Part-E

Water Resources Development Plan

Part-E: WATER RESOURCES DEVELOPMENT PLANS

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Part-E: WATER RESOURCES DEVELOPMENT PLANS

E1 Introduction

This Part-E describes all the aspects related to the water resources development in the Agos River Basin, focussing especially on the formulation and evaluation of alternative water resources development plans in the Agos River Basin, which are envisaged for water supply to Metro Manila for a planning horizon up to year 2025. While the succeeding Chapters E2 to E7 discuss mainly the formulation and evaluation of water resources development plans, the Chapters E8 and E9 deal with water resources potentials and water demands in the lowermost reach of the Agos River and preliminary flood control plan for Infanta and General Nakar, respectively.

A lot of studies have been carried out in connection with the water resources development in the Agos River Basin in the past. Prior to preparation of alternative development plans, these previous studies were carefully reviewed to incorporate the useful data and information in the present Master Plan Study. Those data and information obtained through the review are presented in Section E3.

The previous studies have identified five (5) potential water source development sites: i.e. (i) Laiban Dam and (ii) Kaliwa Low Dam on the Kaliwa River, (iii) Kanan No.1 Dam, (iv) Kanan No.2 Dam) and (v) Kanan B1 Dam on the Kanan River (these three Dams on the Kanan River are mutually exclusive), and (vi) Agos Dam on the Agos mainstream. In addition to these dam sites, the Study identified two run-of-river type development sites: i.e. vii) Kanan Low Dam on the Kanan River and viii) Laiban Low Dam on the Kaliwa River (its location is almost same with that of "(i) Laiban Dam" above, but the development type is modified from high dam to low dam for run-of-river development). These potential water source sites in the Agos River Basin are shown in Figure E1.1.

Water supply shortage in Metro Manila system for the planning horizon up to year 2025 is foreseen to be in the order of 3,300-3,400 MLD on a daily average basis, in the case no new water resource development project is realized until the year. The Study assumes that, of this water supply demand, about 3,000MLD would be met by the development of the Agos water resources after the first project is commissioned around year 2010.

Although the Study focuses on formulating water resource development schemes for water supply to Metro Manila, some of the schemes are formulated as multi-purpose scheme incorporating hydropower development. Further, hydropower single-purpose scheme is also taken into account as the case may require. For instance, Kanan-B1 Dam has been planned purposing specifically for hydropower generation, since it could not be a direct source of the water supply due to its location. Depending on the combination of water source development schemes to be selected for water supply, there is a possibility that Agos Dam, Laiban Dam and Kanan Dam may also be developed as a scheme for hydropower generation. These hydropower schemes may come up on the stream of multi-purpose development of the basin and hence are included in the development plans formulated in the Study.

Kaliwa Low Dam scheme functions initially as a run-of-river intake to divert water available from low flow of the Kaliwa River. Subsequently, it will terminate its function, being submerged and replaced by the development of Agos Dam, which enables the water supply for Metro Manila over a long range. Thus, the Kaliwa Low Dam is regarded as a temporary intake dam in the case that the Agos Dam is built in the subsequent stage. Alternatively, it will act as a permanent intake dam in the case it receives augmented water from upstream dams (Laiban Dam and/or Kanan Dam as the case may be).

E2 Basic Framework of Plan Formulation

E2.1 Development Scale for Meeting Water Demand up to Year 2025

As presented in Part-B of this Supporting Report, water demand of the MWSS's service area is projected as tabulated below:

Water Demand Projection

Year	2000	2005	2010	2015	2020	2025	2030	2040
Projected Water Demand (MLD):								
- Day average demand	3,663	3,783	4,250	5,033	5,866	6,980	7,973	10,401
- Day peak demand	4,090	4,577	5,143	6,090	7,097	8,446	9,647	12,585

Note: Water demand projected for period of 2025 onward is approximate.

Although the present capacity of the existing water supply facilities in Metro Manila is around 4,090 MLD on a daily peak basis, it is estimated that the available water 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. While, the present daily peak demand is estimated at about 4,400 MLD in the case a day peak factor of 1.21 adopted in this Study is taken into account (3,663 MLDx1.21=4,400 MLD). This indicates that the present potential peak demand in Metro Manila is already much larger than the existing water supply capacity, resulting in the constrained balance of water demand and supply as evidenced by rationing of water supply imposed so often.

On the other hand, the earliest attainable commissioning of the water supply scheme in the Agos River Basin is foreseen to be around year 2010. This Study assumes that water demand growth till year 2010 would be met by other immediate water source development schemes (defined here as the interim schemes) as much as possible. The interim schemes under contemplation by MWSS at present 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).

If these three interim schemes (700 MLD in total capacity) are added, the supply capacity becomes 4,790 MLD (=4,090 MLD+700 MLD), which affords stable water supply of 3,960 MLD in terms of daily average quantity. In this case, the total water development need towards year 2025 is 3,020 MLD (=6,980 MLD-3,960 MLD) for meeting daily average demand. This should be met by water development of the Agos River basin. If more interim schemes (say, 1,053 MLD) are added, the total supply capacity becomes 5,143 MLD, which could suffice both peak and average demands up to year 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 supply quantity.

Taking into account the development requirement estimated above and uncertainty associated with the projection of future water demand and supply balance, the Study conservatively estimates that the standard target development scale of the Agos

River Basin would be 3,000 MLD on a daily average basis. The development scale of 3,000 MLD is equivalent to about 1.1 times the net growth of water demand between 2010 and 2025. In other words, the standard target level is set to meet the increment of water demand between 2010 and 2025, taking about 10% allowance thereof.

The water resources development schemes in the Agos River Basin are formulated in accordance with the following principles:

i) The optimum development scale of reservoir schemes is determined so that the unit water cost is the lowest. In case the water resource development scheme(s) are not able to yield 3000 MLD, they are combined with other schemes to be able to supply the daily average water of 3,000 MLD for Metro Manila towards year 2025. Those water resource schemes thus combined constitute one of the alternative development scenarios.

ii) In case the water available at the source is in excess of the 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 transbasin tunnel, a powerhouse will be proposed at its downstream end.

iii) In the case the 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.

E2.2 Water Exploitable at Each Development Scheme

Based on the hydrological studies in Part-C of this Supporting Report and optimized scale of the reservoirs (see Section E5.2 hereinafter), exploitable water resources at each site have been evaluated in this Study 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 /*
		225	3,770	43.6	
- Agos Dam	159	133	5,210	60.2	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	

Notes:

1. Definition of Dependability
   Reservoir Scheme: Design year is taken as a dry year occurring once in 10 years, corresponding to a 97-98%dependability for the whole period.
   Run-of-River Scheme: 90% dependable discharge, minus river maintenance discharge which is taken at 10% of 80% discharge according to a guideline by NWRB.
2. /* ; The maximum crest elevation of the Kanan No.2 Dam is proposed 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 as described in Part-C of this Supporting Report. Although it was estimated at 1,900 MLD in the 1979 study on Manila Water Supply III Project (MWSP III), this Study adopted the figure of 1,830 MLD estimated in the present hydrological analysis as the exploitable water of Laiban Dam taking into consideration the very minor difference of both estimates.

E3 Formulation of Alternative Development Scenarios

E3.1 Components of Alternative Development Scenarios

The development scenario for water supply to Metro Manila is composed of water source development schemes in the Agos River Basin and the water transfer schemes for conveying water from the water source sites to Metro Manila. The alternative development scenario has been formulated by combining the water resource development scenarios and the water transfer schemes for water supply to Metro Manila.

Out of eight (8) water source development schemes identified in the Agos River Basin that are referred to in Chapter E1, three (3) reservoir development schemes on the Kanan River, the Kanan No.1 Dam, Kanan No.2 Dam and Kanan B1 Dam, are mutually exclusive. With regard to these three (3) reservoir schemes, a comparison study was carried out to select the most favorable scheme from an economic viewpoint so that the Kanan No.2 Dam with FSL 310m was found to be the most advantageous as explained in Chapter E5. Consequently, the following six (6) water source development schemes are retained for setting up the alternative development schemes:

i) Laiban Dam on the Kaliwa River (hereinafter referred to as "Laiban High Dam", so as to distinguish it from the Laiban Low Dam, where necessary)
ii) Laiban Low Dam on the Kaliwa River
iii) Kaliwa Low Dam on the Kaliwa River
iv) Kanan No.2 Dam on the Kanan River
v) Kanan Low Dam on the Kanan River
vi) Agos Dam on the Agos mainstream

With regard to water transfer scheme to convey water of the Agos River Basin, its route needs to be aligned to link the Kaliwa River Basin and Metro Manila, since it is too hard to find out the economically preferable water conveyance route linking Metro Manila directly with the Kanan River Basin owing to the geographical position of the Kanan River Basin. Besides, the Kanan-Umiray Transbasin scheme has been discarded from the promising alternative schemes to be considered in this Study due to its low attractiveness as discussed in the succeeding Section E3.10. Therefore, water to be exploited in the Kanan River Basin has to be once conveyed to a pond or reservoir to be created in the Kaliwa River Basin and thence to Metro Manila. In this respect, the first stage of water resources development in the Agos River has to be one of the schemes identified in the Kaliwa River Basin or the Agos Dam scheme which enables to construct an intake structure of the water conveyance facility on the Kaliwa River. As the water conveyance schemes that are associated with those water source development schemes, the following three water conveyance routes are selected in the previous study and this Study:

Waterway Route Associated with Water Source Development Schemes

No.	Water Source Development Scheme(s) in the Kaliwa/Agos	Waterway Route Linked to Metro Manila	Identified by:
1	Laiban Dam	Laiban-Taytay	- MWSP III, 1979
2/*	Kaliwa Low Dam, Agos Dam	Kaliwa-Angono (B-1c)	- This Study -
3	Laiban Low Dam	Laiban-Angono	- This Study -

Note: /* ; For a water conveyance route associated with Kaliwa Low Dam and Agos Dam, the Kaliwa-Angono Waterway (B-1c route) is selected as the best route out of the three routes, namely B-1a, B-1b and B-1c, through the comparison study as explained in the succeeding Section E5.4..

This Study worked out a total of eight (8) development scenarios by combining the promising six water source development schemes and three water transfer schemes. The eight (8) development scenarios, Development Scenario A to Development Scenario 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	Schemes Involved in Each Development Scenario: 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 2nd	C-1) & C-2) Agos Dam (w/o Kaliwa Low Dam)	1st w/w: Kaliwa-Angono 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 -

Proposed development framework in each of the eight (8) development scenarios is presented in Table E3.1 and the general layout of those schemes are shown in Figure E3.1. Also, the concept of the proposed plans is schematically illustrated in Figure E3.2. Water exploitation and conveyance plans formulated in this Study are summarized in Table E3.2.

The backgrounds and main features of each development scenario as well as water source development schemes involved therein are explained in the succeeding Sections:

E3.2 Alternative Development Scenario A: (Laiban Dam + Kanan No.2 Dam)

This development scenario is virtually same as the one proposed in the Manila Water Supply III Project in 1979.

E3.2.1 Plan A-1: Laiban Dam as the First Stage

(1) Background of Laiban Dam Project

Many studies have been carried out for the Laiban Dam, initiated by a feasibility study in 1979. Major studies so far conducted are as follows:

(a) Manila Water Supply III Project, Feasibility Study, Dec. 1979, Electrowatt, et al (Ref.1)

The previous study examined nine (9) possible water supply sources in various river basins around Metro Manila and identified that Laiban Dam scheme in the Agos River Basin would be the most promising source for water supply to the Metro Manila area.

(b) Manila Water Supply III Project, Detailed Engineering Design, July 1984, Electrowatt, et al (Ref. 5)

The previous study produced a detailed design of the Laiban Dam including preparation of tender documents. The plan envisaged to build a storage reservoir having a full supply level (FSL) at EL. 270 m, which would be capable of yielding 1,900 MLD of water.

(c) Manila Water Supply III, Project Review, Feb. 1997, Electrowatt & Renardet (Ref. 6)

The previous study proposed the modification of a part of the detailed design prepared in 1984. No major change was proposed for dam, intake, water transfer tunnel, hydropower plant and water treatment works. Revision was proposed for facilities downstream from the Pantay water treatment works: i.e. change in the location of service reservoirs and water conveyance route. The revised plan envisages to provide a 120 ML main service reservoir at Taytay (instead of previous Cogeo reservoir), a pressure control station at Taytay (previously at Mayamot), a new 100 MLD pumping station and 20 ML service reservoir at Antipolo, and a 120 ML balancing reservoir at Muntinlupa.

(d) Laiban Dam Project, Final Report, August 2000, Gutterridge Haskins & Davey, et al (Ref. 8)

The previous study examined the method of procurement of the project through BOT process. The report also presented an updated estimate of the project cost.

(e) An Inventory of Needs, Problems and Proposed Solutions of Families Affected by the Proposed Laiban Dam Project, Oct. 2000, UPSARDFI (Ref. 9)

Laiban Dam will inundate 7 Barangays in the proposed reservoir area, requiring the relocation of about 3,000 families. This resettlement issue has long been a bottleneck for the implementation of the Laiban Dam project. Recent status is that people in 7 Barangays are no longer willing to move from the present locations and people in the proposed San Ysiro resettlement area oppose the relocation of families from 7 Barangays.

The UPSARDFI study looked into the issues of resettlement of people who will be affected by impounding of the Laiban reservoir. The previous study conducted interview survey for 2,248 families (out of possible 2,577 families in seven (7) Barangays in the proposed reservoir area), which identified the need of 'people participatory approach' to solve this difficult social issue.

With background of these earlier studies, the Laiban scheme is in the most matured state among the schemes earlier studied and appears to be in the nearest position to the implementation, provided that the resettlement issue is solved successfully at an early period.

(2) Laiban Dam Scheme Proposed in this Study

The Laiban Dam scheme has been optimized through the previous studies and the detailed design already prepared as mentioned above. Hence, there is no significant need of examining alternative plans with different development scales. Accordingly, this Study deals with the Laiban scheme as per proposed in the existing detailed design prepared under the MWSP III.

The reservoir yield is, however, assessed as 1,830 MLD in this Study (see Table E3.2), which is slightly less than the figure planned in the MWSP III (1,900 MLD).

(3) Issues Specifically Examined on Laiban Dam

(a) Reservoir Watertightness

The previous survey noted that there might be a problem of water leakage from the reservoir due to existence of solution-affected limestone (Ref. 4). It identified that a limestone horizon of Masunguit rock, extending in the reservoir near San Andres, could result in seepage loss under certain conditions. The survey, however, finally concluded that there are indications of existence of an intervening groundwater divide, which culminates above the envisaged storage level (EL.270 m), and consequently the watertightness of the reservoir would be assured for reservoir water level up to EL. 270 m.

As stated in Part-D of this Supporting Report, the Study Team's Geologist looked into this problem carefully through reconnaissance survey conducted during the First Field Investigation. As a result, the Geologist's interpretation of this issue is almost identical to the findings in the previous study. Nevertheless, some in-situ geological investigation is required for further confirmation in the next study stage before the implementation of the project.

(b) Resettlement Issue

Whatever the project is implemented by financing from ODA fund or private fund on BOT basis, this kind of 'people-related issue' should be settled with the initiative of the public sector (MWSS). Unless some prospects of solving the issue become foreseeable, it is likely that most private entities will be reluctant in participating in the project on BOT basis.

Solving this issue is a matter needing an earliest action by MWSS. The previous study (Ref. 9) proposed the necessity of mobilizing people-participatory approach to tackle this long-term outstanding issue, which is an activity requiring a certain long period. The Study tentatively assumes that at least three (3) year period will be required to re-mobilize the dialogue with concerned local people and commence the actual land acquisition, compensation and relocation activities at the field. This extra time requirement is a great handicap for the Laiban Dam scheme in terms of delay in commissioning of the project.

The JICA Study Team exchanged discussions on this issue with the representatives of MWSS at Technical Working Group level and requested to hear the MWSS's decision on a further action program to be followed up by MWSS. Depending on the MWSS proposed program, the possibility of the implementation of the Laiban Dam would have to be re-programmed.

(c) Type of Dam

Present design adopted a Concrete Face Rockfill Dam (CFRD). The latest design review (Ref. 7) revealed that CFRD is less costly by 8% than the Roller Compacted Concrete Dam (RCCD).

E3.2.2 Plan A-2: No. 2 Kanan Dam as the Second Stage

(1) Background of Kanan Dam Scheme (either Kanan No.1 or Kanan No.2 Dam)

The Kanan Dam scheme was studied in the following two previous studies:

(a) Manila Water Supply III Project, Dec. 1979, Electrowatt et al (Ref. 1)

The previous study proposed that Kanan No.2 Dam should come up on development stream next to the Laiban Dam scheme (Plan A-1). The scheme is proposed virtually as a scheme to augment the Laiban water by means of 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 study proposed a 160 m high dam of earth-core rockfill construction at a preliminary design level (Ref. 2).

(b) Feasibility Report on Agos River Hydropower Project, March 1981, JICA (Ref. 10)

The previous study examined a dam at Kanan No.1 site as a hydropower single-purpose scheme. The dam is proposed to be of a concrete gravity type to create a reservoir of FSL 300 m (Ref. 12). However, this scheme was finally abandoned from the further study, since this dam scheme is mutually exclusive with the Kanan No.2 Dam proposed for water supply purpose in the previous study (a) above.

(2) Issues Noted in Formulation of Kanan Dam Scheme

(a) Selection of Optimum FSL

Previously proposed plans (FSL 295-310 m) are of nearly a maximum exploitable development scale at the site, judging from topographic and geological features encountered at the site. This development concept is principally acceptable, since the potential of the site should be exploited to a maximum extent as far as it is economically justifiable.

The Study examines the economic attractiveness of various scale development plans and selects the plan yielding the lowest-cost water at the dam as presented in Section E5.2 hereinafter.

(b) Comparison of Damsites

There are two potential damsites: i.e. Kanan No.1 and Kanan No.2 damsites, which are mutually exclusive each other.

From geological viewpoint, thin right abutment at Kanan No.1 site is a matter requiring further detailed review. Width of the abutment ridge at riverbed level (El. 150 m) is some 500m, while the width at FSL 300 m is only 200-250 m. The previous study shows an indicative cross section of the abutments at the Kanan No.1 site (Ref. 2). As described in Part-D of this Supporting Report, steep hydraulic gradient occurring on the right abutment will require extensive water proof grouting work. This topographical handicap at the Kanan No.1 site suggests the selection of the Kanan No.2 dam as a dam on the Kanan River.

Cost index analyzed in Section E5.2 has also revealed that Kanan No.2 Dam is more favorable in cost terms than Kanan No.1 Dam. Hence, Kanan No.2 Dam is assumed in the plan formulation study hereinafter.

(c) Access to the Site

As interpreted on 1/50,000 map, access to the Kanan No. 2 Dam site as well as to transbasin tunnel portals requires the construction of new roads of about 60 km in total length from Laiban Dam, routing in hilly virgin forest lands. In addition to relatively large cost requirement, construction of road in virgin forest area causes adverse impacts in environmental terms. Access to the damsite, if the Kanan-Laiban transbasin tunnel is not included in the scheme, will be via Agos Dam. In this case, the access length is some 20 km from the Agos Dam.

(3) Kanan No. 2 Dam Proposed in This Development Scenario

Kanan No. 2 Dam proposed in this Development Scenario has FSL 310 m and MOL 278 m with reservoir yield of 38.3 m^3/sec or 3,310 MLD (see Table E3.2). The reason of selection of this development scale is described in Section E5.2 hereinafter.

The water is conveyed to the Laiban Dam reservoir through an interbasin tunnel. The combined water yield of Laiban Dam and Kanan No. 2 Dam is 54.1 m^3/sec or 5,110 MLD.

