Part-F

Water Conveyance and Treatment Plant

Part-F WATER CONVEYANCE AND TREATMENT PLANT

Table of Contents

List of Tables

List of Figures

Part-F : WATER CONVEYANCE AND TREATMENT PLANT

F1 Introduction

This Study examines three water conveyance lines proposed in the plan formulation of alternative development scenarios, which are as shown below[1].

- Laiban-Taytay Waterway: from Laiban Reservoir to Taytay Service Reservoir (under Development Scenarios A and F)
- Kaliwa-Angono* Waterway: from the Kaliwa River (at Kaliwa Low Dam No.2 site) to Angono Service Reservoir (Development Scenarios B to G)
- Laiban-Angono* Waterway: from Kaliwa River (at Laiban Low Dam site) to Angono Service Reservoir (Development Scenario H)

Note: * Place of service reservoir. In F/S, the word of 'Taytay' is used. The location of reservoir is remains same.

Laiban-Angono Waterway, was additionally studied in home office work in Japan based on a request in the Steering Committee Meeting held in August 2001. Laiban-Taytay Waterway has been studied at the detailed design level and the definite features are presented in the previous report (Ref. MWS III Project Review Report, 1997). Hence, this Chapter mainly describes the water conveyance lines and treatment plants for the remains.

Figure F1.1 shows the general layout plan of the three waterways, including alternative waterway routes examined for the Kaliwa-Angono Waterway (See Section F2 below).

[1] The definite location and route of waterway facilities were finally determined in the feasibility study stage due to the reasons of topographic and geological conditions observed at the sites, and new findings during the socond field investigation. The final waterway route is shown in Figure 7.1 of Chapter 7 of Volume IV, Main Report of Feasibility Study.

F2 Water Conveyance Facilities

F2.1 General

The water conveyance facilities consist of an intake, tunnels, pipelines, a powerhouse, a valve house for hollow-jet valves, a water treatment plant and receiving service reservoirs[2]. Table F2.1 shows the general features of the three waterways: Laiban-Taytay Waterway, Kaliwa-Angono Waterway and Laiban-Angono Waterway, proposed in the Development Scenarios A, B and H, respectively.

For the Kaliwa-Angono waterway, three (3) alternative routes were compared and the Waterway Route B-1c was selected to be least costly (see Section E5.4 in Part-E of this Supporting Report). The following describe the proposed features of Route B-1c, assuming the case of Development Scenario B as a representative case.

Figure F2.1 shows the proposed route and profile of the Kaliwa-Angono Waterway (Route B1-c).

F2.2 Design Discharge

Kaliwa-Angono waterway system envisages constructing two waterways in two-staged development.

The 1st waterway will be constructed to feed water of 1,500 MLD (17.4 m^3/sec) in terms of daily average water quantity. In the first stage, however, water source is the Kaliwa natural runoff taken at the Kaliwa Low Dam site, which is 6.4 m^3/sec (equivalent to 550 MLD) representing a 90% dependable discharge available at the site. After the Agos Dam is completed, the tunnel will feed water at the full capacity.

The 2nd waterway will also feed 1,500 MLD in daily average water quantity.

The design discharge of each waterway is set at 21.0 m^3/sec (equivalent to 1,820 MLD), taking account of the day peak factor of 1.21 as follows:

$$Q_{max} = Q_f \ x \ MDF = 17.4 \ m^3/sec \ x \ 1.21 = 21.0 \ m^3/sec$$

Where, Q_{max}: Design discharge (or maximum discharge) for water conveyance facilities (m^3/sec)

Q_f: Average discharge for water supply (m^3/sec)

MDF: Day peak factor, taken as 1.21 following the figure adopted in the recent review of the MWSP III Project

F2.3 Waterway Profile Design

The size of tunnel and pipeline to be laid is determined to have sufficient discharge capacity for design discharge mentioned above. Then, the hydraulic longitudinal profile of waterway including the water levels at structures (e.g. water treatment

2 Major water conveyance facilities are also finally determined in the feasibility study stage. The facilities are mentioned in Section 7.1 of Chapter 7 of Volume IV, Main Report of Feasibility Study.

plant, powerhouse, etc.) were determined based on hydraulic loss head calculation. The head loss due to friction in the tunnel and pipeline is calculated using the following William-Hazen formula as follows:

$$H_L = 10.67 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L$$

Where, H_L: Head loss due to friction in waterway

C: Coefficient of roughness, C=110

D: Internal diameter of tunnel or pipeline (m)

Q: Design discharge (m^3/sec)

L: Length of tunnel or pipeline (m)

The design water level of the Angono service reservoir is set at EL. 72 m, which represents the lowest water level required to ensure the distribution of water to the service areas, principally by gravity. Therefore, water level at Angono service reservoir is set as the starting point of the calculation. Hydraulic loss head calculation was made by an equation shown below:

$$WL_u = WL_d + H_L + H_O$$

Where, WL_u: Water level at upstream structure (EL.m)

WL_d: Water level at downstream structure (EL.m)

H_L: Head loss due to friction in pipeline or tunnel between the downstream and upstream structures (m)

H_O: Head loss due to other losses, such as bending loss, etc. (m)

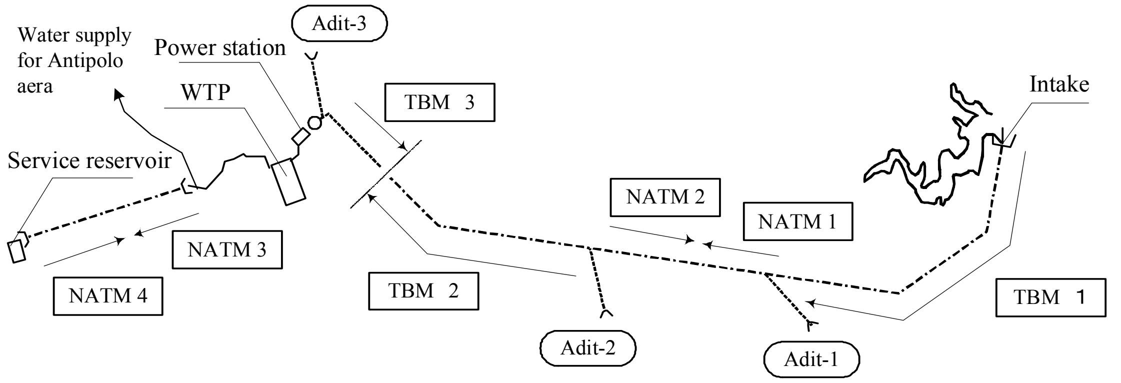
In the calculation above, WL_u is set at the LWL (low water level) proposed at the upstream structure, while WL_d is the HWL (high water level) designed for the downstream structure.

