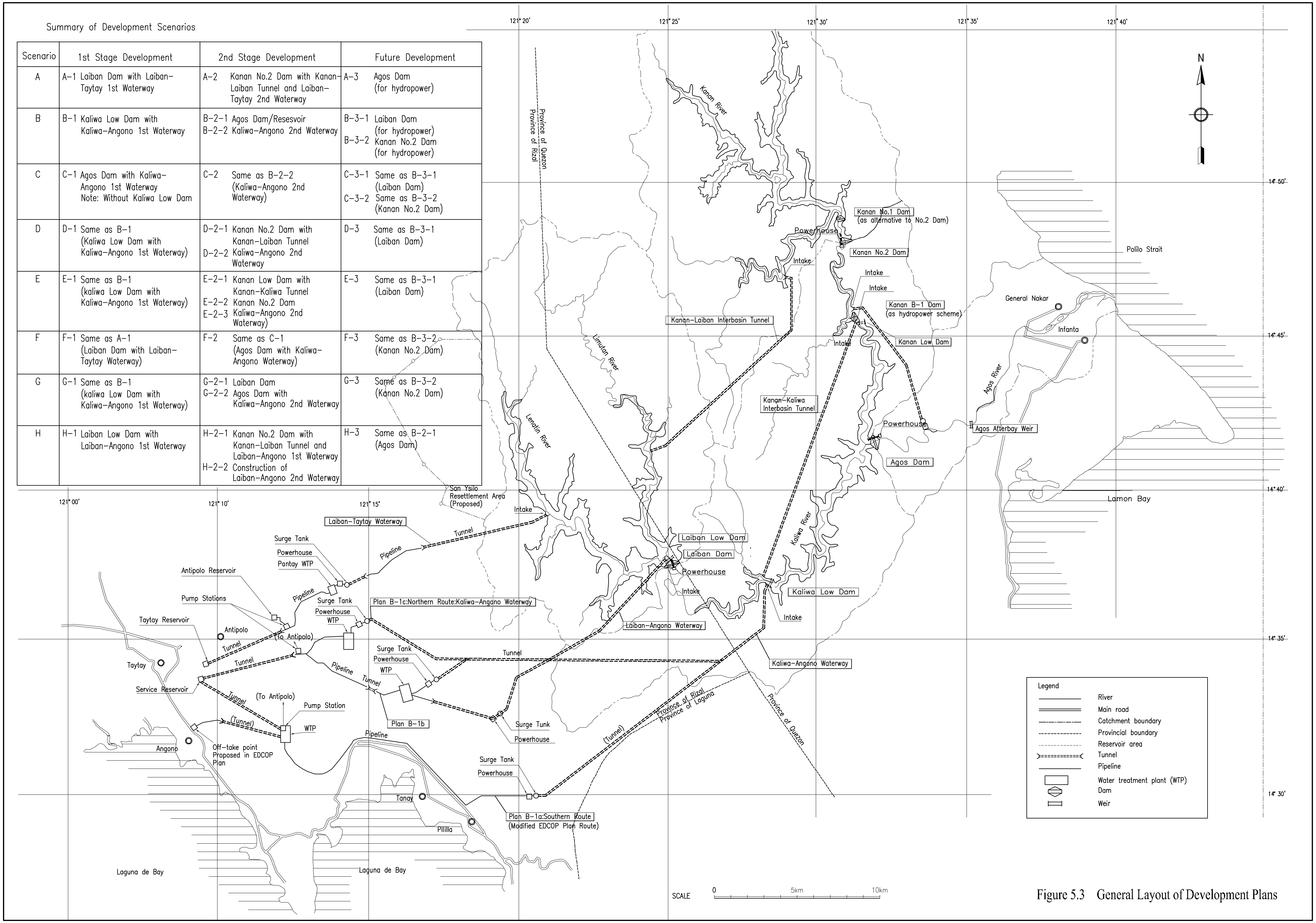



Figure 5.3 General Layout of Development Plans