E3.2.3 Plan A-3: Additional Development Scenario (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:

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

This scheme is just identical to the plan contemplated in the previous Agos Hydropower Feasibility Study (Ref. 10). The Agos Dam can use excess water released from the Laiban and Kanan Dam (including flood flow) and runoff yield from residual basins of 295 km^2 (catchment area is 860 km^2 at Agos Dam, while it is 276 km^2 at Laiban Dam and 289 km^2 at Kanan No.2 Dam). The previous study identified that this Agos scheme would still be attractive as a hydropower project even after the diversion of upstream waters to Metro Manila.

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

This scheme was studied in the feasibility study for Small Hydropower Projects by NPC/ Nippon Koei-Lahmeyer in 1992 (Ref. 14). The plan envisaged to construct a 74.5 m high CFRD with a reservoir of FSL 180 m. Water stored in the Kanan B1 reservoir is conveyed through a headrace waterway of about 9 km long to a powerhouse (112 MW) located some 4 km downstream of the proposed Agos Dam site. The previous study did not take into account the water transfer to Metro Manila in the upper basin and assumed that all water resources of the Kanan River Basin would be available for power generation. Under this water use condition, the scheme was assessed to be feasible. The scheme is mutually exclusive with the Agos Dam scheme stated in (1) above.

This Development Scenario A envisages the construction of Kanan No.2 Dam with a priority for water supply. In this case, the Kanan B1 Dam scheme has two major constraints:

(i) Power generation is greatly dependent on water to be released from the upstream Kanan No.2 Dam in excess of water transfer to the Laiban Dam. If the water transfer to Metro Manila increases up to the full capacity of Kanan No.2 reservoir yield (3,310 MLD) in the future, Kanan B1 Dam could not receive regular release of water from the Kanan No.2 Dam. The residual basin area downstream of the Kanan No.2 Dam is only 66 km^2 (catchment areas are 289 km^2 at Kanan No.2 Dam and 355 km^2 at Kanan B1 Dam). This is a factor making the Kanan B1 Dam scheme less attractive.

(ii) Even if (i) is accepted as a given condition (i.e. power plant is operated for a limited period until the water transfer from Kanan No.2 Dam to Metro Manila reaches the full capacity, say 20 years), another constraint is topographical aspect. The previous study proposed the FSL of the Kanan B1 reservoir to be EL. 180 m. The backwater submerges the downstream toe of the Kanan No.2 Dam (riverbed level EL. 150 m) by about 30 m in depth, which would have an adverse effect on the stability and functions (e.g. bottom outlet) of the Kanan No.2 Dam. The FSL should be lowered to a certain level (say, EL. 165 m), which result in a lesser flow regulating capacity of the Kanan B1 Dam. This factor also makes the attractiveness of the Kanan B1 scheme lesser.

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

In the case the FSL of the downstream Agos reservoir is set at less than EL.159-165 m, there is a possibility of installing a power plant just downstream of the Kanan No.2 Dam. The maximum available head is about 151 m in the case of FSL being EL.310m.

However, same as for the Kanan B1 Dam, a great constraint in this scheme is that power generation is entirely dependent on surplus water available at the Kanan No.2 reservoir in excess of water transfer to the Laiban Dam. The power plant could not receive any water, in the case the requirement of water transfer to Laiban Dam increases to a level of maximum yield rate of the Kanan No.2 reservoir in the future. This is a vital factor making the scheme less attractive. Accordingly, the Kanan No.2 Dam with a hydropower plant just downstream of the dam is realizable only in the case of no water transfer from the Kanan No.2 reservoir to the Laiban reservoir.

(4) Proposed Development Plan of 3rd Stage Onward

Assessing technically the particular constraints involved in the Kanan B1 and Kanan No.2 Dam hydropower schemes stated above, 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 the program of Development Scenario A.

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 deal with the Agos Dam to be a hydropower scheme in the case of this Development Scenario A.

E3.3 Alternative Development Scenario B: (Kaliwa Low Dam + Agos Dam)

E3.3.1 Plan B-1: Kaliwa Low Dam as the First Stage

(1) Background of Kaliwa Low Dam

This scheme was originally proposed by MWSS's in-house consultants and has been studied by a consulting firm (EDCOP). To date, EDCOP conducted a 'Project Identification Assessment & Validation Study' (Ref.15) and subsequently 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 in the estimate 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.

Alternative Development Scenario B proposed in this Study is identical to the development concept proposed in the previous EDCOP study.

(2) Concepts of Development Plans on Kaliwa Low Dam

Kaliwa Low Dam scheme is regarded as the first stage development 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 an earliest period, since the Agos Dam will require a longer lead time of about 10 years until it is commissioned.

Kaliwa Low Dam is planned as an integrated part of the design of Agos Dam. Assuming that ultimate development of the Agos reservoir for Metro Manila water supply is 3,000 MLD (34.7 m^3/sec), plan formulation of the Kaliwa Low Dam scheme adopts the following concepts:

(i) Kaliwa Low Dam itself is a temporary structure functioning only for 3 years until the Agos Dam is completed. The Kaliwa Low Dam is eventually submerged by the Agos reservoir. Accordingly, the Kaliwa Low Dam would be of a least cost construction, having an intake and a simple sediment flushing structure.

(ii) Two water conveyance tunnels are provided at the ultimate stage. The first tunnel will be constructed under the Kaliwa Low Dam scheme. The capacity of tunnels is 1.21 times the average yield: i.e. 3,640 MLD (3,000 MLDx1.21) or 42.0 m^3/sec by two tunnels after the Agos Dam is completed. The capacity of one tunnel is 1,820 MLD or 21.0 m^3/sec. In the initial stage, design intake discharge for the Kaliwa Low Dam is taken at 6.4 m^3/sec (550 MLD), which corresponds to 90% dependable discharge available at the Kaliwa Low Dam site.

(iii) Water treatment plant (3,640 MLD in total capacity) can be implemented stage-wise: i.e. four units of 910 MLD (750MLD x 1.21) capacity at the ultimate stage. Only a unit (910 MLD) will be installed in the first stage.

Water conveyed from the Kaliwa Low Dam (550 MLD in 90% dependable discharge) can be processed by this one unit.

(iv) Hydropower plant will not be installed at the end of waterway tunnel in the first stage. It is apparently less attractive in view of long tunnel (28 km) and small available head (only 30m gross head at intake water level of EL. 125 m). The power plant will be planned at the second stage (after the Agos Dam).

(3) Alternative Plans Examined

(a) Location of Kaliwa Low Dam Site

Figure E1.1 shows two alternative sites for Kaliwa Low Dam, Kaliwa Low Dam No.1 site and No.2 site in the order from upstream. In addition to the survey conducted by EDCOP, these two alternative low dam sites were reconnoitered and compared by the JICA Study Team so as to determine the most favorable dam site from the technical viewpoint as discussed below.

The Kaliwa Low Dam No.1 site is located some 300 m downstream of the confluence of the Kaliwa River and 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 low intake dam site:

- There exists a large volume of sand/gravel deposits at the confluence of Limananin Creek, which is the accumulation of riverbed materials washed out from Kaliwa upstream reaches through a narrow rapid gorge just upstream of the Limananin confluence. In the case the Kaliwa Low Dam No.1 site is selected, the sand/gravel deposits are 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, upstream of Limananin confluence or 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.

The Kaliwa Low Dam No.2 site is identical to 'Kaliwa Downstream Site' surveyed under the MWSP III study in 1979 (Ref. 4). It seems that the site has no problem for constructing a low dam. Geological condition is acceptable for construction of a low dam, according to survey by the Geologist of the JICA Study Team during the First Field Investigation.

The above stated factors clearly show that the Kaliwa Low Dam No.2 site is much more superior to the Kaliwa Low Dam No.1 site from the topographical and geological aspects. Therefore, the Kaliwa Low Dam No.2 site has been selected as the proposed Kaliwa Low Dam site.

(b) Alternative Water Transfer Tunnel Routes

As shown in Figure E3.1, three alternative routes of Kaliwa-Angono water conveyance lines are planned for comparison. General longitudinal profiles of the three routes are shown in Figures E3.3 to E3.5, respectively.

i) <u>Plan B-1a (Southern Route)</u>: Identical to the route proposed in the EDCOP Study. EDCOP proposed that water treatment plant is located at a relatively low level of EL.40m and water delivered to the distributors at an off-take point at EL.10m. For comparison with other alternative routes on an equal basis, it is planned in this comparative study that water is pumped up to Angono Service Reservoir at EL.72 m.

ii) <u>Plan B-1b (Intermediate Route)</u>: Water is conveyed by a longer tunnel (24 km) to a water treatment plant at El. 100m, and further conveyed to Angono Reservoir by gravity.

iii) <u>Plan B-1c (Northern Route)</u>: The plan consists of a further longer tunnel (28 km) and a water treatment plant at EL. 95 m.

Preliminary cost comparison showed that Plan B-1c would be least costly. Detail of the comparison study is presented in Section E5.4 hereinafter.

E3.3.2 Plan B-2: Agos Dam as the Second Stage

(1) Background

The previous feasibility study by JICA in 1981 (Ref. 10) 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.

Under this development scenario, it is assumed that the proposed Agos Dam will receive all water from upstream basins. This is a significant change of concept from that assumed in the previous study.

(2) Concepts of Development Plans

(a) Full Supply Level (FSL) of Agos Reservoir

In planning the FSL of the Agos Dam, the following two primary criteria are set forth:

(i) The potential of future development of the Laiban Dam should be preserved for future water supply need beyond year 2025. This suggests that maximum FSL assumed for the Agos Dam is around EL.165 m associated with the flood retention level of around EL.170-172 m, which corresponds to the riverbed level at Laiban Damsite (around EL.172 m) and hence does not affect the future Laiban Dam construction.

(ii) Lowest FSL of the Agos reservoir may be set at El.159 m, associated with flood retention level of around EL. 163 m. In this case, the main part of Barangay Daraitan (around EL.169 m) will not be affected substantially. This plan should be considered seriously from a viewpoint of avoiding submergence of Barangay Daraitan, thus minimizing the social adverse effects arising from the relocation of people.

At the moment, exact altitude of Daraitan village has not yet been known. According to 1/5,000 air-photo map prepared by NPC, a large part of Barangay Daraitan is higher than EL. 160 m, while 1/50,000 map shows it to be around EL.150 m. On one hand, EDCOP carried out vertical control survey during the pre-feasibility study and found the altitude of the Daraitan area to be as follows:

- El. 169.5 m: Located at intersection of main roads at the center of Barangay Daraitan. It is considered to be the average elevation of Daraitan central community.
- EL. 159.0 m: Located at Daraitan ferry terminal
- EL. 158.8 m: Located at riverbed of the Kaliwa River at Daraitan ferry terminal
- EL. 164.8 m: Flood marks located at Daraitan ferry terminal, reported to be the highest flood level experienced at the location

Even in the case of selection of FSL 159 m for the Agos Dam, provision of river bunds may be required at a river stretch to protect the low-lying areas of the Barangay Daraitan from possible inundation during flood time.

To minimize the social adverse effects as far as possible, the present Master Plan Study adopts EL. 159 m as the most appropriate FSL of the Agos Reservoir, although more economical FSL may be found at a higher level (see Section E5.2 hereinafter for detail).

(b) Relocation of Barangay Daraitan

This issue is related to the planning of the Agos Dam stated in (a) above. It is estimated that approximate 600 households live in Daraitan village. At the next Feasibility Study stage, socio-economic survey is scheduled to acquire firm information on the people's acceptance of relocation. The survey will include public consultation to the people and preparation of resettlement schemes through the people participatory approach. The Agos FSL will be reviewed at the next Feasibility Study stage taking into account the social acceptability of the affected people.

(c) Hydropower Plan

The Study envisages installing hydropower power plant at two locations: one is just downstream of the Agos Dam and the other at the outlet of water conveyance tunnel.

According to information obtained from NPC's engineering personnel during the First Field Investigation, the main role of hydropower plant in the future system would remain to be peak power supply. The present Master Plan Study tentatively assumes that power plant at toe of the Agos Dam will have a peaking function of the order of 6-hour operation a day.

The latter hydropower scheme (power plant at conveyance tunnel outlet) has only a relatively small gross head (30-60 m, varying by Agos FSL/MOL), while a loss head is as large as 30 m owing to long water conveyance tunnel.

(d) Reservoir Watertightness

There exists limestone mass in the vicinity of Barangay Daraitan. The JICA 1981 Report assessed that "leakage problem seems negligible because of shallow water level at this point (Kaliwa riverbed at EL.120-130 m) and the presence of impervious beds beneath the limestone mass (Ref. 10)".

Geological survey conducted under the MWSP III study indicated as follows: "The thickness of the limestone, inferred from surface exposure and dip angle, is in the order of 300 m to 450 m. Solution cavities have developed following bedding planes. Such cavities must be assumed to penetrate the entire limestone complex. The limestone is underlain by conglomerates, soft shale and mudstone (Ref.4). Towards the south of Daraitan ridge, the limestone seems to wedge out or to be cut off by faults, which would exclude water loss in this direction. Nevertheless, geologic evidence in this respect is not conclusive, and hence requires further survey".

During the First Field Investigation, the similar observation was revealed by the reconnaissance of the Geologist of the JICA Study Team. Hence, the present judgement is that there would be no serious concern for this issue. Nevertheless, further detail on the geological condition would have to be confirmed at the next feasibility study stage by in-situ geological investigations consisting of drilling investigation and electric exploration survey.

(e) Necessity of After-bay Construction

The previous study (Ref. 10) 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. The previous study, however, finally concluded that the afterbay weir would not be required for the reason of semi-base load plant operation characteristics (12-hour operation) and relatively small fluctuation of river water levels at Banugao.

The present Master Plan Study contemplates to provide an after-bay weir since the proposed power plant will have a peaking function, say, 6-hour operation a day.

The location of the proposed afterbay weir is shown in Figure E1.1. The storage volume of a pond created by the afterbay weir is estimated at about 2.2 million m^3 with a drawdown of 10.5 m between FSL 25.5 m and MOL 15 m, which is larger than that required for daily regulation of peak operation discharge (88.8 m^3/sec).

In the next Feasibility Study stage, the necessity of the afterbay weir will be examined through the optimization study of hydropower development scheme.

E3.3.3 Plan B-3: Additional Development Scenario (Laiban Dam and Kanan No.2 Dam)

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

Concept of development is just identical to Alternative Development Scenario A-1 mentioned in Section E3.2 above. Need of 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 the case the additional water 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 laying out the 3rd conveyance waterway line and also a larger cost requirement for conveyance waterway than that from the Laiban Dam.

(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 the Agos reservoir as the after-bay pond, the power plant can be designed as a pure 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 yield.

In this case, access to the site is along the left bank of the Kanan River via Agos Dam.

E3.4 Alternative Development Scenario C (Agos Dam without Kaliwa Low Dam)

E3.4.1 Plan C-1&2: Agos Dam in Two Development Stages

This plan is a minor variation of the Alternative Development Scenario B. Plan C-1 envisages implementing only the Agos Dam without advance implementation of the Kaliwa Low Dam.

As proposed in the Alternative Development Scenario B, the Kaliwa Low Dam is constructed as a pre-investment scheme of the Agos Dam development. Extra investment incurred due to the advance implementation of the Kaliwa Low Dam scheme consists only of the costs for a temporary low dam. The Kaliwa Low Dam scheme (Plan B-1) in the Development Scenario B is presumed to complete in 2 to 3 years ahead of the commissioning of the Agos Dam (Plan C-1). The extra costs required for construction of the Kaliwa Low Dam in the Development Scenario B is expected to be offset by the benefits of advanced water supply to Metro Manila by 2 to 3 years.

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.

E3.4.2 Plan C-3: Development Plan of 3rd Stage Onward

The development scenario of the 3rd stage onward is same as Plan B-3 of Development Scenario B, as described in Section E3.3 above.

E3.5 Alternative Development Scenario D (Kaliwa Low Dam + Kanan No.2 Dam)

E3.5.1 Plan D-1: Kaliwa Low Dam as the First Stage

The concept of Plan D-1 in the Development Scenario D is identical to that described for Plan B-1 described in Section E3.3. The Kaliwa Low Dam scheme is regarded as the first stage development with 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 design intake discharge is set at 6.4 m^3/sec (550 MLD)**,** allowing a reduced dependability criterion of 90% for the run-of-river development, that is same as that for the Kaliwa Low Dam constructed as a temporary intake dam in the First Stage of the Development Scenario B.

E3.5.2 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 Kaliwa basin. No power plant is installed at the end of Kanan-Laiban 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 outlet of water conveyance tunnel.

With the development of Kanan No.2 Dam having FSL 310 m and MOL 278 m, it is expected that 38.3 m^3/sec (3,310 MLD) of water will be exploited at a dependability of 97-98%. On one hand, natural runoff available 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 second stage.

E3.5.3 Plan D-3: Development Plan of 3rd Stage Onward

As a future development, Laiban Dam can be built in this Development Scenario D. The proposed features of the Laiban Dam are identical to those described for Plan B-3-1 mentioned in Section E3.3 above. Agos Dam will not be included in the plan, since the Kaliwa Low Dam is built as a permanent structure.

E3.6 Alternative Development Scenario E (Kaliwa Low Dam + Kanan Low Dam + Kanan No.2 Dam)

E3.6.1 Plan E-1: Kaliwa Low Dam as the First Stage

First stage development of this scenario (Plan E-1) is identical to Plan D-1 of the Development Scenario D. Kaliwa Low Dam is built as a permanent structure. 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.

E3.6.2 Plan E-2: Kanan Low Dam (Plan E-2-1) and Kanan No.2 Dam (Plan E-2-2) as the Second Stage

An idea proposed in this Plan E-2 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 the Kaliwa Low Dam, a 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 water demand of the Metro Manila area up to year 2025 (Plan E-2-2). Different from the case of water transfer to Laiban Dam, where a relatively high MOL has to be designed due to the location of the transfer intake at a higher altitude in the upstream reach, Kanan No.2 reservoir in this case can be designed to have a lower MOL of EL.225m. The reservoir will yield 3,770 MLD (43.6 m^3/sec) in daily average quantity.

The Kanan-Kaliwa transbasin tunnel will have a capacity of 3,770 MLD (43.6 m^3/sec), which 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. A total daily average flow by two tunnels is 4,060 MLD (290 MLD from the Kaliwa runoff (see Section E3.4) + 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 (Plan E-1 and E-2-2), although a dam (Kanan No.2 Dam) will be required eventually in the ultimate stage (Plan E-2-2).

E3.6.3 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 described in Section E3.3 above. Agos Dam will not be included in the plan, since the Kaliwa Low Dam is built as a permanent structure.

E3.7 Alternative Development Scenario F (Laiban Dam + Agos Dam)

E3.7.1 Plan F-1: Laiban Dam as the First Stage

The Plan F-1 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 (1,830 MLD).

E3.7.2 Plan F-2: Agos Dam as the Second Stage

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

E3.7.3 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.

E3.8 Alternative Development Scenario G (Kaliwa Low Dam + Laiban Dam + Agos Dam)

E3.8.1 Plan G-1: Kaliwa Low Dam as the First Stage

This Scenario is a variation of Scenario B. 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), same as for the case in the Development Scenario B.

E3.8.2 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, the Laiban reservoir 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 toe of the Laiban Dam.

Since the reservoir yield of Laiban Dam (1,930 MLD) is not enough for meeting water demand up to year 2025, Agos Dam with 2nd Waterway (Plan G-2-2) is required at the second stage. Water conveyance is made through the Kaliwa-Angono waterway (Route B-1c), which is identical to that of the Development Scenario B mentioned in Section E3.3 above.