The head loss due to friction and other loss is calculated at 12.2m between the Angono service reservoir and water treatment plant (L=9,300m, 5,700m tunnel + 3,600m pipeline), and at 1.1m between water treatment plant and Pantay power station/valve house (L=800m, channel and pipeline).

F2.4 General Features of the Proposed Waterways

The tunnel section in Kaliwa-Angono waterway will pass through geological zones of Maybangain Formation, Kinabuan and Barenas-Baito formation as described in Part-D of this Supporting Report. The geology appears suitable for using TBM (tunnel boring machine) for tunneling. In consideration of rock class and limited construction time, construction of the tunnel will be carried out by means of combination of TBM and NATM with 3 adits as shown below[3]:

[3] As already mentioned in Section F1 in Part-F of this Supporting Report, the location and route of waterway facilities were determined in the feasibility study stage, and the final waterway route is shown in Figure 7.1 of Chapter 7 of Volume IV, Main Report of Feasibility Study.



Schematic Diagram of Waterway

The pipeline will be basically installed along the existing road connecting Antipolo city and Riza village, passing through a variety of areas such as forest and shrubs, paddy field, upland farm, residential land and shoulder of the existing road. Land use along the proposed pipeline was measured on 1:15,000 aerial photographs taken in year 2000. The length by land use category is shown below:

Area	Forest and shrubs	paddy field	upland farm	residential land	Shoulder of road
Length (m)	863	302	57	122	2530

Construction of pipelines and water treatment plant involves the relocation of some households. The resettlement issue along the water conveyance route is described in Part-H of this Supporting Report.

F3 Water Treatment Plant

F3.1 Proposed Site

Water treatment plant site has been selected by examining 1/50,000 map and aerial photographs, and conducting field visit to the site. In selecting the site, the following factors were taken into consideration:

- Availability of required area
- Topographical features
- Geotechnical conditions
- Availability of canal(s) for release of excess water discharged from the plant

The proposed site for the Kaliwa-Angono Waterway is situated in the boundary of municipality of Morong and Teresa, about 3 km east of Antipolo. The site is located nearby the provincial road connecting Riza and Antipolo. The site is very close to a small stream (unnamed on 1/50,000 map), which flows down to San Gabriel, Plenza and further to San Juan on the coast of the Laguna Lake. Aerial distance from the treatment plant site to the proposed Angono service reservoir is approximately 9 km. The area consists of mixture of farm land, uncultivated land and hilly areas, with about 10 to 20 houses/buildings at scattered locations. The land is presumably privately owned. The plan envisages acquiring a land of 70 ha, including the land required for future second stage development.

The elevation of the area ranges from EL. 90-100 m in relatively flat area to EL. 120 m on the hills, generally descending gently to the southward. Construction of the plant yard will require several million m^3 of earth works.

F3.2 Raw Water Quality and Water Treatment Process

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

i) Color reading ranging from 5 to 1000 color units
ii) Iron content ranging from 0.05 to 3.5 mg/l
iii) Alkalinity ranging from 100 to 200 mg/l as $CaCO_3$
iv) Hardness appears to be moderate with a low of around 70 and a high of about 100 mg/l as $CaCO_3$
v) pH from 7.8 to 8.4
vi) Turbidity from a low of 0.2 to a maximum in excess of 420 turbidity units, with a mean of 3 NTU
vii) Pesticides and herbicides show no detectable level
viii) Total organic carbon (TOC) varying from 0.6 to 5.9 mg/l

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

Likewise, in this Study, water quality analysis was carried out for river water of one sample collected from each of the Kaliwa, Kanan and Agos Rivers. Their analysis results are shown in Table C3.3 in Part-C.

Water quality of the said rivers shows that concentration of health-related inorganic constituents such as arsenic, cadmium, chromium, cyanide, fluoride, lead, mercury and nitrate are very low and below the detectable limits. BOD_5, COD, $KMnO_4$ and ammonium, which are indicators of contamination, also show low level.

From the viewpoint of water treatment, color, turbidity, pH, alkalinity, iron, manganese, etc. of the Agos River water are at almost same level as those of La Mesa Dam water. Table F3.1 shows raw water and treated water quality of La Mesa No.1 Water Treatment Plant in August 2000 and March 2001.

Compared the water quality of the Agos River with water quality at the existing WTPs in Metro Manila, the conventional water treatment process adopted at La Mesa No.1/Balara No.2 WTP can also be employed for the Agos River water. Even higher Iron contents seen in the samples can be easily removed by employing the conventional unit process (coagulation/flocculation, horizontal flow sedimentation and rapid sand filtration). In addition, the direct filtration may be applicable for water of low turbidity during the dry season. For safety, feeding apparatus of activated carbon may need to be equipped to keep up with unexpected water contamination in the future.

F3.3 Preliminary Plant Design[1)]

(1) Design Principles

Preliminary computation and conceptual design are prepared for the first stage development of the proposed water treatment facilities (1,820 MLD in capacity, out of the ultimate capacity of 3,640 MLD).

For determination of design capacity of the treatment facilities, water loss within the yard of treatment plant is planned to be minimal as much as possible. Wash water from the filters is returned to receiving well, and sludge from sedimentation basin is thickened and supernatant water also returned to receiving well through filter wash water storage. Thus, water loss at treatment process, which is generally assumed at 3 to 5% of raw water volume, is negligible.

The treatment process units are selected and designed in view of economic construction and easy operation and maintenance aspects. Simple structures will bring flexibility to the variation of raw water quality and unpredictable constraints on operation and maintenance works. As for coagulant, poly aluminum chloride (PAC) is recommendable, since its performance shows much more advantages improving floc density/settling velocity through the experience world widely. Further, applying PAC for water treatment does not require coagulant aid such as poly-electrolytes.

[1)] Preliminary plant design of the WTP was modified during F/S stage (Phase II), taking account of the site conditions of topographic condition and land availability as well as required cost.

The design of unit process has been carried out with due consideration of functionally appropriate layout and environmental aspects.