E3.8.3 Plan G-3: Development Plan of 3rd Stage Onward

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.

E3.9 Development Scenario H (Laiban Low Dam + Kanan No.2 Dam)

E3.9.1 Plan H-1: Laiban Low Dam as the First Stage

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).

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, preferably close to the Laiban High Dam site so that the waterway built for the Laiban Low Dam can be connected to the Laiban High Dam in the future stage. However, there is no suitable site for the Laiban Low Dam in the reach downstream of the Laiban High Dam site. Only a conceivable location is at a site about 3 km downstream of the High Dam site or 1.5 km upstream of Daraitan Village as shown in Figure E3.6. However, this site was discarded in view of unfavorable topography and river morphology occurring at the site.

As shown in Figures E3.1, hence, 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 90% discharge available at the Laiban Low Dam site is 3.9 m^3/sec (or 340 MLD), which is the design intake discharge at the Plan H-1 stage.

Waterway is laid out crossing over the existing diversion tunnels. Since the elevation of conveyance waterway (around EL.195m at intake site) is much higher than the case of Scenario B (EL. 115m), the waterway cannot be aligned along the Route B-1c and hence a new waterway route has to be planned as shown in Figure E3.1. The waterway for the Laiban Low Dam is called Laiban-Angono waterway.

E3.9.2 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 (Plan H-2-1). Kanan No. 2 Dam will transfer 3,310 MLD (daily average) of water to the Laiban Low Dam intake site and, in addition, 10-year probable low flow of 140 MLD from the Kaliwa basin is available at the Laiban Low Dam site. The combined available water of 3,420 MLD (slightly less than the simple addition of 3,310 MLD and 140 MLD) is more than enough to meet the water demands of the Metro Manila area up to year 2025. The 2nd waterway will be built (Plan H-2-2) before the water conveyance through the 1st waterway reaches its full capacity.

E3.9.3 Plan H-3: Development Plan of the 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-2-1 above.

E3.10 Other Potential Plans

The following plans are also conceivable, but ruled out from further study by the reasons stated below. The schematic plan of these two plans is shown in Figure E3.2.

E3.10.1 Kanan B1 Dam

As stated hereinbefore, Kanan B1 Dam is mutually exclusive with both Kanan No.2 Dam and Agos Dam. If the Kanan-2 Dam is built at riverbed El 150 m, no effective storage capacity is virtually available for the Kanan B1 Dam (Riverbed EL. 130 m). On one hand, if the Kanan B1 Dam is built at EL.130 m, FSL of the Agos Dam could not be raised above EL. 130-140 m, which implies that Kanan B1 Dam can only be conceived in the case both the Kanan No.2 Dam and Agos Dam are not proposed.

E3.10.2 Kanan-Umiray Transbasin Water Transfer

This scheme envisages transferring the Kanan River water to the existing Angat reservoir in two steps. In the first step, the Kanan River water is conveyed to the Umiray River through a newly constructed Kanan-Umiray tunnel and thence to the Angat reservoir through the existing Umiray-Angat transbasin tunnel completed recently under the Umiray-Angat Transbasin Project. Accordingly, this scheme requires construction of 10 to 12 km long Kanan-Umiray interbasin tunnel as well as a run-of-river intake or Kanan No.2 Dam on the Kanan River.

A map study of this plan revealed that the plan would involve the following constraints:

(i) The intake sill elevation of the existing Umiray-Angat tunnel is at EL. 235 m. On a basis that water transfer is through a run-of–river type intake built on the Kanan River, the catchment area of the Kanan River Basin higher than EL. 235 m is only 50 km^2, where only limited quantity of dry season flow could be exploited (say, 1.0-1.5 m^3/sec). For transfer of this small quantity of water, construction of a 12 km long tunnel will be required.

(ii) If the Kanan No.2 Dam is constructed (e.g. FSL 295-310 m/MOL 278 m), there is no difficulty of conveying water to the Umiray basin. However, there seems to be no particular necessity to transfer the Kanan water by two systems: one is to Laiban/Pantay system and the other to Angat/La Mesa system, with investment of an extra cost for the Kanan-Umiray tunnel of 10-12 km long.

This plan will only be justifiable in the case of vital need of augmentation of dry season inflow into the Angat reservoir. Otherwise, the plan has little attractiveness in terms of cost effectiveness. Hence, this plan is ruled out from further consideration in this Study.

An alternative idea is to build a storage reservoir on the Umiray River to seasonally regulate the river flow. However, the existing Umiray-Angat transbasin tunnel already diverts average annual flow of 15.7 m^3/sec, while average natural flow at the diversion site is 21.5 m^3/sec (Ref.16). In order to develop additional water resources (21.5-15.7=5.8 m^3/sec at the maximum), it will require the construction of a large storage reservoir to regulate almost all of annual runoff of the Umiray River. The reservoir should be located upstream from the diversion site to utilize the existing run-of-river intake and free flow diversion tunnel. However, potential dam/reservoir site meeting such a large regulation requirement is not found on the 1/50,000 map and moreover it is questionable whether the scheme would be economically viable. Hence, this plan is also ruled out.

E4 Hydropower Development Plans Associated with Alternative Development Scenarios

E4.1 Power Sector in the Philippines

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

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. NPC also plans to establish a transmission company (TRANSCO).

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 E4.1. The earliest commissioning of the first power plant of Agos river basin development is foreseen to be around year 2011-13. Power market for the Agos power schemes is therefore the whole interconnected system, although the actual supply area would be the Luzon grid in view of its location.

E4.2 Power Development Program by NPC

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

E4.2.1 Power Demand Projection

Power demand projection in the PDP is based on the government's forecast of the Gross Domestic Products (GDP), taking into account strong correlation between electricity demand and GDP. The forecast of GDP growth made by NEDA in April 2000 is shown in Table E4.1, which includes two scenarios: low and high scenarios.

The 2000 PDP adopted the low scenario for base case simulation of future power demand. The low GDP growth scenario translates to an average annual growth rate in electricity sales of 7.9% for major island grids during the planning period (2000-2010). 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 E4.2.

Energy sale and peak power demand of the interconnected system in 2010 will be 91,284 GWh and 15,794 MW, respectively, which are 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.

E4.2.2 Capacity Addition

Table E4.3 shows the system capacity addition program for the three main grids during the period 2000-2010. The program foresees to install a total capacity of 9,844 MW.

Of the total 9,844 MW, about half (4,806 MW) are ongoing or committed projects of NPC (2,605 MW), Meralco IPP (2,195 MW) and Provincial IPP (16 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.

E4.2.3 Future IPP Projects

The remaining 5,028 MW will have to be identified and commissioned during the period of 2007-2010 on top of 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 the role 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). The 2000 PDP shows an indicative shopping list of prospective merchant plants as reproduced in Table E4.4. Although the details of these schemes are not known at the moment, Agos hydropower schemes should be competitive with these listed schemes.

E4.2.4 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.

According to the Meralco’s Annual Report for year 2000, Meralco utilized a total of 24.4 billion kWh of energy in year 2000, which is around 54% of the total Philippines energy generation. Sold energy was 21.9 billion kWh, with 36% going to residential customers, 34% to commercial customers and 29% to industrial customers.

Meralco’s franchise area covers a total of 9,338 km^2. Although the area is only 3% of the whole Philippine land area, it accounts for 48% of the country’s GDP, 30% from Metro Manila alone. The Meralco system serves some 3.7 million customers in 20 cities and 91 municipalities. A total population of 18.7 million lives in the franchise area, which is almost a quarter of the country's population of 76.3 million.

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.

Operating Statistics of the Meralco power supply system are shown in Table E4.5, which was reproduced from the Meralco Annual Report.

E4.2.5 Power Tariff

Power tariff of the Luzon Grid is around Peso 3.9/kWh (NPC) as at the beginning 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 as shown in Table E4.6.

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 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. It is presumed that NPC would be willing to purchase the power if the price is reasonably low, preferably below Peso 2.5/kWh.

E4.3 Hydropower Schemes in Agos River Basin

E4.3.1 Hydropower Schemes Associated with Water Supply Schemes

In conjunction with studies of alternative development scenarios for water supply schemes, a number of hydropower schemes have been identified at a master plan study level. They are listed in Table E4.7 (1/2).

Characteristics of the proposed power plants vary by Development Scenario examined. The following give a brief explanation of the proposed power schemes:

(1) Development Scenario A:

- Plan A-1: A power plant is planned at Pantay at the downstream end of the conveyance waterway from the Laiban Dam (22.6 MW). The plant will be operated basically as a base load plant (24-hour operation) using water conveyed for water supply purpose (1,830 MLD=21.2 m3/sec). Water conveyed in excess of the water supply requirement will be spilled out to a nearby river.
- Plan A-2: After the completion of Kanan No.2 Dam and 2nd conveyance waterway, the capacity of Pantay power plant will be expanded to the ultimate capacity (54.1 MW). The plant remains to be operated as a base-load plant (5,110 MLD=59.1 m3/sec).
- No power plant is planned at the outlet of Kanan-Laiban trans-basin tunnel due to small head available.

(2) Development Scenario B:

- Plan B-1: In the initial stage when the water is taken from Kaliwa Low Dam, no power plant will be installed at the outlet of conveyance waterway in view of a relatively small discharge (6.4 m^3/sec) and small effective head available (less than 10 m).
- Plan B-2-1: A powerhouse is built at toe of the Agos Dam (85.6 MW). The plant uses the water available in excess of water transferred from the Kaliwa Low Dam. The plant is planned to be a 6-hour peaking plant (subject to further review in the next feasibility study) with providing an afterbay pond in the downstream reach.
- Plan B-2-2: After the raising of head water level by the impoundment of Agos reservoir and the completion of the 2nd waterway, a power plant will be built at the conveyance waterway outlet at Abuyod (12.5 MW). Due to a large variation of effective head dependent on the drawdown of the Agos reservoir water level, 95% guaranteed power output is relatively small (7.0 MW). The plant is operated as a base-load plant using water conveyed for water supply (3,000 MLD=34.7 m^3/sec).

(3) Development Scenario C:

- Plan C-1: Same as for Scenario B, a power plant is proposed at the conveyance waterway outlet at Abuyod (6.2 MW). The plant will use water conveyed for water supply (1,500 MLD=17.4 m^3/sec) and hence is operated as a base-load plant.
- Plan C-1: Also, a power plant will be built at the toe of Agos dam. The proposed capacity of the plant is identical to Plan B-2-1 (85.6 MW).
- Plan C-2: With the construction of the 2nd waterway, the capacity of Abuyod power plant will be increased to 12.5 MW. Water quantity available is double that of the Plan C-1 (3,000 MLD=34.7 m^3/sec).

(4) Development Scenario D:

- Plan D-1: No power plant is planned at the conveyance waterway outlet at Abuyod in consideration of relatively small effective head available (approximately 10 m).
- Plan D-2: After the completion of Kanan No.2 Dam with construction of the Kanan-Kaliwa transbasin tunnel and 2nd waterway, a power plant will be built at the outlet of conveyance waterway at Abuyod (5.2 MW, 3,600 MLD =41.7 m^3/sec). The plant will be operated as a base-load plant using water conveyed for water supply to Metro Manila.

(5) Development Scenario E:

- Plan E-1: Same as for Plan D-1, no power plant is proposed at the outlet of conveyance waterway.

- Plan E-2-1: No power plant is proposed at the outlet of Kanan-Kaliwa transbasin tunnel (connecting the Kanan Low Dam and Kaliwa Low Dam) in view of small head available between the tunnel inlet and outlet.
- Plan E-2-2: In this Scenario, Kanan No.2 Dam releases the water to Kanan Low Dam located downstream. A power plant is proposed at the toe of Kanan No. 2 Dam (51.5 MW). Since the present plan of Kanan Low Dam is not proposed to have a re-regulating capacity, the Kanan No.2 plant is operated as a base-load plant using the water released for water supply (3,770 MLD=43.6 m^3/sec). In case the Kanan Low Dam is proposed to have a re-regulating capacity, the plant installed capacity can be increased to 209.5 MW.
- Plan E-2-3: As well as Plan D-2 in the Development Scenario D mentioned above, a power plant with an installed capacity of 6.1 MW (4,060 MLD = 47.0 m^3/sec) will be installed at the outlet of the waterway at Abuyod.

(6) Development Scenario F:

- Plan F-1: This plan is identical to the Plan A-1 above. A power plant is provided at the outlet of conveyance waterway at Pantay (22.6 MW). The plant characteristics are same as described for Plan A-1.
- Plan F-2: Similar to Plan C-1 above, a power plant is provided at the outlet of conveyance waterway at Abuyod (6.2 MW). The plant will use the water conveyed for water supply (1,500 MLD=17.4 m^3/sec) and hence is operated as a base-load plant.
- Plan F-2: Similar to Plan B-2 and C-1, a power plant is built at the toe of Agos Dam (91.3 MW). The plant characteristics are identical to the case of Plan B-2-1.

(7) Development Scenario G:

- Plan G-1: The 1st conveyance waterway is build at this stage. However, same as for Plan B-1, no power plant is proposed in this initial stage.
- Plan G-2-1: Different from the case of Scenarios A and F, Laiban Dam releases the water to the downstream Kaliwa Low Dam and hence a power plant is planned at toe of the dam. At the initial stage, the power plant will be operated in conjunction with water release for water supply and hence act as a base-load plant (17.6 MW). After the completion of Agos Dam (Plan G-2-2), the power plant will be operated as a peaking plant (69.6 MW), where the Agos reservoir will function as an afterbay pond.
- Plan G-2-2: After the completion of Agos Dam with construction of the 2nd waterway, a power plant will be built at the outlet of conveyance waterways at Abuyod (11.4 MW). The plant will be operated as a base-load plant using water conveyed for water supply (3,430 MLD=39.7 m^3/sec).
- Plan G-2-2: Similar to the case of Scenarios B, C, and F, a power plant will be built at toe of Agos Dam (87.5 MW). The plant uses the water in excess of water supply and is planned as a peaking plant.

(8) Development Scenario H:

- Plan H-1: No power plant is proposed at the outlet of conveyance waterway due to small discharge available for water supply at this stage (340 MLD=3.9 m^3/sec).
- Plan H-2-1: This Scenario envisages the Laiban High Dam to be not built in the future stage. Hence, a power plant is proposed at the outlet of Kanan-Laiban trans-basin tunnel (12.3 MW). Since the present plan of Laiban Low Dam does not have a re-regulating capacity, the plant will be operated as a base-load plant in conjunction with the release of water from the Kanan No.2 reservoir for water supply (3,310 MLD=38.3 m^3/sec).
- Plan H-2-1: After the Kanan No.2 Dam is completed with increase of water conveyance quantity, a power plant is planned at the outlet of conveyance waterway led from the Laiban Low Dam (Balimbing P/S, 9.8 MW). The plant will be operated as a base-load plant using water conveyed through the 1st waterway (1500 MLD=17.4 m^3/sec).
- Plan H-2-2: After the completion of the 2nd waterway, the capacity of Balimbing power plant will be expanded (22.4 MW, 3,420 MLD=39.6 m^3/sec). The plant remains to be operated as a base-load plant.

E4.3.2 Hydropower Schemes Independent from Water Supply Schemes

Other than multi-purpose schemes (water supply + hydropower), there still remain potentials of hydropower development, mostly as hydropower single purpose scheme. Such potential is found at Agos, Laiban and Kanan No.2 Dams. Owing to the difference of configuration of multi-purpose schemes at the other sites, the potential of hydropower single purpose scheme is slightly different by the Development Scenario. The potential schemes under each Scenario are shown in Table E4.7 (2/2).

(1) Under Development Scenario A:

Agos Dam can be developed as a hydropower single purpose scheme (Plan A-3). The concept of this scheme is identical to that studied by JICA in 1981. In this Scenario, water exploited at the Laiban Dam and Kanan No.2 Dam is transferred for water supply to Metro Manila. Hence, the proposed Agos hydropower scheme will use water resources available from the residual basin downstream of the Laiban and Kanan No.2 Dams and flow spilled out from the two Dams.

Under this Study, the development potential of Agos hydropower scheme was assessed as 104.7 MW in installed capacity and 374.8 GWh in annual energy production. The plant is proposed as a 6-hour/day peaking power plant by providing an afterbay pond in the downstream reach.

(2) Under Development Scenario B:

Under this Development Scenario, there are two potential sites for hydropower development: one is Laiban Dam (Plan B-3-1) and the other Kanan No.2 Dam (Plan B-3-2).

Laiban Dam scheme is just identical to the scheme proposed under Development Scenario G (Plan G-2-2). The installed capacity will be 69.6 MW and annual energy production 136.2 GWh. The plant will be a peaking plant (6-hour/day) with use of the downstream Agos reservoir as afterbay pond. Alternatively, the Laiban Dam can be developed for water supply purpose for meeting the demand of year 2025 onward.

Kanan No.2 Dam will be developed solely for hydropower development. Same as for the Plan E-2-2, the power plant will be built at toe of the dam as a peaking plant. The installed capacity is 209.5 MW and annual energy production 503.6 GWh. The back water level of Agos reservoir (FSL 159 m) reaches the Kanan No.2 Dam site (riverbed elevation around EL. 150 m).

(3) Under Development Scenario C:

Hydropower schemes conceivable are same as for the Scenario B, i.e. Laiban Dam (Plan C-3-1) and Kanan No.2 Dam (Plan C-3-2). Both the installed capacity and annual energy production are identical to those of Plan B-3-1 and B-3-2, respectively.

(4) Under Development Scenario D:

Under this Scenario, Laiban Dam can be developed as a multi-purpose scheme for hydropower and flow augmentation for future water supply (Plan D-3). In this Scenario, Laiban Dam will receive water transferred from Kanan No.2 reservoir. The plant will be built at toe of the dam and planned as a peaking plant with raise of the downstream Kaliwa Low Dam to have a re-regulating capacity. The installed capacity is 188.5 MW and annual energy production 351.0 GWh.

(5) Under Development Scenario E:

Laiban Dam can be developed for hydropower (Plan E-3). In this Scenario, water resources available at the Laiban Dam are runoff from the Kaliwa upstream basin. The proposed plant is identical to Plan A-3-1. The installed capacity is 69.6 MW and annual energy production 136.2 GWh.

(6) Under Development Scenario F:

Kanan No.2 Dam will be developed for hydropower (Plan F-3). The scheme is identical to Plan B-3-2 as a peaking plant. Agos reservoir will function as an afterbay pond. The installed capacity is 209.5 MW and annual energy production 503.6 GWh.

(7) Under Development Scenario G:

Kanan No.2 Dam will be developed for hydropower (Plan G-3). The scheme is identical to Plan B-3-2 or Plan F-3 as a peaking plant. Agos reservoir will function as an afterbay pond. The installed capacity is 209.5 MW and annual energy production 503.6 GWh.

(8) Under Development Scenario H:

Agos Dam can be developed for hydropower (Plan H-3). The plant will use the water available in excess of water transfer to Metro Manila at the Laiban Low Dam. The installed capacity is 111.5 MW and annual energy production 367.0 GWh.

E4.4 Connection to Existing Transmission System

Figure E4.2 shows major transmission and substation systems operated by NPC in the vicinity of the Agos river basin. As indicated in the Figure, 500 kV and 230 kV transmission lines run in the area east to the Laguna Lake. There also exist 115 kV and 69 kV systems in the area.

Substations nearest to the Agos river basin are the substation of Malaya Gas-Turbine Power Station (230 kV) and Dolores Substation (230 kV) owned by NPC and New Teresa Substation (115 kV) owned by Meralco as shown in Figure E4.3. According to NPC, a further study will be required to confirm whether the Malaya Power Station could accommodate additional feeder bays and also whether the capacity of the existing transmission lines from the Malaya Power Station would be sufficient to transmit additional power to the Metro Manila area. This will be looked into at the next feasibility study stage.

In the case power schemes of the Agos Dam, Kanan No.2 Dam and Laiban Dam are developed as peaking plant, the installed capacity will be the order of 70 to 200 MW. In these cases, the proposed transmission line will be of 230 kV capacity and connected to either the existing Malaya Power Station or Dolores Substation.

Installed capacity of power schemes proposed at the outlet of conveyance waterways (Pantay, Abuyod and Tanay Power Stations) ranges from 12 to 40 MW. Since the location of the proposed power plants is at a relatively short distance from the New Teresa Substation (10 to 15 km), the generated power could be transmitted by 115 kV line (subject to further review by each scheme). Figure E4.3 shows relative locations of the proposed power schemes and the New Teresa Substation.

A part of the power generated at Agos and Kanan No.2 Power Station will be sent to a QUEZELCO substation at Infanta by a 69 kV line.

E4.5 Economic Benefit of Hydropower

E4.5.1 Alternative Thermal Cost

Hydropower benefit is represented by alternative thermal power costs. Hydropower schemes conceived in the Agos river water resources development are classified into two groups. One is 10-40 MW class plant conceived at the outlet end of water conveyance tunnels either from Laiban High Dam, Laiban Low Dam or Kaliwa Low Dam, and the other 70-200 MW class plant conceived at the Agos Dam, Laiban High Dam and Kanan No.2 Dam. It is assumed that alternative thermal plant will be either the diesel, gas turbine or combined-cycle thermal power plant depending on the type of hydropower plant proposed.

kW and kWh Costs of Alternative Thermal Power Plant

Item	Gas Turbine (10-40 MW)	Diesel (10-40 MW)	Combined Cycle (70-200 MW)
1. kW Cost (US$/kW) - Capital Cost	585	850	700
- Fixed O&M Cost	12.4	20.0	28.65
2. kWh Cost (US$/kWh)			
- Fuel Cost	0.0217	0.0137	0.0217

Source: NPC

E4.5.2 Adjustment Factor

The concept of adjustment factor will be introduced in order to take into account the difference in operating flexibility and reliability between hydropower and thermal power. The adjustment factor is calculated as 1.279 for kW value and 1.061 for kWh value, respectively, as shown below:

i) Adjustment Factor for kW Value:

Item	Hydropower (%)	Thermal Power (%)
- Transmission loss	3.0	2.0
- Forced outage	1.0	5.0
- Outage for overhauls and inspection	2.7	14.0
- Consumption for station services	0.3	9.0

1. Power loss and time loss are assumed.
2. Adjustment Factor = (1-0.03)/(1-0.02) x (1-0.01)/(1-0.05) x (1-0.027)/(1-0.14) x (1-0.003)/(1-0.09) = 1.279

ii) Adjustment Factor for kWh Value:

Item	Hydropower (%)	Thermal Power (%)
Transmission loss	3.0	2.0
Station service	0.3	7.0

1. Energy loss assumed.
2. Adjustment Factor = (1-0.03)/(1-0.02) x (1-0.003)/(1-0.07) = 1.061

E5 Comparison of Alternative Facilities Plans

E5.1 General

Formulation of alternative development scenarios discussed in Chapter E3 involves the need of comparative study to determine several items of facilities plan. This Chapter E5 describes the findings of comparative studies in the following items:

- Selection of Optimum Full Supply Water Level (FSL)
- Selection of Dam Type
- Selection of Kaliwa-Angono Conveyance Waterway Route

E5.2 Selection of Optimum Full Supply Water Level (FSL)

The Study examined five storage dams: Kanan No.1 Dam, Kanan No.2 Dam, Kanan B1 Dam, Agos Dam and Laiban Dam. The reservoir storage capacity curves of these dams are compiled in Appendix E-1. Of these dams, FSL and dam height of Laiban Dam have been optimized in the previous detailed studies, which will be adopted in the Study as they are. Optimum FSL of the other four dams was evaluated by comparing an index of cost per m^3/sec of exploitable water, which is calculated by dividing dam construction cost by m^3/sec of reservoir water yield. The results of the comparison study are presented in Table E5.1 and graphically shown in Figure E5.1 and summarized below:

Optimum FSL of Four Dams

Dam	Optimized FSL (EL. m)	Estimated Construction Cost of Dam (US$ Mill.)	Reservoir 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	381.5	72.1	5.3	El. 165 m
	El. 165	349.6	59.2	5.9	
	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 smaller unit costs with the increase of dam height as shown in Figure E5.1. On the other hand, the maximum FSL levels of Kanan No.1 and No.2 dams are El. 300 m and El. 310 m, respectively, from the topographic and geological conditions at these dam sites. Hence, the optimal FSL of both dams are set at the maximum levels. Table E5.1 indicates that unit water cost evaluated for the Kanan No.1 Dam with FSL 310 m is higher than that of Kanan No.2 Dam with

FSL 320 m. This suggests that Kanan No.2 Dam should be taken up in further development planning, and Kanan No.1 Dam will be ruled out at this study stage.

Cost index of the Agos Dam is lowest in the case of FSL 175 m. This plan was however not adopted since it submerges the Barangay Daraitan entirely and further affects the construction of the future Laiban Dam. The present Master Plan Study adopts the FSL of Agos Dam to be EL. 159 m in order to minimize the resettlement requirement. The possibility of raising the FSL up to EL. 165 m or higher will be examined in the subsequent feasibility study stage on the basis of findings of further socio-economic studies.

E5.3 Selection of Dam Type

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

For the Agos Dam, the ELC's study in 1990 (Ref. 12) recommended the adoption of RCCD, instead of ECRD proposed in the former JICA's F/S study in 1981. In the previous study, shear strength of 5 kg/cm^2 was adopted for the foundation rock of Agos Dam so as to check 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 too hard to secure the safety factor of more than 4 for the dam with a height of more than 150m, even in the case such typical section with moderate upstream and downstream slopes of 1:0.1 and 1:0.8 respectively is adopted. As a result, the RCCD is discarded from the examination to select the optimal dam type.

Construction cost of the dam was assessed for two different types of dam: i.e. Concrete Face Rockfill Dam (CFRD) and Earth Core Rockfill Dam (ECRD). Figure E5.2 shows the cross sectional design of the two dam types adopted in the cost comparison.

The results of cost comparison of CFRD and ECRD for Kanan No.2 Dam and Agos Dam are shown in Table E5.2 and summarized below:

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 Section E4.1 above)

The cost comparison revealed that CFRD is more economical for both the Kanan No.2 and Agos Dam. With regard to Agos Dam, however, CFRD and ECRD are found almost comparable, and therefore require more detailed cost comparison in the subsequent feasibility study. CFRD is more advantageous to ECRD in view of a merit 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 project.

The previous studies conducted in 1979-1981 proposed an Earth Core Rockfill Dam (ECRD) for both the Kanan No.2 Dam (Ref. 2) and Agos Dam (Ref. 10). The previous studies did not make a study on CFRD, since construction of CFRD was not so popular at that time.

The aforesaid previous study in 1990 (Ref. 12) studied the possibility of constructing a Roller Compacted Concrete Dam (RCCD) for the Agos Dam. The study suggested that RCCD is geologically acceptable and less costly than the ECRD by about 18% at direct implementation cost level (Ref.13). However, the RCCD cannot satisfy the required safety factor for sliding as mentioned above. Besides, the previous study envisages recuperating concrete aggregates from river deposits: 2 million m^3 from dam foundation area and 3 million m^3 from river deposits in the Agos reaches downstream from the damsite (Ref.13). A problem foreseen is that, if 3 million m^3 of sand and gravel are recuperated from the downstream river deposits, it will change the conditions of riverine environment in the downstream reaches and, further, reduce sediment transport to the Agos lower plain to a great extent, resulting in change of river mouth environments.

With these backgrounds, construction of CFRD is proposed at this study stage from viewpoint of least cost requirement as revealed in table above. In addition, CFRD seems preferable from both technical and environmental viewpoints, since it requires less quantity of concrete works and accordingly less river aggregates recuperation compared with RCCD and also less rock quarry excavation compared with ECRD.

More detailed comparison study to select the optimal dam type will be performed in the feasibility study stage based on the results of geological investigation including core drilling, seismic exploration, laboratory tests, etc.

E5.4 Selection of Kaliwa-Angono Waterway Route

In this Study, the following three waterways for water supply to Metro Manila are conceived:

- Laiban-Taytay Waterway : Water conveyance from Laiban High Dam
- Laiban-Angono Waterway : Water conveyance from Laiban Low Dam
- Kaliwa-Angono Waterway : Water conveyance from Kaliwa Low Dam and/or Agos Dam

For the Kaliwa-Angono Waterway, three alternative routes from Kaliwa Low Dam to Angono Service Reservoir are proposed for comparison. The layout plan is shown in Figure E3.1 and their profiles are shown in Figures E3.3 to E3.5, respectively. Technical features of the three routes are described in Table E5.3. Each route has some technical problems to be solved by proper design of the facilities. The result of cost comparison is shown in Table E5.4 and summarized below:

Comparison of Cost of Alternative Waterway Routes

Alternative Plan	Estimated Construction Cost (US$ M)	Total Waterway Length (km)	Total Hydraulic Loss Head (m)
Plan B-1a: Southern Route	545.2	45.0	54.0
Plan B-1b: Intermediate Route	533.4	38.5	46.8
Plan B-1c: Northern Route	501.5	39.0	45.2

Notes:
1. Plan B-1a includes pump-up of water from water treatment plant (EL.40m) to Angono Service Reservoir (EL.72m).
2. The above represents the cost for two waterway lines to be provided at the ultimate stage (3,000 MLD in the case of Scenario B)
3. Cost of hydropower facilities is excluded from the above comparison

The above indicates that Plan B-1c is least costly. Hence, further planning study adopts Plan B-1c as the most preferable route of waterway.

A particular aspect to be noted is that, owing to limited head available between the Agos MOL (EL.133m) and Angono Service Reservoir (EL.72m), the waterway diameter has to be slightly larger than the case of Laiban-Taytay waterway for Laiban Dam.

E6 Preliminary Design and Cost Estimate

E6.1 Preliminary Design of Proposed Structures

E6.1.1 Dam in Reservoir Type Scheme

This Study contemplated three (3) dams, Agos Dam, Kanan No.2 Dam and Laiban Dam, to work out the development scenarios. As described in Section E5.3 above, a Concrete Face Rockfill Dam (CFRD) has been selected for both the Agos Dam and Kanan No.2 Dam. Laiban Dam is also designed to be CFRD in the detailed design under the MWSP III. Hence, all the dams are proposed as CFRD.

The preliminary design of each dam is carried out in accordance with the following design standards and criteria:

- Upstream and downstream surface slopes of the main dam are set at 1:1.5 with reference to those adopted for Laiban Dam in MWSP III.
- Diversion tunnels combined with cofferdams are adopted as the diversion method in order to discharge a 20-year probable flood during the construction of the main dam.
- Design discharge for spillway is 1.2 times 200-year probable flood. Besides, spillway has a capacity to pass probable maximum flood with a freeboard of 1m at least.

The main design features of each dam are described below.

(1) Agos Dam

Preliminary layout design of Agos Dam with FSL 159 m is shown in Figure E6.1 (subject to further refinement in the feasibility study). As the spillway of Agos dam, the combined type of gated and non-gated spillways is adopted. The non-gated spillway has a capacity of regulating peak discharges of less than 1.2-year probable flood without the use of gated spillway. The afterbay weir is proposed to re-regulate power discharge released from the powerhouse for peak power operation. The further study on Agos Dam and its appurtenant structures will be carried out in the next feasibility study stage.

(2) Kanan No.2 Dam

While FSL of Kanan No.2 Dam is set at EL. 310 m, the minimum operation level (MOL) thereof varies by the development scenario, namely MOL 278 m in the Development Scenario A (Plan A-2), Development Scenario D (Plan D-2) and Development Scenario H (Plan H-2), and MOL 225 m in the Development Scenario E with a powerhouse to be installed at the toe of the Kanan No.2 Dam. Preliminary layout design of Kanan No.2 Dam in the Development Scenario E is illustrated in Figure E6.2.

(3) Laiban Dam

As for Laiban Dam, the layout plan and dimensions of main structures in the 1984 detailed design under MWSP III are adopted in this Study.

E6.1.2 Low Dam in Run-of-River Scheme

Three (3) run-of river schemes were proposed to work out the alternative development scenarios, namely Kaliwa Low Dam and Laiban Low Dam on the Kaliwa River, and Kanan Low Dam on the Kanan River.

(1) Kaliwa Low Dam

For Kaliwa Low Dam, two types of development, a temporary structure to be submerged by Agos Dam and a permanent structure, are preliminarily designed as mentioned below.

(a) Temporary Kaliwa Low Dam

The Kaliwa Low Dam, designed as a temporary structure (Development Scenarios B and G), is constructed using random materials produced from excavation of the intake and waterway tunnel. The downstream surface is protected with cribs filled with rocks to allow for overtopping of flood flow. The Kaliwa Low Dam is planned to function for three years until the completion of Agos Dam. A sand flush gate is provided on right bank side close to intake structures for two Kaliwa-Angono waterways, so as to periodically discharge the sands in front of the intake structures. A preliminary layout plan is shown in Figure E6.3 (subject to further refinement in the feasibility study).

(b) Permanent Kaliwa Low Dam

While, the permanent Kaliwa Low Dam (Development Scenarios D and E) is of about 35m high concrete dam. The permanent Kaliwa Low Dam is equipped with 5 spillway gates and 4 sand flush gates. Sands deposited in the upstream pond are discharged downstream through operation of these gates. In addition, sand settling basin is provided just downstream of the water intake. Larger sizes of sands contained in the Kaliwa River water will be settled and flushed out before flowing into tunnels for the Kaliwa-Angono waterway.

(2) Laiban Low Dam

The site selected for Laiban Low Dam is almost same as that of the Laiban High Dam where two diversion tunnels are already built on the right bank. The Kaliwa River water stored in a pond to be created by Laiban Low Dam is conveyed to Metro Manila through the Laiban-Angono waterway. The similar design concepts to those on the permanent Kaliwa Low Dam are applied to the preliminary design. The intake structures for tunnels of the Laiban-Angono waterway are provided on the right bank side of Laiban Low Dam. The tunnels are aligned to pass above the existing diversion tunnels built under MWSP III. A preliminary layout plan is shown in Figure E6.4.

(3) Kanan Low Dam

Kanan Low Dam is designed to be of a 36 m high concrete dam provided with 5 spillway gates and 5 sand flush gates. A pond to be created by Kanan Low Dam is linked with the permanent Kaliwa Low Dam through a 16.5-km long Kaliwa-Kanan interbasin tunnel. The intake structure for the interbasin tunnel of 5.1m diameter is provided on the left bank. The design discharge for intake structure and interbasin tunnel is 43.6 m^3/sec.

The principal features of the proposed water source structures are shown in Table E6.1.

E6.1.3 Waterway

Conveyance waterway for supply of water to Metro Manila consists of tunnels and pipelines. This Study performed preliminary design for the three (3) waterway routes to convey water of the Agos River Basin to Metro Manila, namely Kaliwa-Angono, Laiban-Angono and Laiban-Taytay waterways, as explained hereinafter.

(1) Kaliwa-Angono Waterway

Water is taken at intake in the river/reservoir and conveyed through about 28 km long tunnel. After a larger head becomes available by realization of Agos Dam, a powerhouse will be built at the end of the tunnel. Two by-pass hollow–jet valves will also be installed at the tunnel outlet. Water is then conveyed, either through water turbines or hollow-jet valves, to a water treatment plant and further to the service reservoir through combination of pipelines and tunnels.

Tunnel is excavated either by using Tunnel Boring Machine (TBM) or applying conventional method (NATM). The present Master Plan Study assumes that TBM could be used in relatively hard geological zones of Kinabuan Formation and Barenas-Baito Formation (shale, sandstone, basalt, aggromerate, etc.), while tunneling by NATM has to be assumed in the soft and geologically complicated layers of Pleistocene Sediments of Laguna Formation (tuff, volcanic breccia, sandstone, etc). The general geological conditions along the tunnel routes are shown in geological maps in Part-D of this Supporting Report.

Approximately 400,000 to 500,000 m^3 of tunnel muck is produced from the tunnel excavation. The muck will be disposed to spoil bank nearby work adit portals or used for embankment of water treatment plant site, depending on the location of muck disposal.

About 4.4 km long Pipeline is of steel pipe construction laid out in an excavated trench by cut-and-cover method. Since the pipeline runs hilly areas, there may be necessity of crossing valleys by aqueduct or piercing hills by tunneling at some locations. After passing through the pipeline, water is again conveyed by about 5.7 km long second tunnel to service reservoir. Before entering into the tunnel, a part of water is lifted to Antipolo by pump station. The inside surface of the second pipeline is steel-lined in partial sections.

(2) Laiban-Angono Waterway

In the case of the Laiban-Angono waterway, water taken at Laiban Low Dam is conveyed to water treatment at Kalan Batu through about 14 km long tunnel and short pipeline. To harness a relatively large head between Laiban Low Dam and outlet of the tunnel, a powerhouse will be built at the outlet site. Thereafter, the waterway takes the same route as the B-1b as shown in Figure E3.1.

(3) Laiban-Taytay Waterway

This waterway route is same as that designed under MWSP III.

E6.2 Preliminary Cost Estimate

Cost estimate at this study stage is of a very preliminary level. Basic price information was obtained from the cost estimate for the Laiban Dam Project prepared in 1997. The prices are updated to 2001 price level by applying GDP deflator indices. The estimate is based on unit prices for major work items, cost per length of structures (tunnel, pipeline) and use of empirical cost formula for plant works (power plant, water treatment plant).

Estimate of the cost at this stage was prepared only for the selected water supply schemes to be implemented for meeting the water demand up to year 2025: that is, the schemes categorized as the First Stage Development and the Second Stage Development in Table E3.1.

A summary of the estimated costs for alternative development scenarios is presented in Table E6.2. Breakdown of the cost estimate is presented in Appendix E-2 to this Part-E.

E7 Selection of Priority Development Scenario

E7.1 Formulation of Eight Development Scenarios/Plans

Figures E7.1 to E7.8 show the development plans of the eight development scenarios worked out based on the development concepts described in Chapter E3.

Water development potential of the Agos river basin is maximized when three major dams, i.e. Laiban Dam, Kanan No.2 Dam and Agos Dam, are constructed. If it is assumed that all water resources are exploited for water supply purpose, total development potential is estimated to be 7,800 MLD (90 m^3/sec) at about 97% dependability.

E7.2 Implementation Schedule

A preliminary implementation schedule of the First and Second Development Schemes of respective Scenarios is shown in Figure E7.9. Timing of the implementation is determined so as to meet the water demand growth up to year 2025.

In preparing the implementation schedule, the following were taken into account:

- Scenario A : A constraint in the implementation of Laiban Dam is the resettlement issue. This Study tentatively assumes that the dialogue with the project-affected people will take around three years and, due to this, the completion of the project will be around year 2013 at the earliest.
- Scenario B : The 1st stage project, Kaliwa Low Dam with 1st Waterway, aims at completion towards year 2010. For enabling this, a rushed program is required in pre-construction activities, such as financing arrangement, basic design and contract procurement.
- Scenario C : Implementation of Agos Dam will require 11-year time period. Hence, the completion will be attainable only in year 2012.
- Scenario D : Implementation of Kana No. 2 Dam constitutes the critical path of this development scenario and the earliest attainable completion is estimated to be year 2015. In relation to this, the 1st stage project, Kaliwa Low Dam with 1st Waterway, should be deferred by two years, i.e. completion in 2012, since the Kaliwa Low Dam can only meet the water demand growth for three years before the commissioning of the Kanan No. 2 Dam.
- Scenario E : In this Scenario, construction of Kanan Low Dam is on the critical path. The completion is scheduled in 2014. By the similar reason to that stated for Scenario D, the completion of the 1st stage project can be deferred by one year, i.e. completion in 2011.
- Scenario F : Completion of Laiban Dam will be in 2013 with the same reason as stated for Scenario A.