(2) Layout of major facilities

Layout of treatment plant facilities is arranged within the proposed site of about 75 ha as shown in Figure F3.1. Whereas, the proposed facilities at the ultimate stage (for additional 1,820 MLD) is planned to be aligned in the adjacent area. Sludge drying beds are planned so as to enable easy discharging of supernatant water to a nearby stream.

(3) Flow diagram of the system

The proposed water treatment system is planned for the maximum day demand of 1,820 MLD in the first stage. Figure F3.2 gives the flow diagram required to compute and determine the capacity of each process unit in the system. Sludge in the sedimentation basin will be separated at the sludge thickeners and subsequent supernatant water is returned to the receiving well together with wash water generated in the filter.

(4) Major facilities

(a) Receiving well

The structure is a reinforced concrete rectangular type with dimensions of 11 m (W), 11 m (L) and 5 m (D) for the first unit of 910 MLD. Another unit will be constructed in the subsequent stage in accordance with increase of water demand in Metro Manila.

(b) Mixing chamber

The rapid mixing chamber is located following the receiving well. The structure is of reinforced concrete and parallel twin rectangular channel type. The structural dimensions are 6 m (W), 10 m (L) and 5 m (D). Two (2) units of chamber are required for the 1st stage. Hydraulic jump will be used for mixing energy to avoid the use of mechanical and electric equipment.

(c) Flocculation basin

The flocculation basin consists of 3 reinforced concrete channels. G-values are designed to grow flocs gradually within 60 to 20 sec. To attain sufficient mixing energy, mechanical flocculator or baffled wall shall be provided. The retention time is planned for 20 minutes. Width, length and depth of the flocculation basin are 4 m, 36 m and 4 m, respectively. Eight (8) units of the basin are required for the 1st stage.

(d) Sedimentation basin

Due to comparatively good condition of raw water throughout year with 3 NTU turbidity in average, horizontal flow sedimentation is selected. To save the volume of basin as well as improve settling performance, plate settler may be equipped. The structure of the basin is a reinforced concrete type with dimensions of 12 m (W), 40 m (L) and 4.5 m (D). For the sludge removal, a cable-operated under water bogie or flight chain sludge collector is equipped to remove sludge effectively and to save manpower.

(e) Rapid sand filter

The filter is of a constant rate and dual media type, having 24 filter units consisting of 150 m^2 each. Filter basin is located immediately after the sedimentation basin connected by the channels. The filter is planned to be operated at a filtration rate of 250 m/day. The filter media comprises anthracite and sand. Backwashing and surface washing rates are set at 0.75 m/min and 0.15 m/min, respectively.

(f) Clear water basin

Filtered water is conveyed by two connection pipes of 3,000mm in diameter to the clear water basin located downstream of the filter basin. The structure is of reinforced concrete construction (beam type). Dimension of the structure is 44m (W), 88m (L) and 5m (D). Two (2) units of basin are required at the 1st stage.

(g) Backwash wastes returning tank

The backwash wastes retuning tank consists of 2 units of 25.0 m (Dia.) x 4.2 m (D) cylinder tanks. The structure is a reinforced concrete type provided with recycling pump system to return backwash wastes to the receiving well.

(h) Sludge thickening tank

Sludge thickening tank consists of 4 units of 27.5 m (W) x 27.5 m (L) x 5 m (D) tanks. The structure is a reinforced concrete type provided with outlet gallery. The thickened sludge is pumped to the sludge drying bed.

(i) Sludge drying bed

Sludge drying beds are provided adjacent to the nearby small streams. On the basis of the computation of sludge volume, five (5) beds are provided to dry up sludge. The structure of drying beds is a reinforced concrete type with dimensions of 36 m (W), 88 m (L) and 1 m (D).

Design criteria and dimension of major facilities for the first unit (910 MLD) and the two units (1,820 MLD) are summarized in Table F3.2.

F4 Transmission and Distribution Facilities

F4.1 Transmission Mains and Delivery Facilities

(1) Transmission Mains

Proposed route of transmission pipe for the 1st stage between the water treatment plant and Angono service reservoir is shown in Figure F2.1. Transmission trunk main comprises pipeline and tunnel. A total length is about 9.3 km (3.6 km of embedded pipeline and 5.7 km of tunnel). At the junction of tunnel and pipeline, a pump station to deliver water to Antipolo area will be constructed.

Design flow capacity of trunk main is 21.0 m^3/sec to meet the maximum daily water demand as stated earlier. The proposed diameter of the pipe is 3,400 mm so that the water therein flows at a maximum velocity of 2.32 m/sec.

(2) Taytay Service Reservoir[2)]

Storage capacity of service reservoir (to act as distribution reservoir) is designed to have an eight (8) to twenty-four (24)-hour retention volume. It is desirable that storage facilities have as large capacity as possible for ensuring the safety of water supply in the case of stoppage of supply from upstream facility. However, the facilities should be planned taking into account the factors of the site condition and structural requirements as well as stage-wise development according to the increase of water supply.

Under the condition of the proposed site, storage capacity is proposed to be 360,000 m^3 (180,000 m^3 each for the 1st and 2nd stage) as an effective volume, which is equivalent to about 6-hour retention volume. HWL and LWL of the reservoir are preliminarily set at EL.72 m and EL.66 m, respectively, taking account of the altitudes of the service area ranging generally between EL.5m and EL.50m. The exception is Antipolo area with ground elevations of higher than 200 m, to which water is planned to be pumped up.

The service reservoir is proposed to be located at moderately gentle hill in Taytay area. Structural dimensions of one unit of reservoir are 75 m (Width) x 210 m (Length) x 6 m (Effective depth). A total of 360,000 m^3 for the 1st and 2nd stages may be the maximum size that can be constructed at the proposed site. Additional two units (180,000 m^3 each for 3rd and final stage) shall be constructed in the adjacent area at the ultimate stage according to increase of water demand.

The off-take point for delivering to the water distributors is planned to be at this Angono service reservoir.

(3) Antipolo Pump Station and Service Reservoir[3)]

With regard to Antipolo area, a large volume of water supply is anticipated due to high population growth rate and high service coverage scheduled under the existing

[2)] Structural dimensions of Taytay Service Reservoir were modified during F/S stage (Phase-II)

[3)] Structural dimensions of Antipolo Pump Station and Service Reservoir were modified during F/S stage (Phase-II)

Concession Agreement. In this Study, required volume of water supply for Antipolo area using new water source is assumed to be about 90 MLD in 2015, 340 MLD in 2020 and 680 MLD in 2025. Regarding water supply system, pumping system is a requisite for delivery of water due to high altitude of the service area situated at more than EL. 200 m. Required facilities are a pump station, a transmission pipe and a service reservoir.