- Scenario G : Same as for Scenario B.
- Scenario H : Completion of the 1st stage project should be deferred till 2013 with same reason as stated for Scenario D. Laiban Low Dam can only meet the water demand growth for two-year period before Kanan No. 2 Dam is commissioned.

Based on this implementation schedule, cash flow analysis was attempted to compare the unit water cost of each scenario. The result is presented in the following Section E7.3.

E7.3 Comparison Study to Select the Priority Development Scenario Based on Unit Water Cost Index

E7.3.1 Methodology and Procedure Adopted

As noted above, the relative attractiveness of the eight (8) development scenarios was compared in terms of the index of "unit water cost" per m^3 of water. Each development scenario contains the future plans as the third stage development program, which are mostly hydropower development schemes. The comparison of unit water cost was, however, made for the First Stage and Second Stage development plans that are relevant to the water supply for Metro Manila towards 2025. To estimate the unit water cost for each development scenario, a cash flow for each of the project cost and revenue was prepared in accordance with the following procedures:

(1) Evaluation Horizon and Base Year

In the present Master Plan study, the cost index was evaluated for an evaluation horizon of 40 years (2011-50). Base year for assessing the present worth of cost and revenue streams is set at 2001.

(2) Components of Project Cost

The project cost estimated at this stage covers those for water source exploitation works (dam/reservoir), water treatment plant, and water conveyance facilities up to a main service reservoir planned at Taytay in the Laiban-Taytay Waterway (Development Scenarios A and F) or at Angono in the Kaliwa-Angono Waterway (Development Scenarios B to G) and Laiban-Angono Waterway (Development Scenario H). Hence, the "unit water cost" evaluated herein represents the cost at the main service reservoir, which is regarded as the off-take point for distribution to the supply network of Metro Manila.

The project cost, estimated on financial cost basis, covers the base cost estimated at 2001 price (consisting of construction cost, land acquisition and compensation costs, engineering and administration costs, physical contingency), price contingency, Value Added Tax (VAT) for the construction works, and interest during construction. Operation and maintenance cost incurred for water and energy supply operations is also taken into account.

(3) Financial Condition

It is assumed in this comparative study that the project would be implemented as a Government project using ODA loan. The following conditions are set forth:

(a) Base cost

Base cost estimated in Table E6.2 represents the estimate at the June 2001 price level (exchange rate of US$1=Peso 52). The base cost is divided into F/C and L/C portions.

(b) Disbursement schedule

The construction costs are disbursed in accordance with the implementation schedules shown in Figure E7.9.

(c) Price contingency

The price escalation rates adopted are 2.0% per annum for F/C, and 5.2% for 2001-2004 and 3.0% for 2005 onward for L/C. The rates for L/C were derived from the forecast given in the Philippines National Development Plan, 1998, NEDA.

(d) Value added tax

An amount equivalent to 10% of both F/C and L/C of construction cost is adopted as the value-added tax.

Note: This tax was specifically taken into account in view of its relatively large impact to the water cost. Other taxes were not considered at this study stage.

(e) Loan interest rate

The rates tentatively assumed are 4.5% per annum for F/C (mixture of loans from bilateral aid and international aid) and 14.5% for L/C (local bank loan).

(f) Electricity selling price

Peso 2.5/kWh (US$ 0.0481/kWh) is adopted as the price in the base year, which is escalated at 3% per annum, for the subsequent years.

(4) Operation and Maintenance Cost

The annual operation and maintenance costs are estimated applying the following rates:

- Water treatment cost: Peso 0.25 per m^3 (US$ 0.005) of water produced
- Maintenance of facilities: 0.5% of initial capital cost of the facilities

(5) Cost Stream and Water Supply Quantity Stream

Disbursement schedule of the implementation costs was prepared based on assumptions of financial condition set forth above. Discounting this cost stream by applying a rate of 12%, present worth of the investment cost was calculated at 2001 price. O&M cost is also discounted by the same manner.

(6) Revenue Stream and Derivation of Unit Water Cost

Soon after the commissioning of the 1st stage scheme, the scheme supplies water to meet the water demand in the respective years until the demand reaches the full supply capacity of the scheme. Thereafter, the 1st stage scheme supplies water at its full capacity towards the end of the evaluation horizon. After the 2nd stage scheme is commissioned, it will supply water to meet the growing portion of the demand exceeding the supply capacity of the 1st stage project. The supply by the 2nd stage scheme will continue till the end of the evaluation horizon. On this basis, the stream of water supply quantity was constructed.

Most of the development scenarios involve hydropower development as a component of the proposed projects. Sale of electricity energy is therefore taken into account in the cash flow analysis.

The “unit water cost” is calculated in a manner of comparing the present worth of total incurred costs and the present worth of water/energy sale, which are discounted to 2001 price at a discount rate of 12% per annum. It was considered that a part of the invested cost is recovered by energy sale and the remainder should be recovered by water sale. A trial calculation was attempted to find a marginal unit water cost that would equalize the present worth of the cost to be recovered by water sale and the present worth of water sale amount.

The unit water cost for each development scenario is estimated under the following three (3) conditions to compare the eight (8) development scenarios:

i) Indexes on the Basis of Same Time-frame

ii) Indexes on the Basis of Assumed Implementation Schedule (Figure E7.9)

iii) Indexes on the Basis of Assumed Implementation Schedule with Consideration of a Penalty for Delay in Completion

The results of the comparison study under the above (3) different conditions are described in the following Subsections E7.3.2 to 7.3.4.

E7.3.2 Comparison of Indexes on the Basis of Same Time-frame

The evaluation assumes a fixed time frame common to all Scenarios: that is, the 1st stage project of all Scenarios would be completed in 2010 and commissioned in 2011. The results of the evaluation are shown as ‘Case-A’ in Table E7.1.

Table E7.1 shows that the index of Scenario B is evaluated most favorably followed by Scenarios C, D, F, and H where the latter four are comparable almost equally. Table E7.1 also shows that the cost index of the Laiban Dam is derived at a very low value, which is almost same as that of Development Scenario B.

E7.3.3 Evaluation of Indexes on the Basis of Assumed Implementation Schedule

Figure E7.9 shows the earliest attainable completion schedule of each Development Scenario. Among the eight scenarios, the 1st stage project of Scenario B and G can be completed in year 2010, while that of the other six Development Scenarios (A, C, D, E, F and H) can only be completed in 2011-2013 as explained in the foregoing Section E7.2.

For confirmation purpose, 'Case- B' of TableE7.1 shows the cost indexes assessed for the Scenarios A, C, D, E, F, and H according to the implementation schedule shown in Figure E7.9. The indexes calculated were found to be almost equal to those evaluated for the Case-A. This is because the relative composition of cost-revenue stream is almost similar between Case-A and B, where the stream of Case-B lags by two to three yeas from that of Case-A.

E7.3.4 Evaluation of Indexes in Consideration of Penalty for Delayed Completion

A bold assumption was made to evaluate quantitatively the effect of delay in the completion of Scenarios A, C, D, E, F, and H. In the evaluation, the following concepts were introduced:

i) Scenario B produces water sale amounting to US$ 9.4 million in 2011, US$ 17.2 million in 2012, and US$ 23.8 million in 2013, respectively

ii) This production is not possible in the case of Scenarios A, C, D, E, F, and H due to delay in completion, which is regarded as a loss of national economic production

iii) As a penalty factor for the delayed completion, the corresponding amount of production of Scenario B is applied to Scenarios A, C, D, E, F, and H to be the negative benefit (loss of water sale)

Based on this bold assumption, unit water cost index for the Scenarios A, C, D, E, F, and H are evaluated for reference purpose. The result is shown as 'Case-C' in Table E7.1. If this concept is included in the comparison of Scenarios, relative position of the index of Scenario B becomes much more favorable compared with the others.

E8 Water Resources Potentials and Water Demands in Lower Agos Area

E8.1 Present Situation

According to the rainfall records at Infanta station, an annual rainfall of 3,000 to 4,000 mm 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 are 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 of 1,400 ha in the future. 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 Part-C of this Supporting Report takes into consideration the irrigation water required for the future irrigation water demand.

This Chapter 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.

E8.2 Water Supply for Infanta and General Nakar

(1) Current Status of Municipal Water Supply

At present, the municipalities of Infanta and General Nakar are served by the Infanta-General Nakar Water District with respect to the piped water supply. Considering the current number of the service connections (1,666), population served by the piped water supply system is estimated approximately at 10,000 living in the relatively urbanized areas of these two municipalities, which correspond to 13% of the total population of 75,000, consisting of 51,000 in Infanta and 24,000 in General Nakar. Accordingly, the majority of people are served by other community-based small-scale waterworks or privately owned wells.

The water sources for the piped water supply system operated by the Water District are groundwater extracted by deep wells with a total water production of 0.34 MLD. On the basis of the water production capacity and served population, the current per capita water consumption is calculated to be as low as 40 Lpcd. Owing to the low service coverage as well as low water supply capacity, the Water District has a plan to implement a project to expand the water supply system. However, implementation of the project is delayed due to financial constraints, causing the issue between LWUA and WD at present.

(2) Future Water Demand and Availability of Water Source

Although the existing water supply system for the municipalities of Infanta and General Nakar covers very limited areas and population at present, it is expected that the population served will increase with the expansion of the water supply system from now on. The water demand for the piped water supply system of the Water District is projected applying the following conditions and assumptions:

i) Population in 2025 is projected with reference to the socio-economic projection made for Quezon Province, which is described in Part-A of this Supporting Report.

ii) The service coverage ratio is adopted to conform to the national target, which is set at 95% for urban area and 93% for rural area in the "Water supply, Sewerage and Sanitation Master Plan of the Philippines, 1988 – 2000", except for the assumption that 10% of households will use privately owned wells in the future. Thus, 90% is adopted as the target service coverage ratio of the piped water supply system in 2025.

iii) 166 Lpcd of per capita consumption and share of domestic use (90%) to total water demand are employed to project water demands of other sectors than the domestic sector in 2025, considering the current status of the two municipalities.

iv) A peak day demand factor of 1.21 is employed to project the maximum day demand as well as the water demand projection for Metro Manila that is discussed in Part-B of this Supporting Report.

As a result of the water demand projection for the Lower Agos area, the water demands of Infanta and General Nakar in 2025 are estimated at about 19 MLD and 9 MLD, respectively, as shown below:

Projected Water Demand in Infanta and General Nakar in 2025

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

It is expected that the future water demands projected above be met by the development of groundwater in alluvial plains of the Lower Agos. The potential groundwater resources in General Nakar and Infanta are assessed in the 'Rapid Assessment of Water Supply Sources' prepared by NWRB in 1982. According to the previous assessment, the potential well capacities in Infanta and General Nakar are estimated at 85 MLD and 347 MLD, respectively, as summarized below:

Potential Well Capacity in Infanta and General Nakar

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

Data Source: Rapid Assessment of Water Supply Sources, May 1982, NWRB
Abbreviation: W; Shallow tube well, DW; Deep well

As shown in a table above, the exploitable groundwater resources in Infanta and General Nakar are both by far larger than the water demands in 2025. From the above examination, accordingly, it is concluded that there is a sufficient quantity of groundwater sources in the Lower Agos area to meet the future water demands.

E9 Flood Damages in Lowermost Reach of the Agos

E9.1 General

The municipalities of Infanta and General Nakar of Quezon Province are the major municipalities within the Agos River basin, and the Agos River delineates these municipalities. 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 the storm surge due to typhoons, overbank flow of the Agos River or the combination of the storm surge and overbank flow of the Agos River.

E9.2 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-hour rainfall is Typhoon Kading in 1978. Table E9.1 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 E9.2. 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
October, 2000	Typhoon Reming	PHP 1,400,000
November, 2000	Typhoon Seniang	

The inundation map of the municipality of Infanta is shown in Figure E9.1. The area with slight seasonal flooding (approximately 4,000 ha) is assumed to be the inundated area caused by the overbank flow of the Agos River. Since there was no enough data available, it is necessary to carry out further examination on flood damages in consideration of the land use in the Lower Agos River basin to determine the damages by various magnitudes of floods.

E9.3 Present Condition

E9.3.1 Land Use

The present land use of the Lower Agos is agricultural croplands as shown in Figure E9.2. The two major crops in this area are rice and coconut, which are almost equal in coverage.

The overall land use of Infanta is shown in a table below:

Present Land Use in the Municipality of Infanta

Classification of Land Use	Area Coverage (ha)	Percent Share (%)
Agricultural Croplands		
Riceland	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	45.5%
Natural/semi-natural vegetation		
Woodland	6,327.07	
Second growth forest	2,080.27	
Forest with grasses	4,246.80	
Wet lands	5,710.16	
Mangrove, palm	1,217.76	
Mangrove, tree	3,315.13	
Fishponds	1,177.27	
Subtotal	12,037.23	53.5%
Special Land Uses		
Built up areas	188.58	
Beach sand	40.93	
Subtotal	229.51	1.0%
Total	22,500.00	100.0%

In above table, woodland indicates the forestlands in the hilly and mountainous portion on the western area of Infanta. The wetland represents the southern portion of the low-lying area facing Lamon Bay. Both woodland and wetland can be discarded from the subjective area of the flood damage study.

The present land use of low-flat lands of General Nakar is mostly of rice paddy, coconut field and built-up area as shown in Figure E9.3. The built-up area is about 108 ha.

E9.3.2 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 deposits 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 E9.4. 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 E9.5. Photo 1 shows the exisitng training 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, both the approaches to the bridge were washed away, leaving the bridge 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.

E9.3.3 Carrying Flow Capacity of the Lower Agos

The carrying flow capacity of the Agos River is examined by non-uniform flow analysis with the river cross sections surveyed in the 1981 JICA feasibility study (Ref. 10) as well as the high tide at the river mouth of the Agos River. The high tide at the Agos River mouth is determined to be EL. 2.0 m based on the tidal levels recorded at Real, which were collected from NAMRIA during the First Field Investigation. To estimate the design river levels of the Lower Agos for the 10-year probable flood, the starting point for the non-uniform calculation was set at the river mouth. The results show that most of river cross sections can pass a flood of 1,500 to 2,000 m^3/sec, which is equal to 2- to 3-year probable flood. However, it appears that the carrying flow capacity has changed as the river changes its flow direction and width. The present carrying flow capacity of the Lower Agos will be reviewed in the next feasibility study stage when the present river cross sections and topographic maps of the Lower Agos area are available.

E9.3.4 Existing Flood Control Facilities

(1) Municipality of Infanta

Existing flood control facilities in the Municipality of Infanta are presented in the following table:

Existing Flood Control and Drainage Facilities in Infanta Municipality

Location	Type of Facility	Length (m)	
Boboin	Grout Riprapping	a)	55.40
		b)	38.20
		c)	458.50
Poblacion 38	Grout Riprapping	a)	30.20
		b)	16.20
		c)	64.50
		d)	85.96
		e)	23.70
		f)	57.20
Bantilan	Grout Riprapping	a)	270.00
		b)	43.90
	Concrete Lining	a)	115.10
		b)	240.00
Ilog	Grout Riprapping		119.70

Note: Data as of 1998

Source: Ecological Profile, Infanta, Quezon (1999)

The municipality of Infanta has proposed the DPWH to provide the concrete training wall starting from the downstream site of the bridge construction (ADB-PMO of DPWH) in Barangay Banugao to the river mouth. While, the municipality has already completed a part of the training wall in Barangay Ilog. The municipality is now looking for funds to complete the whole part. The municipality office strongly hopes to formulate the flood control plan on a comprehensive basis and to design the flood control works based on the flood control plan. These design works of the flood control facilities are still required to be conducted prior to the start of the construction work. In addition, the drainage canals are provided in the town proper.

(2) Municipality of General Nakar

There is no flood control facility in the municipality of General Nakar except for the Poblacion area where the canal type drainage facility is provided. However, it does not effectively function at present.

E9.3.5 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 E9.3.

(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 deep inundation due to flooding every year. During the floods, Barangay halls, church, schools, and neighbors are used as evacuation centers. The most serious flood took place in October 1989 (Typhoon Rosing). Due to the Typhoon Rosing, the inundation was approximately four feet deep. 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 has constructed and maintained the drainage canal which is 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. Recently, the river shape has changed from narrow to wide. As a result, an old bridge connecting the right and the left bank of the Lamigan River, as mentioned above, is now left in the middle portion of the Agos River.

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

i) Dredging of the riverbed of the Agos River to increase the flow capacity;

ii) Construction of drainage canals from town proper to the sea;

iii) Completion of the training wall along the river.

(2) Municipality of General Nakar

Barangay Poblacion and Banglos in General Nakar have been suffering from one foot depth of inundation occasionally. There is no major drainage system; however, according to the Barangay captain of Barangay Banglos, the inundation subsides quickly and flows out to nearby creeks. On the other hand, erosion of the river bank is the imminent problem. Previously, the municipal office (town proper) was very far from the river bank, but due to the massive erosion, the town proper is now at just 200 meters from the river bank. The river is still incising the bank. It is reported that a house was washed away due to the bank erosion very recently. The Barangay captains requested to implement the bank protection works to prevent further bank erosions and loss of lands.

E9.3.6 Characteristics of Flood in Lower Agos

Based on the review of the existing data and site reconnaissance conducted during the First Field Investigation, characteristics of flood in low-lying areas of Infanta and General Nakar municipalities are shown in Figure E9.6. Judging from the survey in Infanta municipality, there are two areas where flood water intrudes and causes the inundation. One area is the low area in Barangay Ilog and Barangay Catambungan. Once flood water enters the low land, it flows toward the town proper area which is the lowest land of Infanta municipality. Another area affected by flood is Barangay Bobain close to the Bantilan River. During the high tide, the backwater enters through the Bantilan River and flows toward the town proper area. The flood water will stay in municipality area until the tide level goes down. During the high tide, the water level of the Agos River rises as well.

E9.4 Preliminary Flood Damage Mitigation Measures Proposed

E9.4.1 Hydraulic Analysis

A 10-year probable flood is adopted for the formulation of the flood damage mitigation plan in the Lower Agos with reference to the flood protection levels applied to other flood control projects in the Philippines. The 10-year probable flood for the Lower Agos is estimated at 3,550 m^3/sec (3,438 m^3/sec at Agos Dam site) through the hydrological analysis. In the next feasibility study stage, the non-uniform flow analysis will be carried out to clarify the present flood water level under the present topographic conditions.

E9.4.2 Preliminary Flood Damage Mitigation Measures

As explained above, the major flood damages in the Lower Agos are caused by improper drainage facilities coupled with intrusion of floodwater of the Agos River in Infanta and river bank erosion in General Nakar. Taking into account the present situation of flood damages, a preliminary flood mitigation plan is worked out by combining the following works:

- Extension of concrete training wall provided by the municipality office of Infanta;
- Provision of spur dikes along the left bank to protect General Nakar from river bank erosion;
- Provision of earth dikes along the both banks of the Lower Agos;
- Provision of a sluiceway at Bantilan River where it meets the Agos River.