Pump station is planned at the junction of tunnel and transmission pipe from water treatment plant. The pump house accommodates the required units of booster pump up to year 2020. Specifications of a pump are 0.99 m^3/min in capacity, 205 m in pumping head, and 2,500 kW in motor power. Required number of pump unit is two (2) for year 2015, five (5) for 2020 and ten (10) for 2025, including two (2) stand-by units, respectively. Thus, expansion of pump station will be needed towards year 2025. In addition, countermeasure against water hammer is a requisite. The possible solution is a provision of air vessel at suction part and surge tank at delivery part.

While, service reservoir with a capacity of 30,000 m^3 to meet water demand for year 2015 is proposed to be located at EL. 260 m on a moderately gentle hill of Antipolo plateau. Structural dimensions are 51 m (Width) x 72 m (Length) x 6 m (Effective depth). After 2015, additional service reservoirs (30,000 m^3 x 2 units for year 2020 and 30,000 m^3 x 3 units for year 2025) are required in order to meet rapid increase of water demand.

Transmission main with a diameter of 1,600 mm and a length of 3 km is planned to be installed at the 1st stage and another transmission main of the same size at final stage.

F4.2 Preliminary Plan of Distribution Trunk Mains in MWSS's Service Area

(1) Existing Distribution Trunk Mains

Existing distribution mains are presently utilized for water supply from Balara and La Mesa WTPs.

It is presumed that total length of the existing distribution trunk mains, diameter of 600 mm to 3,000 mm, is about 250 km within the service area as of 1994. Figure F4.1 shows the location of the existing trunk mains. Some of the existing trunk mains are to be used for water supply from the new water treatment plant. In particular, the existing trunk mains along EDSA and Ortigas Avenue are considered to form the boundary between the service areas supplied from the Balara WTPs and the proposed new WTP.

(2) Preliminary Plan of New Distribution Trunk Mains

Service area to be supplied from proposed Angono service reservoir is planned to cover the southwestern part (Cavite area), southern part (Muntinlupa area) and southeastern part (Rizal towns).

Figure F4.2 presents a staged layout plan of distribution trunk mains together with related facilities (water treatment plant, service reservoir, booster pump and transmission main). A total length of distribution trunk mains is estimated to be about 120 km. This Study contemplates that the new distribution trunk mains be installed in three stages as mentioned below and hydraulic analysis in each stage is shown in Tables F4.1 to F4.6.

(a) First stage to meet 910 MLD

A 4,000 mm diameter distribution trunk main from the proposed Taytay service reservoir and two trunk mains with a diameter of 3,400 mm, which will be installed for Taytay-Cainta-Pasig route and Taytay-Pateros-Taguig route to connect with the existing primary main at Pasig and Taguig, are first to be installed. Further, 3,200 mm of pipe is planned to augment the supply capacity of the existing primary main (diameter of 450 to 1,200 mm) supplying Pasig-Makati-Pasay area. As for Cavite area, 700 to 1,500 mm of trunk mains shall be installed to connect with the existing 1,300 mm at Bacoor. For the Antipolo area, a 1,000 mm diameter primary main from the service reservoir is planned.

(b) Second stage to meet 1,820 MLD

In the 2nd stage, trunk mains of 900-2,200 mm diameter are planned between Taguig-Muntinlupa and Pasay-Paranaque-Las Pinas to augment supply capacity to meet a total of 1,820 MLD in the service area.

(c) Final stage to meet 3,640 MLD

In the final stage, bulk water supply is planned for the southeastern part, such as Cardona-Moron-Baras-Tanay-Pililla and Jala-Jala, by extending the trunk mains with a diameter of 350 to 1,500 mm. To meet full development of water supply, additional trunk mains with diameter of 3,400 to 4,000 mm are planned for Taytay service reservoir-Taytay-Pasig route.

(3) Preliminary Cost Estimate for New Distribution Trunk Mains

Required cost for new distribution trunk mains, including small diameter pipes delivering water to Teresa, was estimated on the basis of the following assumptions:

(a) Specification of the pipe is referred to the MWSS's standards. For the pipes with a diameter of more than 700 mm, steel pipes with epoxy lining and coal tar enamel coating with asbestos felt wrapping are used. Likewise, for the pipes with diameters of 500 mm to 600 mm, steel pipes of cement mortar lining and coating are utilized. While, for the pipes with small diameter of 250 mm, PVC pipe is used.

(b) The construction costs of the pipes with diameter of 250 mm to 3,000 mm including their laying costs are estimated at current price level referring to the prices in the previous contracts of the MWSS projects. Cost estimation for the pipes with large diameter of 3,200 mm to 4,200 mm was made based on correlation between pipe diameter and the above unit costs for pipes with diameters of 250 mm to 3,000 mm.

(c) Costs for breaking and restoration of roadways are considered for pipe installation. Type of road is assumed to be of 250 mm thick concrete-paved, which is the majority of road construction in Metro Manila.

(d) Costs for other items such as valves, valve chamber, etc. are assumed at 20% of pipe material and pipe-laying cost.

Based on the above, the estimated cost by stage is summarized in Table F4.7. A total cost of about13.2 billion Pesos (US$ 254 million equivalent) will be required for the installation works of distribution trunk mains.