Figure E9.7 shows a very preliminary plan of the proposed flood control and river stabilization measures.

The alignment of earth dike is proposed taking account of the present land use in the Lower Agos. The dike on the left bank of the Lower Agos was aligned to minimize the number of houses to be relocated and land compensation cost for General Nakar. Based on the non-uniform flow analysis with the river condition in 1981, the height of the earth dike was estimated to be approximately 2 to 3 meters.

The proposed location of the spur dikes will be determined in consideration of the recent river course changes mentioned in Section E9.3.2. It is recommended that, as a first step, a pilot project be implemented to confirm the effectiveness of the spur dikes which will be constructed to protect the riverine lands from bank erosion and to stabilize the river stream course. Additional spur dikes should be installed after the confirmation of its effectiveness.

The proposed measures will be refined in the next feasibility study.

References in Part-E

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Ref. 21: Prefeasibility Study for the Agos River Multi-Purpose Development, Draft Report, May 2001, EDCOP

Tables

Table E3.1 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 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) 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) 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 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) 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 E-2-2: Kanan No.2 Dam – net additional 180 MLD 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) 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) 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 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 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 E3.2 Water Exploitation and Transfer Quantities of Each Development Scenario

Scenario	Plan	Scheme	Water Rources Exploited		Conveyance Waterway to Manila	Transbasin Tunnel	Source of Water	Water Conveyance Tunnel: Condition	Water Transfer Quantuty (Daily Average)		Waterway Capacity (Daily Peak)		Installa-tion of WTP: Unit	Unit Cap.	Waterway Diameter
			(MLD)	(m3/s)					(MLD)	(m3/s)	(MLD)	(m3/s)	No. (#)	(MLD)	(m)
A	**(Source Development)**		**5,110**	**59.1**											
	A-1	Laiban High Dam with MOL 237m	1,830	21.2											
	A-2	Kanan No.2 Dam with MOL 278m	3,310	38.3		Kanan-Laiban	Kanan Reservoir		3,310	38.3					4.7
	(Water Conveyance to Metro Manila)								**5,110**	**59.1**					
	A-1	Laiban High Dam w/1st Waterway			1st Waterway *L		Laiban Reservoir		**1,830**	**21.2**	2,214	25.6	#1 - #3	740	3.2
	A-2	Kanan No.2 Dam w/2nd Waterway			2nd Waterway *L		Kanan Reservoir		**3,310**	**38.3**	4,005	46.4	#4 - #6	1,340	4.3
B	**(Source Development)**		**3,000**	**34.7**											
	B-1	Kaliwa Low Dam	550 / 0 *1	6.4 / 0 *1											
	B-2	Agos Dam	3,000	34.7											
	(Water Conveyance to Metro Manila)								**3,000**	**34.7**					
	B-1	Kaliwa Low Dam w/1st Waterway			1st Waterway *K		Kaliwa + Agos		**1,500**	**17.4**	1,815	21.0			3.4-3.5
							-Kaliwa Runoff	Initial period	550	6.4	666	7.7	#1	910	
								After Agos Dam	0	0.0	0	0.0			
	B-2-1	Agos Dam					-Agos Reservoir	After Agos Dam	1,500	17.4	1,815	21.0	#2	910	
	B-2-2	Construction of 2nd Waterway			2nd Waterway *K		Agos Reservoir		**1,500**	**17.4**	1,815	21.0	#3 - #4	910	3.4-3.5
C	**(Source Development)**		**3,000**	**34.7**											
	C-1&2	Agos Dam	3,000	34.7											
	(Water Conveyance to Metro Manila)								**3,000**	**34.7**					
	C-1	Agos Dam w/1st Waterway			1st Waterway *K		Agos Reservoir		**1,500**	**17.4**	1,815	21.0	#1 - #2	910	3.4-3.5
	C-2	Agos Dam w/2nd Waterway			2nd Waterway *K		Agos Reservoir		**1,500**	**17.4**	1,815	21.0	#3 - #4	910	3.4-3.5
D	**(Source Development)**		**3,600**	**41.7**											
	D-1	Kaliwa Low Dam	550 / 290 *1	6.4 / 3.4 *1											
	D-2	Kanan No.2 Dam with MOL 278m	3,310	38.3		Kanan-Laiban	Kanan Reservoir		3,310	38.3					3.9
	(Water Conveyance to Metro Manila)								**3,600**	**41.7**					
	D-1	Kaliwa Low Dam w/1st Waterway			1st Waterway *K		Kaliwa + Kanan		**1,500**	**17.4**	1,815	21.0			3.4-3.5
							-Kaliwa Runoff	Initial Period	550	6.4	666	7.7	#1	910	
								After Kanan No.2	290	3.4	351	4.1			
	D-2-1	Kanan No.2 Dam					-Kanan Reservoir		1,210	14.0	1,464	16.9	#2	910	
	D-2-2	Construction of 2nd Waterway			2nd Waterway *K		Kanan Reservoir		**2,100**	**24.3**	2,541	29.4	#3 - #4	1,280	3.8-3.9
E	**(Source Development)**		**4,060**	**47.0**											
	E-1	Kaliwa Low Dam	550 / 290 *1	6.4 / 3.4 *1											
	E-2-1	Kanan Low Dam	770 / 0 *1	8.9 / 0 *1		Kanan-Kaliwa	Kanan Runoff & Reservoir Water		3,770	43.6					5.1
	E-2-2	Kanan No.2 Dam with MOL 225m	3,770	43.6											
	(Water Conveyance to Metro Manila)								**4,060**	**47.0**					
	E-1	Kaliwa Low Dam w/1st Waterway			1st Waterway *K		Kaliwa + Kanan		**1,500**	**17.4**	1,815	21.0			3.4-3.5
							-Kaliwa Runoff	Initial Period	550	6.4	666	7.7	#1	910	
								After Kanan No.2	290	3.4	351	4.1			
	E-2-1	Kanan Low Dam					-Kanan Runoff	Initial Period	770	8.9	932	10.8	#2	910	
								After Kanan No.2	0	0.0	0	0.0			
	E-2-2	Kanan No.2 Dam					-Kanan Reservoir	After Kanan No.2	1,210	14.0	1,464	16.9			
	E-2-3	Construction of 2nd Waterway			2nd Waterway *K		Kanan Reservoir		**2,560**	**29.6**	3,098	35.9	#3 - #5	1,040	4.1-4.2
F	**(Source Development)**		**3,330**	**38.6**											
	F-1	Laiban High Dam with MOL 237m	1,830	21.2											
	F-2	Agos Dam	1,500	17.4											
	(Water Conveyance to Metro Manila)								**3,330**	**38.6**					
	F-1	Laiban High Dam w/1st Waterway			1st Waterway *L		Laiban Reservoir		**1,830**	**21.2**	2,214	25.7	#1 - #3	740	3.2
	F-2	Agos Dam w/2nd Waterway			2nd Waterway *K		Agos Reservoir		**1,500**	**17.4**	1,815	21.0	#4- #5	910	3.4-3.5
G	**(Source Development)**		**3,430**	**39.7**											
	G-1	Kaliwa Low Dam	550/ 0 *1	6.4/ 0 *1											
	G-2-1	Laiban High Dam with MOL 230 m	1,930	22.3											
	G-2-2	Agos Dam	1,500	17.4											
	(Water Conveyance to Metro Manila)								**3,430**	**39.7**					
	G-1	Kaliwa Low Dam w/1st Waterway			1st Waterway *K		Kaliwa + Laiban		**1,930**	**22.3**	2,335	27.0			3.7-3.8
							-Kaliwa Runoff	Initial Period	550	6.4	666	7.7	#1	1,170	
								After Laiban Dam	0	0.0	0	0.0			
	G-2-1	Laiban High Dam					-Laiban Reservoir	After Laiban Dam	1,930	22.3	2,335	27.0	#2	1,170	
	G-2-2	Agos Dam w/2nd Waterway			2nd Waterway *K		Agos Reservoir		**1,500**	**17.4**	1,815	21.0	#3 - #4	910	3.4-3.5
H	**(Source Development)**		**3,420**	**39.6**											
	H-1	Laiban Low Dam	340/140 *1	3.9/1.6 *1											
	H-2	Kanan No.2 Dam with MOL 278	3,310	38.3		Kanan-Laiban	Kanan Reservoir		3,310	38.3					3.9
	(Water Conveyance to Metro Manila)								**3,420**	**39.6**					
	H-1	Laiban Low Dam w/1st Waterway			1st Waterway *A		Kaliwa + Kanan		**1,500**	**17.4**	1,815	21.0			3.1-3.2
							-Kaliwa Runoff	Initial Period	340	3.9	411	4.7	#1	910	
	H-2-1	Kanan No.2 Dam						After Kanan No.2	140	1.6	169	1.9			
							-Kanan Reservoir	After Kanan No.2	1,360	15.7	1,646	19.0	#2	910	
	H2-2	Construction of 2nd Waterway			2nd Waterway *A		Kanan Reservoir		**1,920**	**22.2**	2,323	26.9	#3 - #4	1,170	3.5

Notes: *L Laiban High Dam-Taytay Waterway *K Kaliwa Low Dam-Angono Waterway *A Laiban Low Dam-Angono Waterway WTP: Water Treatment Plant

*1 At run-of river intake, 90% discharge is assumed as a temporal design intake discharge in the initial stage. After completion of permanent water spurce (dam), design dependability is upgrac to a level of once 10-year dry discharge, which corresponds to design dependability adopted for assessment of reservoir yie

Scenario / Run-of River Intake	Temporal Intake Discharg (90% runoff)		Permanent Intake Discharge (1/10 year Dry Flow)		Source of Permanent Discharge
B-1: Kaliwa Low Dam	550 MLD	6.4 m3/s	0	0	All water is deemed to be Agos reservoir yiel
D-1: Kaliwa Low Dam	550 MLD	6.4 m3/s	290 MLD	3.4 m3/s	1/10 year dry runoff from Kaliwa basin at Kaliwa Low Dam site
E-1: Kaliwa Low Dam	550 MLD	6.4 m3/s	290 MLD	3.4 m3/s	1/10 year dry runoff from Kaliwa basin at Kaliwa Low Dam site
E-2-1: Kanan Low Dam	770 MLD	8.9 m3/s	0	0	All water is deemed to be Kanan No.2 reservoir yiel
G-1: Kaliwa Low Dam	550 MLD	6.4 m3/s	0 MLD	0.0 m3/s	1/10 year dry runoff from residual basin downstream of Laiban Dan
H-1: Laiban Low Dam	340 MLD	3.9 m3/s	140 MLD	1.6 m3/s	1/10 year dry runoff from Kaliwa basin at Laiban Low Dam site

Table E4.1 GDP Target Forecasted by NEDA in April 2000

Year	Low Scenario	High Scenario
1998	(0.5)	(0.5)
1999	3.3 Actual	3.3 Actual
2000	4.0	5.0
2001	4.0	5.0
2002	5.0	6.0
2003	5.5	6.5
2004	5.5	6.5
2005-2010	4.8	5.8

Note: For the period 2005-2010, the annual growthe rates used were based on the average growth rates during the period 2000-2004

Source: 2000 Power Development Program, NPC, November 2000

Table E4.2 Energy Sales and Peak Power Demand in 2000 Power Develoment 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 E4.3 System Capacity Addition - 2000 Power Development Program

(For Main Grids only)

Year	Luzon Grid				Visayas Grid				Mindanao Grid				Phil.
Year	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 E4.4 Indicative Shopping List of Prospective Merchant Plants

Plant	MW	Location
Luzon:		
Sual Coal (Excess)	180	Sual, Pangasinan
Kanan Hydro	113	Infanta, Quezon
Batangas Cogeneration	35	FPIP, Batangas
Apec Cogeneration	100	TIPCO, Pampanga
Austral Energy Asia	25	Sn. Simon, Pampanga
Isabera Coal	300	Cauayan, Isabela
Wind Power	40	Ilocos, Norte
Abuan Hydro	60	Ilagan, Isabela
Ilaguen Hydro	88	Sn. Mariano, Isabela
Nalatang Hydro	75	Buguias, Benquet
Addalam	46	Cabaroguis, Quirino
Agbulu Hydro	360	Kabugao, Apayao
Binongan Hydro	175	Bangued, Abra
Diduyon Hydro	332	Alicia, Quirino
MUDC Natural Gas	325	Batangas
Sub-total	**2,254**	
Visayas:		
Timbaban Hydro	29	Madalag, Aklan
Villa Siga Hydro	32	Bugasong, Antique
Ogden Coal	50	Bacolod, Neg. Occ.
Mambucal Geothermal	40	Bacolod, Neg. Occ.
Pacuan Hydro	33	Negros Oriental
Toledo Power (Excess)		Toledo, Cebu
Sub-total	**184**	
Mindanao:		
Tagoloan Hydro	68	Sumilao, Bukidnon
Agus III Hydro	225	Lanao Norte & Sur
Pulangi V Hydro	225	Roxas, N. Cotabato
Bulanog Batang Hydro	132	Talakag, Bukidnon
Sub-total	**650**	
Total	**3,088**	

Source: 2000 Power Development Program, NPC, November 2000

Table E4.5 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:						
10 Years	6.8%	5.4%	1.6%	1.7%	6.7%	
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

Table E4.6 Effective Rates for Luzon Grid - March 2000 to March 2001(As Billed)

(Unit: Peso/kWh)

Month	Basic Rate	Adjustments			Effective Rate
		FCA	PPCA	FOREX	
(A)	(B)	(C)	(D)	(E)	(F=B+C+D+E)
Mar. 2000	1.8743	0.2517	0.6347	0.2881	3.0486
Apr.	1.8743	0.2417	0.6445	0.2887	3.0492
May	1.8743	0.3304	0.5898	0.2889	3.0834
June	1.8743	0.4294	0.5544	0.2989	3.1570
July	1.8743	0.3410	0.6894	0.3270	3.2317
Aug.	1.8743	0.3661	0.6998	0.3503	3.2905
Sept.	1.8743	0.3677	0.7741	0.3704	3.3865
Oct.	1.8743	0.4115	0.8367	0.3966	3.5191
Nov.	1.8743	0.5929	0.7103	0.4456	3.6231
Dec.	1.8743	0.4991	0.9092	0.4503	3.7329
Jan. 2001	1.8743	0.4848	1.0286	0.4503	3.8380
Feb.	1.8743	0.4621	1.1054	0.4649	3.9067
Mar.	1.8743	0.4510	1.1165	0.4380	3.8798

Source: NPC

Note:
FCA: Adjustment for fuel price
PPCA: Adjustment for purchased power cost
FOREX: Adjustment for foreign exchange rate

Table E4.7 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 E4.7 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)

Table E5.1 Cost Comparison of Alternative Development Scales of Dams in the Agos River Basin

Work Item	Kanan No.1 Dam			Kanan No.2 Dam				Kanan B1 Dam						Agos Dam					
	Case 1 FSL: 280	Case 2 FSL: 290	Case 3 FSL: 300	Case 1 FSL: 280	Case 2 FSL: 290	Case 3 FSL: 300	Case 4 FSL: 310	Case 1 FSL: 175	Case 2 FSL: 180	Case 3 FSL: 185	Case 4 FSL: 190	Case 5 FSL: 195	Case 6 FSL: 200	Case 1 FSL: 145	Case 2 FSL: 155	Case 3 FSL: 165	Case 4 FSL: 175	Case 5 FSL: 185	Case 6 FSL: 195
I. Preparatory Works																			
(1) New access road	15,000	15,000	15,000	13,200	13,200	13,200	13200	8040	8040	8040	8040	8040	8040	0	0	0	0	0	0
(2) Improvement of existing roads	3,900	3,900	3,900	3,900	3,900	3,900	3900	3900	3900	3900	3900	3900	3900	3900	3900	3900	3900	3900	3900
(3) Preparatory works (10% of Item II)	12,864	14,169	15,648	12,056	13,472	15,025	16,702	6,735	7,124	7,504	7,861	8,402	9,582	22,396	24,356	26,845	28,893	30,969	33,036
Subtotal-I	31,764	33,069	34,548	29,156	30,572	32,125	33,802	18,675	19,064	19,444	19,801	20,342	21,522	26,296	28,256	30,745	32,793	34,869	36,936
II. Construction Works																			
1 . River Diversion Works																			
(1) Open excavation	854	854	854	1,498	1,498	1,498	1,498	1,288	1,288	1,288	1,288	1,288	1,288	840	840	840	840	840	840
(2) Excavation in tunnel	7,524	7,752	8,094	10,488	10,830	11,058	11,400	7,980	8,322	8,436	8,664	9,006	11,400	6,042	6,384	6,612	6,840	7,068	7,296
(4) Embankment in cofferdams	1,938	1,938	1,938	1,776	1,776	1,776	1,776	4,128	4,128	4,128	4,128	4,128	4,128	7,566	7,566	7,566	7,566	7,566	7,566
(5) Mass concrete in cofferdams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(4) Concrete in inlet and outlet portals	510	510	510	561	561	561	561	969	969	969	969	969	969	459	459	459	459	459	459
(5) Concrete in tunnel lining	1,816	1,884	1,952	2,542	2,610	2,679	2,747	1,951	2,011	2,056	2,101	2,191	2,762	1,557	1,621	1,685	1,749	1,813	1,877
(6) Concrete in tunnel plug	370	370	370	370	370	370	370	482	482	482	482	482	482	325	325	325	325	325	325
(7) Reinforcement bar	908	920	932	1,092	1,103	1,115	1,126	1,458	1,468	1,476	1,484	1,499	1,598	804	814	826	837	848	859
(8) Others (12%)	1,670	1,707	1,758	2,199	2,250	2,287	2,337	2,191	2,240	2,260	2,294	2,348	2,715	2,111	2,161	2,198	2,234	2,270	2,307
2. Main Dam																			
(1) Excavation, common, in open cut	5,675	6,420	7,075	3,930	4,740	5,845	6,950	595	680	765	850	935	1,020	14,365	15,600	17,510	18,190	18,870	19,550
(2) Excavation, rock, in open cut	3,200	3,632	4,000	2,224	2,672	3,296	3,920	336	384	432	480	528	576	8,112	8,816	9,888	10,272	10,656	11,040
(3) Excavation in grout tunnel	88	90	92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(4) Embankment, impervious core	3,552	3,552	3,552	3,560	3,560	3,560	3,560	392	392	392	392	392	392	3,976	3,976	3,976	3,976	3,976	3,976
(5) Embankment, filter	3,390	3,855	4,425	4,305	5,040	5,775	6,555	1,380	1,545	1,725	1,890	2,070	2,459	7,260	8,130	9,375	10,020	10,665	11,310
(6) Embankment, rock	21,060	25,530	30,990	26,880	33,600	40,710	48,540	4,860	5,970	7,080	8,190	9,300	12,910	47,520	57,420	69,300	81,180	93,060	104,940
(7) Concrete in CGD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(8) Structural concrete in CGD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(9) Concrete in face slab	4,300	5,100	6,100	5,600	6,700	8,000	9,400	1,200	1,350	1,550	1,850	2,100	2,400	7,900	9,200	11,100	12,400	13,700	15,000
(10) Concrete in grout gallery	561	683	810	843	960	1,061	1,146	553	572	592	609	628	667	1,032	1,092	1,163	1,212	1,405	1,538
(11) Concrete in grout tunnel	846	869	893	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(12) Reinforcement bar	6,471	7,642	9,087	8,135	9,701	11,526	13,476	1,991	2,207	2,491	2,908	3,258	3,690	11,372	13,169	15,786	17,577	19,464	21,311
(13) Curtain grout	40,042	42,989	45,946	1,401	1,587	1,785	1,994	748	913	1,099	1,306	2,048	2,990	3,570	3,946	4,339	4,749	5,176	5,621
(14) Others (12%)	10,702	12,043	13,556	6,825	8,227	9,787	11,465	1,447	1,682	1,935	2,217	2,551	3,253	12,613	14,562	17,092	19,149	21,237	23,314
3. Spillway																			
(1) Open excavation, common	9	9	9	910	937	965	993	645	667	689	946	975	1,221	3,546	3,591	3,636	3,681	3,726	3,771
(2) Open excavation, rock	115	115	115	11,648	11,994	12,352	12,710	11,696	12,090	12,485	12,109	12,480	11,724	45,389	45,965	46,541	47,117	47,693	48,269
(3) Structural concrete	1,853	1,984	2,114	5,725	5,829	5,933	6,038	3,350	3,767	4,185	4,594	5,316	6,395	7,726	7,856	7,987	8,117	8,248	8,378
(4) Mass concrete	0	0	0	2,171	2,210	2,248	2,295	1,271	1,425	1,586	1,740	2,017	2,426	2,926	2,980	3,026	3,080	3,126	3,180
(5) Reinforcemnet bar	514	551	587	1,589	1,618	1,647	1,676	930	1,046	1,162	1,275	1,476	2,130	2,145	2,181	2,217	2,253	2,289	2,326
(6) Others (12%)	299	319	339	2,645	2,711	2,777	2,845	2,147	2,279	2,413	2,480	2,672	2,867	7,408	7,509	7,609	7,710	7,810	7,911
4. Hydromechanical Works	10,377	10,377	10,377	11,640	11,640	11,640	11,640	13,361	13,361	13,361	13,361	13,361	13,362	17,400	17,400	17,400	17,400	17,400	17,400
Subtotal-II	128,644	141,693	156,475	120,558	134,724	150,251	167,018	67,346	71,239	75,036	78,606	84,017	95,823	223,962	243,562	268,455	288,933	309,690	330,364
III. Land Compensation and Resettlement																			
1. Land Compensation																			
(1) Access Road	745	745	745	664	664	664	664	363	363	363	363	363	363	68	68	68	68	68	68
(2) Dam and Appurtenant Structures	169	234	301	348	410	461	501	194	198	201	203	206	206	457	482	513	532	641	713
(3) Reservoir Area	5,527	7,370	9,212	5,527	7,600	9,673	11,976	967	1,105	1,244	1,382	1,520	1,658	7,185	8,475	10,221	11,962	29,004	16,992
(4) Others (12%)	773	1,002	1,231	785	1,041	1,296	1,577	183	200	217	234	251	267	925	1,083	1,296	1,507	3,566	2,133
2. Resettlement																			
(1) House to be Resettled (Other than Daraitan)	0	0	0	0	0	0	0	510	510	510	510	510	510	0	0	0	0	3,078	3,078
House to be Resettled (Daraitan)	0	0	0	0	0	0	0	0	0	0	0	0	0	11,365	11,365	13,752	18,563	23,375	23,375
(2) Others (12%)	0	0	0	0	0	0	0	61	61	61	61	61	61	1,364	1,364	1,650	2,228	3,174	3,174
Subtotal-III	7,215	9,350	11,490	7,324	9,714	12,093	14,718	2,278	2,437	2,596	2,753	2,910	3,065	21,365	22,837	27,500	34,860	62,906	49,532
Total of Subtotal-I to Subtotal-III	167,623	184,113	202,512	157,037	175,011	194,469	215,537	88,299	92,740	97,075	101,159	107,269	120,410	271,623	294,655	326,701	356,586	407,465	416,832
IV. Engineering Service and Government Administration (7%)	11,734	12,888	14,176	10,993	12,251	13,613	15,088	6,181	6,492	6,795	7,081	7,509	8,429	19,014	20,626	22,869	24,961	28,523	29,178
Base Cost (Total of Subtotal-I to Subtotal-III)	179,357	197,001	216,688	168,030	187,262	208,081	230,624	94,479	99,231	103,870	108,241	114,778	128,839	290,637	315,281	349,570	381,547	435,988	446,011
Unit Cost of Water Resources Development																			
- Water to be Exploited (m3/sec)	4.7	16.8	25.1	5.2	17.2	25.8	38.3	3.5	5.5	7.6	8.5	9.7	10.8	29.4	45.0	59.2	72.1	81.1	84.7
- Unit Water Cost (million US$/m3/sec)	38,161	11,726	8,633	32,313	10,887	8,065	6,022	26,994	18,042	13,667	12,734	11,833	11,930	9,886	7,006	5,905	5,292	5,376	5,266