Tables

Table F2.1 General Features of Proposed Waterways

Item	**Laiban-Taytay Waterway (Waterway Route A)**	**Kaliwa-Angono Waterway (Waterway Route B-1c)**	**Laiban-Angono Waterway (Waterway Route H)**
Waterway Design (1st waterway)	Daily average volume.: 1,830 MLD Daily peak capacity: 2,210 MLD	Daily average volume:1,500 MLD Daily peak capacity: 1,800 MLD	Daily average volume:1,500 MLD Daily peak capacity: 1,800 MLD
Waterway Design (2nd waterway)	Daily average volume.: 3,310 MLD Daily peak capacity: 4,005 MLD	Daily average volume:1,500 MLD Daily peak capacity: 1,800 MLD	Daily average volume:1,920 MLD Daily peak capacity: 2,320 MLD
Total Length	23.3 km	38.1 km	32.5 km
Gross Head	Intake MOL – Taytay S.R. = 155.5 m	Intake MOL-Angono S.R. = 61.0 m	Intake MOL-Angono S.R. = 131.0 m
Design Discharge	25.6 m^3/sec (1st waterway) 46.4 m^3/sec (2nd waterway)	21.0 m^3/sec (1st waterway) 21.0m^3/sec (2nd waterway)	21.0 m^3/sec (1st waterway) 26.9 m^3/sec (2nd waterway)
Intake	A multilevel intake structure feeding flow of 27.5 m^3/sec. After completion of the Kanan transbasin tunnel, Intake No.2 feeding additional 46.0 m^3/sec will be added	An intake structure at Kaliwa Low Dam site, initially feeding 9.9 m^3/sec and subsequently 21.0 m^3/sec after the Agos Dam completed. Expanded to 42.0m^3/sec in the ultimate stage	An intake structure at Laiban Low Dam site, initially feeding 3.9 m^3/sec and subsequently 21.0 m^3/sec after the Agos Dam completed. Expanded to 47.9 m^3/sec in the ultimate stage
Waterway	Tunnel No.1: 7.5 km, 3.2-2.7 m dia. A concrete-lined tunnel is basically selected except the downstream 400m part, where tunnel is to be steel-lined. Pipeline No.1: 4.0 km, 3.2 m dia Pipeline No.1 connects the tunnel No.1 and No.2 and is laid along the Payana River. Tunnel No.2: 1.8 km, 2.7 m dia. A 1.8 km steel-lined tunnel connects pipeline No.1 and powerplant.	Tunnel No.1: 28.0 km, 3.5 m dia. First 24 km to be concrete-lined tunnel. A part of the last 4 km section to be steel lined, say a half section, depending on geology and ground coverage.	Tunnel No.1: 14.3 km, 3.2 m dia. Steel-lined is not designed, but may be needed depending on geology and ground coverage.
Powerhouse	30 MW installed capacity with 2 units of Francis turbine. During low demand period, excess water discharged to nearby creeks, where topographic and geotechnical survey of the creek bed will be necessary to determine appropriate riverbed protection measures.	12 MW installed capacity with one unit of turbine, to be built after Agos Dam is completed and high head water level is available. Power generation has to be suspended during period of low effective head when Agos reservoir water level is low. No powerplant in initial phase (Kaliwa Low Dam stage).	22.4 MW installed capacity with two units of turbine, to be built after Kanan No.2 Dam is completed and large amount of discharge is available. No powerplant in initial phase (without Kanan No.2 Dam stage).
Channel/Pipeline	Concrete lined channel of approx. 400 m long connecting powerplant and WTP	Channel/Pipeline of 0.8 km connecting powerplant and WTP	Pipeline No.1: 1.2 km, 3.1 m dia. Tunnel No.2: 2.6 km, 3.1 m dia. Pipeline No.2: 1.3 km, 3.1 m dia.
Water Treatment Plant (WTP)	2,400 MLD in total capacity (3 units of 800 MLD), while daily average production is 1,900 MLD.	1.820 MLD in total capacity (2 units of 910 MLD) in the first stage with first waterway where daily average production is 1,500 MLD. Ultimately, 3,600 MLD in capacity (3,000 MLD average) with two waterways.	1.820 MLD in total capacity (2 units of 910 MLD) in the first stage with first waterway where daily average production is 1,500 MLD. Ultimately, 4,160 MLD in capacity (3,420 MLD average) with two waterways.
Waterway	Pipeline No.2: 5.0 km, 3.2 m dia. Tunnel No.3 : 5.0 km, 3.6 m dia. Concrete-lined , non-pressure type	Pipeline No.1: 3.6 km, 3.4 m dia. Tunnel No.2: 5.7 km, 3.4 m dia. Steel lined	Pipeline No.3: 1.7 km, 3.2 m dia. Tunnel No.2: 0.5 km, 3.2 m dia. Pipeline No.4: 5.2 km, 3.2 m dia. Tunnel No.2: 5.7 km, 3.2 m dia.
Service Reservoir	120 ML capacity in 20,000 m^2 pond located at hills in Taytay area. Since only small stream flow is available, some measures should be considered to spill out excess reservoir water safely in case of need.	380 ML capacity in 60,000 m^2 pond. Located on hills in Angono area. Measures for excess water to be considered.	- Same with the left column -

Table F3.1 Water Quality of Raw/Treated Water at La Mesa No.1 Water Treatment Plant

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

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

Table F3.2 Design Criteria and Dimension of Water Treatment Plant 1,820 MLD and 910 MLD (1/2)

Item	Total System (2 Units)	First Unit
Planned Flow	Q = 1,820,000 cu.m/day	Q = 910,000 cu.m/day
	Treatment / Nominal Capacity	Treatment / Nominal Capacity
Plant Capacity	Q = 1,820,000 cu.m/day / 1,800,000 cu.m/day	Q = 910,000 cu.m/day / 900,000 cu.m/day
(Daily Max)	= 75,000 cu.m/hour / 75,000 cu.m/hour	= 37,500 cu.m/hour / 37,500 cu.m/hour
	= 1,250.0 cu.m/min / 1,250.0 cu.m/min	= 625.0 cu.m/min / 625.0 cu.m/min
	= 20.83 cu.m/sec / 20.83 cu.m/sec	= 10.42 cu.m/sec / 10.42 cu.m/sec
(1) Receiving Well		
Criteria	Retention Time T = 1.0 min	Retention Time T = 1.0 min
Dimension	Rectangular 2 units	Rectangular 1 units
	W m x L m x D m x units	W m x L m x D m x units
	11 11 5 2	11 11 5 1
(2) Mixing Chamber		
Criteria	Retention Time T= 1 - 5 min	Retention Time T= 1 - 5 min
Dimension	Rectangular 4 units	Rectangular 2 units
	W m x L m x D m x units	W m x L m x D m x units
	10.0 6.0 5.0 4	10.0 6.0 5.0 2
Mixing	Hydraulic jump	Hydraulic jump
(3) Flocculation Basin		
Criteria	Retention Time T = 20 - 40 min	Retention Time T = 20 - 40 min
	Required Volume V = 25,000 cu.m to	Required Volume V = 12,500 cu.m to
	50,000 cu.m	25,000 cu.m
Dimension	16 units	8 units
Step 1	W m x L m x D m x No. of Channel	W m x L m x D m x No. of Channel
	4.0 30.0 4.0 1	4.0 36.0 4.0 1
Step 2	W m x L m x D m x No. of Channel	W m x L m x D m x No. of Channel
	4.0 30.0 4.0 1	4.0 36.0 4.0 1
Step 3	W m x L m x D m x No. of Channel	W m x L m x D m x No. of Channel
	4.0 30.0 4.0 1	4.0 36.0 4.0 1
Mixing	Mechanical flocculator/hydraulic mixing	Mechanical flocculator/hydraulic mixing
(4) Sedimentation Basin		
Type	Rectangular, Horizontal Flow with Plate Settler	Rectangular, Horizontal Flow with Plate Settler
Unit Flow	q = 4,688 cu.m/hr/basin	q = 4,688 cu.m/hr/basin
Criteria	Retention Time T1 > 1.0 hours	Retention Time T1 > 1.0 hours
	Surface Load a = 4 - 9 mm/min	Surface Load a = 4 - 9 mm/min
	Hori. Flow Velocity v < 0.6 m/min	Hori.. Flow Velocity v < 0.6 m/min
	L/W Ratio L/W = 3 - 8 times	L/W Ratio L/W = 3 - 8 times
	Effective Depth D = 3 - 4 m	Effective Depth D = 3 - 4 m
	Depth of 30 cm or more is provided for sludge settlement.	Depth of 30 cm or more is provided for sludge settlement.
	Retention Time in Plate Settler T2 = 20～40 min	Retention Time in Plate Settler T2 = 20～40 min
Dimension	No. 16 basins	No. 8 basins
	W m x L m x D m x channels x basins	W m x L m x D m x channels x basins
	12 40 4.5 3 16	12 40 4.5 3 8
Plate Settler	Height of Plate Settler H = 3.0 m	Height of Plate Settler H = 3.0 m
	Spaces between Plates P = 100 mm	Spaces between Plates P = 100 mm
	Effective Settling Ratio r = 17.32	Effective Settling Ratio r = 17.32
	Dimensions of Whole Plate Settler Unit	Dimensions of Whole Plate Settler Unit
	W m x L m x D m x channels x basins	W m x L m x D m x channels x basins
	11.9 20.0 3.0 3 16	9.9 20.0 3.0 3 8
Sludge Removal	Cable-operated underwater bogie/chain-flight type sludge collector	Cable-operated underwater bogie/chain-flight type sludge collector
	Water Contents of Drained Sludge	Water Contents of Drained Sludge
	(with wash-out water)	(with wash-out water)
	w = 99.8 %	w = 99.8 %
	Frequency of Cleaning : Continuous	Frequency of Cleaning : Continuous
(5) Rapid Sand Filter		
Type	Down flow, dual dedia	Down flow, dual dedia
No.	48 units (wash 4 units)	24 units (wash 2 unit)
Unit Flow	q = 37,500 cu.m/day/unit	q = 37,500 cu.m/day/unit

Table F3.2 Design Criteria and Dimension of Water Treatment Plant 1,820 MLD and 910 MLD (2/2)

Item	Total System (2 Units)	First Unit
Criteria	Filtration Rate Fr = 200 - 240 m/day	Filtration Rate Fr = 200 - 240 m/day
	= 8.3 - 10.0 m/hour	= 8.3 - 10.0 m/hour
	Filter Area per Unit A ≦ 150 sq m	Filter Area per Unit A ≦ 150 sq m
Dimension	W m x L m x units	W m x L m x units
	15 10 48	10 15 24
	A = 150 sq m/unit	A = 150 sq m/unit
Filtration Rate	Fr = 250 m/day	Fr = 250 m/day
Filtration Rate	Fr'= 273 m/day	Fr'= 273 m/day
during washing	4 units out of 48 are washing	2 unit out of 24 is washing
Filters for Backwashing	1 filters/group	1 filters/group
Frequency	Once a day for each filter	Once a day for each filter
Rate	Surface Washing rate = 0.15 m3/m2/min	Surface Washing rate = 0.15 m3/m2/min
	duration = 5.0 min	duration = 5.0 min
	Backwashing rate = 0.75 m3/m2/min	Backwashing rate = 0.75 m3/m2/min
	duration = 8.0 min	duration = 8.0 min
(6) Chlorination Channel		
Location	at the Inlet of the Clear Water Reservoir	at the Inlet of the Clear Water Reservoir
Criteria	Contact Time T > 5 minutes	Contact Time T > 5 minutes
Required Volume	V = 6,250 cu.m	V = 3,125 cu.m
Dimension	No. 4 units	No. 2 units
	W m x L m x D m x units	W m x L m x D m x units
	4.6 88 4.0 4	4.6 88 4.0 2
(7) Clear Water Reservoir		
Criteria	Retention Time T > 1 hours	Retention Time T > 1 hours
Required Volume	V = 75,000 cu.m	V = 37,500 cu.m
Dimension	No. 2 units	No. 1 units
	W m x L m x D m x conpart. x units	W m x L m x D m x conpart. x units
	44 88 5 2 2	44 88 5 2 1
(8) Backwash Wastewater Storage Tank		
Retention Time	2 hours	2 hours
Frequency of Wash	Once a day 48 filters/day	Once a day 24 filters/day
Required Volume	V = 4,050 cu.m	V = 2,025 cu.m
No.	N = 2 units	N = 1 units
Dimension	Dia. m x D m x units	Dia. m x D m x units
	25 4.2 2	25 4.2 1
(9) Sludge Thickening Tank		
Req'd Retention Time	Tr = 24 hours (24-48)	Tr = 24 hours (24-48)
No.	N = 8 units	N = 4 units
Dimension	W m x L m x D m x units	W m x L m x D m x units
	27.5 27.5 5.0 8	27.5 27.5 5.0 4
(10) Sludge Drying Bed		
Water Contents of Thickened Sludge	w = 96.0 %	w = 96.0 %
Dimension	Rectangular 8 units + 2 unit	Rectangular 4 units + 1 unit
	W m x L m x D m x units	W m x L m x D m x units
	40 75 1.0 10	40 75 1.0 5

Table F4.1 Hydraulic Analysis Jubction Result at 9:00 (910 MLD)