Table E5.2 Cost Comparison of Conceivable Dam Types for Kanan No.2 Dam and Agos Dam

Work Item	Kanan No.2 Dam		Agos Dam	
	CFRD FSL: 310	ECRD FSL: 310	CFRD FSL: 159	ECRD FSL: 159
I. Preparatory Works				
(1) New access road	13,200	13,200	0	0
(2) Improvement of existing roads	3,900	0	3,900	3,900
(3) Preparatory works	16,702	19,433	25,601	25,758
(10% of Item II)				
Subtotal-I	33,802	32,633	29,501	29,658
II. Construction Works				
1 . River Diversion Works				
(1) Open excavation	1,498	1,526	840	854
(2) Excavation in tunnel	11,400	12,426	6,498	7,182
(4) Embankment in cofferdams	1,776	4,200	7,566	14,100
(5) Mass concrete in cofferdams	0	0	0	0
(4) Concrete in inlet and outlet portals	561	595	459	476
(5) Concrete in tunnel lining	2,747	2,879	1,653	1,766
(6) Concrete in tunnel plug	370	414	325	370
(7) Reinforcement bar	1,126	1,190	820	861
(8) Others (12%)	2,337	2,788	2,179	3,073
2. Main Dam				
(1) Excavation, common, in open cut	6,950	9,095	16,555	14,327
(2) Excavation, rock, in open cut	3,920	5,136	9,352	8,088
(3) Excavation in grout tunnel	0	0	0	0
(4) Embankment, impervious core	3,560	12,560	3,976	18,240
(5) Embankment, filter	6,555	9,000	8,753	13,800
(6) Embankment, rock	48,540	62,340	63,360	62,100
(7) Concrete in CGD	0	0	0	0
(8) Structural concrete in CGD	0	0	0	0
(9) Concrete in face slab	9,400	0	10,150	0
(10) Concrete in grout gallery	1,146	1,146	1,127	1,127
(11) Concrete in grout tunnel	0	0	0	0
(12) Reinforcement bar	13,476	13,476	14,478	751
(13) Curtain grout	1,994	1,994	4,142	4,101
(14) Others (12%)	11,465	13,770	15,827	14,704
3. Spillway				
(1) Open excavation, common	993	1,058	3,614	3,817
(2) Open excavation, rock	12,710	13,542	46,253	48,858
(3) Structural concrete	6,038	6,281	7,921	8,161
(4) Mass concrete	2,295	2,387	3,003	3,095
(5) Reinforcemnet bar	1,676	1,744	2,199	2,265
(6) Others (12%)	2,845	3,001	7,559	7,944
4. Hydromechanical Works				
(1) Gates in diversion tunnels	913	1,040	771	876
(2) Valves in diversion gates	2,400	2,400	2,401	2,401
(3) Spillway gates	6,000	6,000	11,040	11,040
(4) Spillway stoplogs	1,080	1,080	1,325	1,325
(5) Others (12%)	1,247	1,262	1,864	1,877
Subtotal-II	167,018	194,330	256,010	257,578
III. Land Compensation and Resettlement				
1. Land Compensation				
(1) Access Road	664	664	68	68
(2) Dam and Appurtenant Structures	501	501	498	498
(3) Reservoir Area	11,976	11,976	9,350	9,350
(4) Others (12%)	1,577	1,577	1,190	1,190
2. Resettlement				
(1) House to be Resettled (Other than Dar	0	0	0	0
House to be Resettled (Daraitan)	0	0	11,365	11,365
(2) Others (12%)	0	0	1,364	1,364
Subtotal-III	14,718	14,718	23,835	23,835
Total of Subtotal-I to Subtotal-III	215,537	241,681	309,345	311,070
IV. Engineering Service and Government Administration (7%)	15,088	16,918	21,654	21,775
Base Cost	230,624	258,599	330,999	332,845

Table E5.3 Technical Features of Three Alternative Waterway Routes (Kaliwa-Angono Waterway)

Item	Waterway Route B-1a	Waterway Route B-1b	Waterway Route B-1c
Total Length	45 km	38.5 km	39.0 km
Gross Head	Intake MOL-Mabato WTP: 90 m (Gravity) Mabato WTP-Angono SR: 32 m (Pump up)	Intake MOL-Angono SR: 65 m (Gravity)	Intake MOL-Angono SR: 65 m (Gravity)
Hydraulic Loss Head	54.0 m, including head loss in pumping	46.8 m	45.2 m
Intake	Intake facilities are common to all three alternative waterway routes. Lowest intake water level is EL. 133m (Agos Reservoir MOL) with flow of 21.0 m3/s. During 1st stage (Kaliwa Low Dam), water flow is 11.9 m3/s which can be taken at a lower intake water level (EL. 125m)	- Same with the left column -	- Same with the left column -
Tunnel to Powerhouse/ Hollow-jet Valve house	First 5 km will pass relatively stable geological zone, but the remaining 14.8 km passes in the zone of soft and complicated Laguna Formation, consisting of alternations of tuffs, volcanic breccia, sandstone, etc. It is foreseen that TBM should not be used in the Laguna Formation. Hence, the tunneling work will be time-consuming.	Tunnel will pass mostly in the Kinabuan formation & Barenas-Baito Formation (shale, sandstone, basalt, aggromerates) and partially in the Laguna Formation. In most sections, TBM can be used. In the last 3.5 km section, tunnel passes in undulating hills of thin ground coverage (about 100m).	Tunnel route up to 21 km point is identical to Plan B-1b. In the last 8 km section, tunnel will pass through ground of thin coverage of around 100-150 m, where some geological difficulty is foreseen in tunneling. In this section, excavation by conventional method (NATM) is proposed.
Powerhouse/ Hollow-jet Valve house	The site is located in area of undulating topography. Layout of surge shaft may require careful selection of the site. Access of 4.5 km long is required.	The site is of undulating and complicated topography, consisting of many thin hills. Layout of the structures will require an elaborated planning.	Topographic condition is similar to Plan B-1b. Although no in-situ geological observation has been conducted, there may be some geological difficulty in aligning the structures.
Pipeline to Water Treatment Plant (WTP)	Pipeline is laid out in hilly areas for the first 4 km and thereafter in flat paddy field for about 14 km. In the latter section, problem of soft foundation should be overcome. Possibility of liquefaction problem is to be examined in area of Baras alluvial plains.	Pipeline length is relatively short of about 1.3 km. Alignment of the pipeline will need an elaborated planning to pass through the area of mountainous topography.	Pipeline length is some 800 m. The area shows undulating topography consisting of low hills and creeks. No major difficulty seems to be involved in aligning the pipeline.
Water Treatment Plant (WTP)	The proposed site is located just east of limestone quarry of Rizal Cement Factory, some 4.5km northwest from town of Mabato (see 1/50,000 map). The area is flat land at the foot of hills, consisting of grass land and paddy field. The construction of plant yard will involve removal of soft soil layers and embankment in consideration of liquefaction problem and protection from floods from nearby river. A housing development company (Phil-Malay Co.) intends to acquire the land for expansion of housing project, which is underway in the area south of the proposed plant site.	The site is located about 1km north of Kalan Batu village(see 1/50,000 map). The area is composed of hills and shallow valleys, descending generally southward from EL.140m to 60m. Construction of the plant yard of 1,000 ha (1st stage and 2nd stage, each 500 ha) will involve a large volume of excavation and embankment works, say, of the order of 20 million m3 in total. The land use is for mostly tree crop plantation such as mangoes and other tree crops. Removal of about 20 tenement houses is also required.	The site is located about 2 km southeast of Abuyod village or 2.5 km southwest of Riza village (see 1/50,000 map). The land is generally flat at elevations ranging from EL.80m to 120m. The land is relatively developed areas, consisting village land, paddy field and upland crops. The paddy land is irrigated by water taken from an intake weir at small stream. Provision of required land (1,000 ha in total) will require to relocate 20-30 houses scattered in the area. Earth works will be roughly of the order of 6-7 million m3 in quantity.
Pipeline and Tunnel to Angono Service Reservoir (SR)	Water is pumped up at a pump station built within the compound of WTP and sent to Angono Reservoir. Cost for pump-up of water is a large burden in this plan.	Pipeline pass through mountainous area for the first 4.4 km, a part of which will have to be by tunneling. The last 3 km will be laid out in the paddy land .	Pipeline length is some 3.6 km. The route is along the existing road running in the paddy land. No major difficulty is foreseen in the work.
Angono Service Reservoir	This is a structure common to three alternative waterway routes. The area is situated on undulating hilly area. Present land use is for upland crop cultivation and tree crop plantation.	- Same with the left column -	- Same with the left column -

Table E5.4 Cost Summary for Kaliwa-Angono Waterway

Item	Kaliwa Low Dam/Agos Dam (Comparison of Water Conveyance Routes)		
	WR B-1a	WR B-1b	WR B-1c
	Stage-1 (Kaliwa Low Dam)	Stage-1 (Kaliwa Low Dam)	Stage-1 (Kaliwa Low Dam)
I. Preparatory Works			
I-1 New access road	4,200.	1,800.	2,400.
I-2 Improvement of existing road	2,100.	600.	900.
I-3 Preparatory works	47,342.	46,407.	43,457.
(10% of Item I+II)			
Total of Item I	53,642.	48,807.	46,757.
II. Hydropower Facilities			
II-1. Weir	8,217.	8,217.	8,217.
II-2. Intake Structure	832.	832.	832.
II-3. Headrace Tunnel			
II-3-1. Headrace Tunnel: Tunnel No.H1-1	89,651.	104,140.	108,668.
II-3-2. Pipeline No.H1	0.	0.	0.
II-3-3. Headrace Tunnel: Tunnel No.H1-2	0.	24,391.	33,631.
II-4. Surge Tank	1,542.	1,598.	1,615.
II-5. Pressure Shaft	2,881.	3,591.	2,881.
II-6. Powerhouse			
II-6-1. Substructure	236.	236.	236.
II-6-2. Superstructure	0.	0.	0.
(Sub-total)	236.	236.	236.
II-7. Switchyard	0.	0.	0.
II-8. Hydromechanical Works			
II-8-1. Intake Trashrack	894.	894.	894.
II-8-2. Intake Gate (High Head roller gate)	365.	365.	365.
II-8-3. Penstock	1,379.	1,718.	1,379.
II-8-4. Tailrace gate (Roller gate)	252.	252.	252.
II-8-5. Valve	2,240.	2,240.	2,240.
(Sub-total)	5,129.	5,468.	5,129.
II-9. Power Equipment	0.	0.	0.
II-10. Transmission Line	0.	0.	0.
Total of Item II	108,489.	148,474.	161,209.
III. Water Conveyance Facilities			
III-1. Pipeline No.P-1	86,837.	6,378.	3,817.
III-2. Water Treatment Facility (WTP)	165,453.	175,287.	158,287.
III-3. Tunnel No.T-1 (Steel-lined)	45,953.	4,031.	45,953.
III-4. Pipeline No.P-2	0.	8,341.	17,177.
III-5. Water Supply Facilities for Antipolo	18,831.	11,216.	11,216.
III-6. Pump Station	10,950.	0.	0.
III-7. Tunnel No.T-2 (Steel-lined)	0.	47,924.	0.
III-8. Pipeline No.P-3	0.	25,512.	0.
IIII-9. Taytay Service Reservoir	36,911.	36,911.	36,911.
III-10 Taytay Pressure Control Station	0.	0.	0.
Total of Item III	364,934.	315,599.	273,361.
(Total of Item II and Item III)	473,423.	464,074.	434,570.
Base Cost (Total-I + Total-II+Total-III)	527,065.	512,881.	481,327.
IV. Land Compensation and Resettlement	18,122.	20,483.	20,135.
Total Cost (I + II + III + IV)	**545,187.**	**533,364.**	**501,462.**

Table E6.1 Principle Features of Proposed Major Structures

Item				Name of Dam Plan/Alternative Development Scenario Concerned/Purpose of Development												
				1	2		3	4		5	6			7	8	
				Kanan No.1 Dam	Kanan No.2 Dam		Kanan B1 Dam	Agos Dam		Agos Afterbay	Laiban Dam			Kanan Low Dam	Kaliwa Low Dam	
					(Case-1)	(Case-2)		(Case-1)	(Case-2)		(Case-1)	(Case-2)	(Case-3)		(Case-1)	(Case-2)
			Concerned Scenario	-	Scenario A	Scenario E, H	-	Scenario B, C	Scenario F, G	Scemario A, B, C, F and H	Scenario G	Scenario A, F	Scenario H	Scenario E	Scenario D, E	Scenario B
			Purpos / Unit	(WS)	(WS)	(WS & HP)	(HP)	(HP)	(WS & HP)	(HP)	(WS & HP)	(WS & HP)	(WS)	(WS)	(WS & HP)	(WS)
1. Hydrology	- Catchment Area		(km2)	284.	289.	289.	355.	860.	860.		276.	276.	276.	356.	366.	366.
	- Average Annual Inflow		(m^3/sec)	54.0	55.0	55.0	62.3	115.7	115.7		25.8	25.8	25.8	67.7	32.1	32.1
2. Reservoir	Reservoir Water Level	=FSL	(El. m)	300.	310.	310.	195.	159.	159.		270.	270.	203.	150.00	133.	125.
		=MOL	(El. m)	278.	278.	225.	183.	133.	133.		230.	237.	203.	150.00	133.	125.
		=RWL	(El. m)	293.	299.	282.	175.	150.	150.		257.	259.	-	-	133.	-
		=SDL	(El. m)	214.	208.	208.	169.	87.	87.0		202.8	202.8	180.0	-	-	-
	- Gross Storage Capacity		(10^6 m^3)	670.	974.	974.	95.	718.	718.		650.	650.	-	-	-	-
	- Effective Storage Capacity		(10^6 m^3)	335.	607.	913.	35.	544.	544.		470.	470.	-	-	-	-
	- Average Discharge Yield by Reservoir		(m^3/sec)	28.5	38.0	41.7	13.4	54.7	59.9		21.3	21.3	-	-	-	-
3. Dam	- Dam Type		-	CFRD	CFRD	CFRD	CFRD	CFRD	CFRD	CW/EFD	CFRD	CFRD	CGD	CGD	CGD	CFED
	- Dam Crest Elevation	=DCL	El. m	305.	315.	315.	200.0	164.0	164.0	32.0	275.0	275.0	213.5	153.00	137.00	129.00
	- Freeboard	=DCL-FSL	m	5.0	5.0	5.0	5.0	5.0	5.0	2.7	5.0	5.0	4.0	-	4.00	4.0
	- Dam Height		m	157.	170.	170.	85.	164.	164.	21.	113.	113.	35.	-	42.	34.
	- Dam Embankment Volume		10^6 m^3	7.0	9.1	9.1	1.8	11.7	11.7	0.6(CW)/0.9(EFD)	6.2	6.2	-	-	-	-
4. Spillway	- Type of Spillway		-	Gated Ogee	Gated Ogee	Gated Ogee	Gated Ogee	Gated Ogee	Gated Ogee	Gated Ogee	Free-Overflow	Free-Overflow	Free-Overflow	Gated Ogee	Gated Ogee	Free-Overflow
	- Design Flood		(m^3/sec)	5,365. (200-yr)	5,459. (200-yr)	5,459. (200-yr)	6,500. (200-yrx1.2)	9,618. (200-yrx1.2)	9,618. (200-yrx1.2)		4,885. (10,000-yr)	4,885. (10,000-yr)	4,885. (10,000-yr)	5,097. (200-yr)	2,810. (50-yr)	5,174. (200-yr)
	- PMF		(m^3/sec)	7,100.	7,170.	7,170.	8,020.	17,300.	17,300.		4,885.	4,885.	4,885.	7,710.	8,150.	8,150.
	- Non-Gated Overflow Section	Crest El.	El. m	-	-	-	-	-	-	-	270.0	270.0	204.0	-	-	125.0
		Crest Length	m	-	-	-	-	-	-	-	650.0	650.0	150.0	-	-	-
	- Spillway Gates	Nos. of Gates	Nos.	4	4	4	4	6	6	5	-	-	-	5	5	-
		Width	m	11.0	12.0	12.0	12.0	14.0	14.0	20.0	-	-	-	14.0	14	-
		Height	m	15.1	14.5	14.5	16.2	14.5	14.5	11.0	-	-	-	11.0	11.3	-
	- Gated Overflow Section	Crest El.	El. m	284.9	295.5	295.5	178.8	144.5	144.5	15.0	272.3	272.3	-	139.0	121.7	-
5. Diversion Facilities	Method to be Adopted		-	Cofferdam/ Tunnel	Cofferdam/ Tunnel	Cofferdam/ Tunnel	Cofferdam/ Tunnel	Cofferdam/ Tunnel	Cofferdam/ Tunnel	Diversion Channel/ Cofferdam	Cofferdam/ Tunnel (Completed)	Cofferdam/ Tunnel (Completed)	Cofferdam/ Tunnel (Completed)	Partial River Closure	Partial River Closure	Partial River Closure
	Design flood		m3/sec	1,480. (5-yr flood)	2,480. (20-yr flood)	2,480. (20-yr flood)	2,780. (20-yr flood)	5,210. (20-yr flood)	5,210. (30-yr flood)		5,210. (50-yr flood)	5,210. (50-yr flood)	5,210. (50-yr flood)	250. (Max. flow in dry season)	200. (Max. flow in dry season)	200. (Max. flow in dry season)
	Diversion Tunnel	Nos.	Nos.	2	2	2	2	2	2	-	2	2	-	1	-	-
		Diameter	m	9.8	9.6	9.6	11.0	9.0	9.0	-	9.0	9.0	-	9.6	-	-
		Length	m	690.	2,100.	2,100.	810.0	1,860.	1,860.	-	476.0	476.0	-	190	-	-
	Upstream Cofferdam	Type	-	Fill	Fill	Fill	Fill	Fill	Fill	-	Fill	Fill	Fill	Fill	Fill	Fill
		Crest El.	El. m	176.0	206.0	206.0	151.0	93.0	93.0		202.0	202.0	-	-	-	-
6. Interbaisn Tunnel	Name of Tunnel		-	-	Kanan-Kaliwa Interbasin Tun.	-	-	-	-	-	-	-	-	Kanan-Kaliwa Interbasin Tun.	-	-
	Tunnel Dimensions	Type	-	-	Pressue Type	-	-	-	-	-	-	-	-	Pressure	-	-
		Length	km	-	14.5	-	-	-	-	-	-	-	-	16.2	-	-
		Diameter	m	-	3.7	-	-	-	-	-	-	-	-	5.1	-	-
		Discahrge	m3/sec	-	38.3	-	-	-	-	-	-	-	-	44.0	-	-
		Slope	%	-	0.3									0.1	-	-
7. Waterway for Hydropower	- Headrace Tunnel	Length	m	-	-	190.	8,770.	201.	201.	-	7,800.	7,800.	-	-	-	-
		Diameter	m	-	-	3.5	5.6	6.8	6.8	-	3.2	3.2	-	-	-	-
	- Penstock (& pipeline)	Length	m	-	-	230.	250.	572.	572.	-	1,800.	1,800.	-	-	-	-
		Diameter	m	-	-	3.0	3.5	6.1	6.1	-	2.7	2.7	-	-	-	-
8. Generating Equipment	- Installed Capacity		MW	-	-	50.	100	100	110	-	20	20	-	-	6	-
	- Max Unit Discharge		m3/sec	-	-	43.0	67.0	81.5	81.5	-	13.75	13.75	-	-	17.4	-
	(Remarks)					(P/S is just d/s of dam)					(Pantay P/S)	(Pantay P/S)	(Balimbing P/S) 2nd Stage		(Abuyod P/S)	
9. Transmission Line	Voltage		kV	-	-	230	230	230	230	-	230	115	115	-	115	-
	Length		km	-	-	73	65	61	61	-	34	12	8	-	6	-
10. New Access Road	To Dam Site		km	26.8	24.4	24.4	14.6	3.0	3.0	0.5	3.0	3.0	3.0	13.0	-	-

Abbreviations

FSL: Full Supply level
MOL: Minimum Operation Level
RWL: Rated Wate Level for Hydropower Generation
SDL: Sediment Deposit Level

CFRD: Concrete Face Rockfill Dam
CFED: Concrete Face Earthfill Dam
EFD: Earthfill Dam
CGD: Concrete Gravity Dam

Table E6.2 Cost Summary for Alternative Development Scenarios

(Exchange Rate: 1US$ =52.0 PhP)

Senario	Plan	Name of Scheme	Average Capacity (MLD)	Land Acquisition /Resettlement (x 10^3US$)	Construction Cost (x 10^3US$)	TOTAL Cost (x 10^3US$)	Foreign Currency (x 10^3US$)	Local Currency (x 10^3US$)	TOTAL Cost (x 10^3US$)	Engineering & Administration 7%	Physical Contingencies 15%	**Grand Total** (x 10^3US$)
A	A-1	Laiban Dam with 1st Waterway	1,830	96,055	611,660	707,715	433,338	274,377	707,715	49,540	113,588	870,843
	A-2	Kanan No.2 Dam with 2nd Waterway	3,280	55,099	1,070,887	1,125,985	762,302	363,683	1,125,985	78,819	180,721	1,385,525
		Senario Total	5,110	151,154	1,682,547	1,833,700	1,195,640	638,060	1,833,700	128,359	294,309	**2,256,368**
B	B-1	Kaliwa Low Dam with 1st waterway	550/0 *2	20,135	413,683	433,819	298,643	135,176	433,819	30,367	69,628	533,814
	B-2-1	Agos Dam + WTP #2	3,000	18,044	485,265	503,309	324,132	179,177	503,309	35,232	80,781	619,322
	B-2-2	Kaliwa-Angono 2nd Waterway + WTP #3 + 4		29,077	517,600	546,677	379,248	167,429	546,677	38,267	87,742	672,686
		Senario Total	3,000	67,257	1,416,548	1,483,804	1,002,023	481,782	1,483,804	103,866	238,151	**1,825,821**
C	C-1	Agos Dam with 1st Waterway	1,500	38,179	904,503	942,682	627,849	314,833	942,682	65,988	151,300	1,159,970
	C-2	Kaliwa-Angono 2nd Waterway	1,500	23,308	513,304	536,612	376,242	160,371	536,612	37,563	86,126	660,302
		Senario Total	3,000	61,488	1,417,807	1,479,295	1,004,091	475,204	1,479,294	103,551	237,427	**1,820,272**
D	D-1	Kaliwa Low Dam with 1st waterway	550/290 *2	20,505	447,731	468,236	322,476	145,760	468,236	32,777	75,152	576,164
	D-2-1	Kanan No.2 Dam + WTP #2	1,210	15,585	380,300	395,885	252,892	142,993	395,885	27,712	63,540	487,136
	D-2-2	Kaliwa-Angono 2nd Waterway + WTP #3 +4	2,100	32,987	633,995	666,982	466,226	200,756	666,982	46,689	107,051	820,721
		Senario Total	3,600	69,077	1,462,025	1,531,102	1,041,594	489,509	1,531,102	107,177	245,742	**1,884,021**
E	E-1	Kaliwa Low Dam with 1st waterway	550/290 *2	20,505	441,999	462,505	318,464	144,041	462,505	32,375	74,232	569,112
	E-2-1	Kanan Low Dam with tunnel	770/0 *2	6,749	265,078	271,827	190,443	81,384	271,827	19,028	43,628	334,484
	E-2-2	Kanan No.2 Dam with 2nd Waterway	3,770	51,123	1,002,621	1,053,744	715,542	338,202	1,053,744	73,762	169,126	1,296,632
		Senario Total	4,060	78,377	1,709,698	1,788,076	1,224,449	563,627	1,788,076	125,165	286,986	**2,200,227**
F	F-1	Laiban Dam with 1st Waterway	1,830	96,055	614,671	710,726	436,115	274,612	710,726	49,751	114,072	874,549
	F-2	Agos Dam with 1st Waterway	1,500	38,179	928,699	966,878	645,163	321,715	966,878	67,681	155,184	1,189,743
		Senario Total	3,330	134,234	1,543,370	1,677,604	1,081,277	596,327	1,677,604	117,432	269,255	**2,064,292**
G	G-1	Kaliwa Low Dam with 1st waterway	550/0 *2	23,045	486,821	509,866	351,772	158,094	509,866	35,691	81,833	627,390
	G-2-1	Laiban Dam + WTP #2	1,930	71,872	302,253	374,124	207,394	166,731	374,124	26,189	60,047	460,360
	G-2-2	Agos Dam with 2nd Waterway	1,500	35,745	936,741	972,487	652,114	320,373	972,487	68,074	156,084	1,196,645
		Senario Total	3,430	130,662	1,725,815	1,856,477	1,211,279	645,198	1,856,477	129,953	297,965	**2,284,395**
H	H-1	Laiban low dam with 1st Waterway	340/140 *2	29,073	427,455	456,528	304,124	152,404	456,528	31,957	73,273	561,758
	H-2-1	Kanan No.2 Dam + WTP #2	3,280	15,585	396,749	412,334	264,407	147,928	412,334	28,863	66,180	507,378
	H-2-2	2nd Waterway + WTP #3 & #4		20,483	555,384	575,867	371,098	204,768	575,867	40,311	92,427	708,604
		Senario Total	3,420	65,141	1,379,588	1,444,730	939,630	505,100	1,444,730	101,131	231,879	**1,777,740**

Notes: Total Cost = Land Acquisition/Resettlement Cost + Construction Cost
Engineering/Administration Cost = Total Cost x 7%
Physical Contingencies = (Total Cost + Engineering/Administration Cost) x 15%
Grand Total =Total Cost + Engineering/Administration Cost + Physical Contingencies

Table E7.1 Unit Water Cost Index for Comparison of Alternative Development Scenarios

Evaluation Horizon: 40 Years (2011-2050)

Scenario	Development Scheme	Proposed Supply Capacity (MLD)	Total Project Cost *1 (US$ M)	Present Worth of Cost or Q'ty Value			Present Worth of Revenue		Marginal Unit Water Cost *3 ($/m3)
				Cost (US$ M)	Water Supplied (M. m3)	Energy produced (GWh)	Etimated Energy Sale *2 (US$ M)	Water Sale Required (US$ M)	
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Case-A: Comparison on a Basis of Same Time Framework									
	(Assumed that 1st Stage Project of All Scenarios would be Completed in Year 2010)								
A	Laiban Dam + Kanan No.2 dam	5,110	2,256	1,490	1,650	756	62	1,429	0.400
B	Kaliwa Low Dam + Agos Dam (FSL 159m)	3,000	1,826	1,215	1,449	1,071	88	1,129	0.379
C	Agos Dam (FSL 159m) w/o Kaliwa Low Dam	3,000	1,820	1,285	1,449	1,596	114	1,171	0.391
D	Kaliwa Low Dam + Kanan No.2 Dam	3,600	1,884	1,252	1,531	45	4	1,248	0.389
E	Kaliwa Low Dam + Kanan Low Dam + Kanan Dam	4,060	2,200	1,459	1,580	534	50	1,411	0.421
F	Laiban Dam + Agos Dam	3,330	2,064	1,313	1,498	897	78	1,236	0.390
G	Kaliwa Low Dam + Laiban Dam + Agos Dam	3,430	2,284	1,393	1,513	588	58	1,337	0.424
H	Laiban Low Dam + Kanan No.2 Dam	3,420	1,778	1,289	1,511	393	36	1,254	0.398
	(For Reference)								
A & F	Laiban Dam w/1st Waterway+WTP #1 - #3	1,830	871	907	1,166	532	40	868	0.380
Case-B: Comparison according to Assumed Schedule									
	(Assumed that Project would be Implemented according to Most Likely Schedule. See Figure 7.3)								
A	Laiban Dam + Kanan No.2 dam	5,110	2,256	1,154	1,213	534	48	1,108	0.393
	(Completion of 1st Stage Project in 2013)								
C	Agos Dam (FSL 159m) w/o Kaliwa Low Dam	3,000	1,820	1,099	1,174	1,266	101	1,002	0.394
	(Completion of 1st Stage Project in 2012)								
D	Kaliwa Low Dam + Kanan No.2 Dam	3,600	1,884	1,077	1,244	40	4	1,076	0.393
	(Completion of 1st Stage Project in 2012)								
E	Kaliwa Low Dam + Kanan Low Dam + Kanan Dam	4,060	2,200	1,331	1,426	475	46	1,287	0.415
	(Completion of 1st Stage Project in 2011)								
F	Laiban Dam + Agos Dam	3,330	2,064	1,017	1,111	636	60	939	0.378
	(Completion of 1st Stage Project in 2013)								
H	Laiban Low Dam + Kanan No.2 Dam	3,420	1,778	1,016	1,108	327	32	987	0.397
	(Completion of 1st Stage Project in 2012)								
	(For Reference)								
A & F	Laiban Dam w/1st Waterway+WTP #1 - #3	1,830	871	702	844	383	32	671	0.376
	(Completion in 2013)								
Case-C: Assessment of Effect of Delayed Completion									
	(In Consideration of Production Loss for Delayed Completion Compared with Scenario B)								
A	Laiban Dam + Kanan No.2 dam	5,110	2,256	1,154	1,213	534	48	1,106	0.410
	(Completion of 1st Stage Project in 2013)								
C	Agos Dam (FSL 159m) w/o Kaliwa Low Dam	3,000	1,820	1,099	1,174	1,266	101	1,004	0.405
	(Completion of 1st Stage Project in 2012)								
D	Kaliwa Low Dam + Kanan No.2 Dam	3,600	1,884	1,077	1,244	40	4	1,074	0.402
	(Completion of 1st Stage Project in 2012)								
E	Kaliwa Low Dam + Kanan Low Dam + Kanan Dam	4,060	2,200	1,331	1,426	475	46	1,287	0.418
	(Completion of 1st Stage Project in 2011)								
F	Laiban Dam + Agos Dam	3,330	2,064	1,017	1,111	636	15	986	0.397
	(Completion of 1st Stage Project in 2013)								
H	Laiban Low Dam + Kanan No.2 Dam	3,420	1,778	1,016	1,108	277	29	989	0.398
	(Completion of 1st Stage Project in 2012)								
	(For Reference)								
A & F	Laiban Dam w/1st Waterway+WTP #1 - #3	1,830	871	702	844	383	32	671	0.404
	(Completion in 2013)								

Notes: *1 Project Cost represents Base Cost at 2001 price including Physical Contingency (15%) and Engineering/Administration Cost (7%)

*2 Eledctricity selling price is assumed to be Peso 2.5/kWh (US$ 0.0481/kWh) at 2001 price, with escalation at 3% per annum

*3 Marginal unit water cost at 2001 price level which equalizes the present worths of cost and water sale. Water cost assumed to escalate at a rate of 3% per annum.

Table E9.1 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	234.7	Infanta	Signal #3
			Nov. 04-05			
	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

Source: PAGASA

Table E9.2 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 E9.3 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

Figures

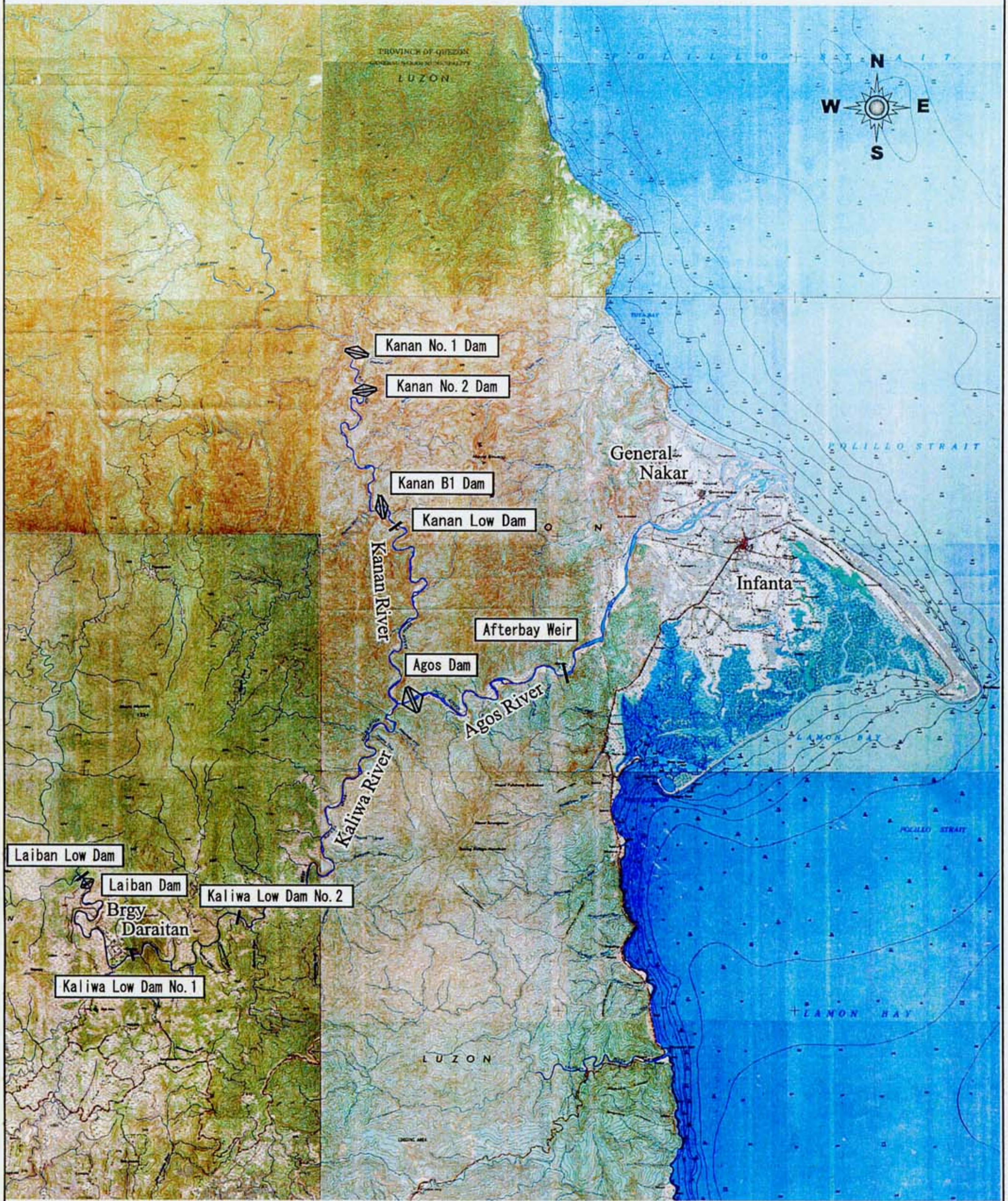

Figure E1.1
Proposed Dam Development Sites in the Agos River Basin