Label	Elevation (m)	Demand (Ml/d)	Demand Calculated (Ml/d)	Calculated Hydraulic Grade (m)	Residual Pressure (m)
Antipolo	200	43.27	71.40	255.49	55.46
Bacoor 1	5	17.30	28.55	66.25	61.22
Bacoor 2	5	17.30	28.55	65.40	60.37
Cainta	20	26.68	44.02	65.07	45.05
Cavite City	2	17.07	17.07	54.16	52.14
J-1	60	0.00	0.00	87.44	27.43
J-2	5	0.00	0.00	70.15	65.12
J-5	20	36.55	60.30	64.89	44.87
J-6	20	36.55	60.30	64.57	44.55
J-8	10	0.00	0.00	64.74	54.72
J-15	2	0.00	0.00	57.97	55.94
J-17	2	0.00	0.00	63.10	61.07
J-19	5	0.00	0.00	63.47	58.44
J-20	5	0.00	0.00	63.60	58.57
J-22	5	0.00	0.00	60.60	55.57
J-23	5	0.00	0.00	65.45	60.42
J-24	10	0.00	0.00	66.04	56.01
J-25	10	0.00	0.00	64.74	54.72
J-26	20	36.55	60.30	33.13	13.12
J-27	20	36.55	60.30	42.30	22.29
J-28	20	0.00	0.00	67.39	47.37
J-29	10	0.00	0.00	67.31	57.28
J-30	10	0.00	0.00	67.44	57.41
J-31	10	0.00	0.00	67.94	57.91
J-34	15	0.00	0.00	67.38	52.35
J-35	20	28.18	46.50	68.38	48.36
J-36	20	0.00	0.00	67.38	47.36
J-37	20	0.00	0.00	66.37	46.34
J-38	5	0.00	0.00	68.27	63.24
J-39	20	0.00	0.00	67.99	47.97
J-40	10	0.00	0.00	68.51	58.48
J-42	60	43.27	-43.27	45.37	-14.62
J-46	10	0.00	0.00	63.23	53.20
J-48	60	43.27	43.27	87.40	27.39
Kawit	2	12.76	12.76	58.18	56.15
Las Pinas 1	5	52.78	87.08	57.75	52.72
Las Pinas 2	10	52.78	87.08	67.48	57.45
lmus	10	16.83	16.83	64.69	54.66
Makati	30	36.55	60.30	64.89	34.88
Muntinlupa	10	0.30	0.50	68.12	58.09
New WTP	90	910.00	-910.00	89.02	-0.98
Noveleta	2	4.54	4.54	56.67	54.64
Paranaque 1	5	30.14	49.73	65.36	60.33
Paranaque 2	5	30.14	49.73	60.43	55.40
Paranaque 3	10	30.14	49.73	60.24	50.22
Paranaque 4	10	30.14	49.73	63.80	53.77
Paranaque 5	10	15.00	24.75	67.80	57.77
Pasay2	5	11.68	19.27	64.99	59.96
Pasig 1	20	70.69	116.64	63.28	43.26
Pasig 2	30	70.69	116.64	62.02	32.00
Pateros 1	20	5.68	9.36	67.19	47.17
Pateros 2	20	5.68	9.36	66.88	46.86
Rosario	2	13.57	13.57	54.86	52.84
Taguig 1	5	40.58	66.95	69.13	64.09
Taguig 2	15	40.58	66.95	66.04	51.01
Taytay	10	28.32	46.73	69.74	59.71

Table F4.2 Hydraulic Analysis Pipe Result at 9:00 (910 MLD) (1/2)

Label	From Node	To Node	Diameter (mm)	Length (m)	Hazen-Williams C	Discharge (Ml/d)	Velocity (m/s)	Headloss Gradient (m/km)
P-49e	Paranaque 2	J-15	1,100	3,100	100	65.45	0.80	0.79
P-51e	Paranaque 1	Paranaque 2	1,100	2,600	100	104.72	1.28	1.90
P-53e	J-20	J-19	500	700	100	3.77	0.22	0.19
P-56e	J-17	J-20	600	3,900	100	-4.98	0.20	0.13
P-57e	J-19	Las Pinas 1	500	1,200	100	21.63	1.28	4.77
P-58e	J-20	Bacoor 1	400	1,000	100	-8.75	0.81	2.65
P-59e	J-19	Las Pinas 2	500	1,200	100	-17.86	1.05	3.34
P-60e	J-17	Bacoor 2	600	1,000	100	-23.58	0.97	2.30
P-61e	Kawit	J-17	600	1,500	100	-28.56	1.17	3.28
P-62e	Paranaque 2	J-22	500	100	100	-12.28	0.72	1.67
P-63e	J-23	Paranaque 1	500	100	100	8.68	0.51	0.88
P-64e	J-22	J-23	500	2,900	100	-12.28	0.72	1.67
P-65e	J-24	J-25	450	4,500	100	3.59	0.26	0.29
P-66e	Taguig 2	J-24	450	1	110	3.59	0.26	0.24
P-67	Taytay	Taguig 1	3,400	7,500	110	411.94	0.53	0.08
P-67e	J-25	J-8	450	1	100	3.59	0.26	0.29
P-68e	J-26	J-6	400	2,500	100	-20.31	1.87	12.58
P-69e	J-27	J-26	600	1,500	100	39.99	1.64	6.11
P-70	Las Pinas 2	J-39	2,800	7,000	110	-230.56	0.43	0.07
P-70e	J-27	Makati	750	2,000	100	-100.29	2.63	11.30
P-71	J-39	Muntinlupa	2,800	1,800	110	-230.56	0.43	0.07
P-72	J-38	Muntinlupa	2,800	2,100	110	231.05	0.43	0.07
P-73	J-40	Taytay	3,400	3,500	110	-905.43	1.15	0.35
P-74	J-29	J-40	3,200	5,500	110	-594.92	0.86	0.22
P-74e	J-28	J-29	2,100	1,500	100	84.55	0.28	0.05
P-75	J-40	J-35	1,500	700	110	72.53	0.48	0.18
P-75e	J-29	J-30	1,050	2,000	100	-14.94	0.20	0.06
P-76	Cavite City	Noveleta	700	5,000	110	-17.07	0.51	0.50
P-76e	J-30	J-31	750	1,500	100	-14.94	0.39	0.33
P-77	Rosario	Noveleta	600	2,600	110	-13.57	0.56	0.69
P-77e	J-31	Taguig 1	600	1,200	100	-14.94	0.61	0.99
P-78	Noveleta	Kawit	1,000	4,500	110	-35.17	0.52	0.34
P-78e	Pasig 1	J-28	1,200	2,500	100	-121.96	1.25	1.65
P-79	Kawit	lmus	500	2,000	110	-19.37	1.14	3.26
P-80	J-15	Las Pinas 1	1,200	500	110	65.45	0.67	0.44
P-82	J-28	J-40	2,200	4,500	110	-237.98	0.72	0.25
P-84	Taguig 1	J-38	3,000	8,500	110	330.05	0.54	0.10
P-86	Paranaque 5	J-38	1,500	1,500	110	-99.00	0.65	0.32
P-89	Pateros 2	Pateros 1	2,600	1,200	110	-377.78	0.82	0.26
P-90	Taguig 2	Pateros 2	2,600	4,500	110	-317.53	0.69	0.19
P-91	J-23	Taguig 2	2,200	3,500	110	-193.07	0.59	0.17
P-92	Bacoor 2	Bacoor 1	1,350	2,000	110	-88.31	0.71	0.43
P-93	Bacoor 1	Las Pinas 2	1,350	1,500	110	-125.61	1.02	0.82
P-96	Paranaque 1	J-23	1,500	100	110	-172.11	1.13	0.88
P-97	Pateros 1	J-29	3,000	300	110	-688.81	1.13	0.39
P-100	New WTP	CWR	5,000	100	110	900.00	0.53	0.05
P-100e	J-34	J-28	2,100	1,100	100	-31.47	0.11	0.01
P-101	CWR	J-1	3,400	4,500	110	899.61	1.15	0.35
P-101e	J-34	Cainta	600	3,000	100	13.05	0.53	0.77
P-102e	Cainta	J-35	600	1,200	100	-26.02	1.07	2.76
P-103e	J-36	J-34	2,200	1,500	100	-4.95	0.02	0.00
P-104	PMP-1	PSV-2	1,600	2,200	110	43.27	0.25	0.05
P-104e	J-36	J-37	400	1,100	100	4.95	0.46	0.92
P-105	PSV-2	Antipolo SR	1,600	10	110	43.27	0.25	0.05
P-105e	J-37	Cainta	450	2,500	100	4.95	0.36	0.52

Table F4.2 Hydraulic Analysis Pipe Result at 9:00 (910 MLD) (2/2)

Label	From Node	To Node	Diameter (mm)	Length (m)	Hazen-Williams C	Discharge (Ml/d)	Velocity (m/s)	Headloss Gradient (m/km)
P-106	Antipolo SR	Antipolo	1,000	1,700	110	71.40	1.05	1.24
P-107	J-1	FCV-1	3,400	5,500	110	855.00	1.09	0.32
P-108	FCV-1	PSV-1	3,400	40	110	855.00	1.09	0.32
P-109	PSV-1	Taytay SR	3,400	10	110	855.00	1.09	0.32
P-111	Makati	Pateros 1	1,000	2,000	110	-68.35	1.01	1.15
P-117	PMP-1	J-42	2,000	6,800	110	-43.27	0.16	0.02
P-138	Bacoor 2	lmus	1,000	2,000	110	36.19	0.53	0.35
P-144e	Pasig 2	J-34	500	2,700	100	-13.48	0.79	1.99
P-147	J-1	Teresa	300	500	110	1.34	0.22	0.28
P-148	J-48	J-1	2,000	2,200	110	-43.27	0.16	0.02
P-148e	Makati	J-46	1,200	2,000	100	84.48	0.86	0.83
P-149e	J-46	Pasig 2	1,200	1,000	100	103.17	1.06	1.21
P-150e	Pasig 1	J-46	1,200	1,000	100	18.69	0.19	0.05
P-201	Taytay SR	J-2	4,000	2,000	110	1,364.10	1.26	0.34
P-202	J-2	Taytay	4,000	1,200	110	1,364.10	1.26	0.34
P-209e	Pasig 1	Pateros 1	500	2,000	100	-13.37	0.79	1.96
P-210e	Pateros 1	Makati	1,500	2,000	100	180.68	1.18	1.15
P-211e	Makati	J-5	1,200	800	100	3.97	0.04	0.00
P-212e	J-5	J-6	1,300	2,700	100	36.56	0.32	0.12
P-213e	Pateros 1	Pateros 2	1,200	1,200	100	44.86	0.46	0.26
P-214e	Pateros 2	J-5	1,200	2,000	100	92.90	0.95	0.99
P-215e	Pateros 2	Taguig 2	450	4,500	100	2.85	0.21	0.19
P-216e	J-6	Taguig 2	900	2,000	100	-36.98	0.67	0.73
P-217e	Taguig 2	J-8	900	5,600	100	19.79	0.36	0.23
P-219e	Paranaque 5	Paranaque 4	900	1,500	100	74.25	1.35	2.67
P-220e	J-8	Paranaque 4	900	3,000	100	23.39	0.43	0.31
P-221e	Paranaque 4	Paranaque 3	900	3,000	100	47.91	0.87	1.19
P-222e	Paranaque 3	Paranaque 2	450	2,300	100	-1.82	0.13	0.08
P-223e	J-6	Pasay2	650	2,500	100	-7.08	0.25	0.17
P-224e	Pasay2	Paranaque 1	1,050	2,000	100	-26.35	0.35	0.19
P-249e	J-29	Pateros 1	500	300	100	5.60	0.33	0.39

Note: Pipe lavel with e represents the existing primary main.

Table F4.3 Hydraulic Analysis Jubction Result at 9:00 (1,820 MLD)

Label	Elevation (m)	Demand (Ml/d)	Demand Calculated (Ml/d)	Calculated Hydraulic Grade (m)	Residual Pressure (m)
Antipolo	200	86.54	142.79	250.59	50.56
Bacoor 1	5	34.60	57.09	48.47	43.45
Cainta	20	53.37	88.05	61.02	41.00
Cardona	20	0.00	0.00	67.80	47.78
Cavite City	2	34.14	34.14	27.60	25.59
J-1	60	0.00	0.00	83.32	23.31
J-2	5	0.00	0.00	68.23	63.20
J-5	20	73.09	120.60	56.29	36.27
J-6	20	73.09	120.60	53.54	33.52
J-8	10	0.00	0.00	56.57	46.55
J-15	2	0.00	0.00	52.22	50.19
J-17	2	0.00	0.00	43.01	40.99
J-19	5	0.00	0.00	53.00	47.97
J-20	5	0.00	0.00	49.15	44.12
J-22	5	0.00	0.00	52.60	47.58
J-23	5	0.00	0.00	56.97	51.94
J-24	10	0.00	0.00	58.02	47.99
J-25	10	0.00	0.00	56.57	46.55
J-26	20	73.09	120.60	48.35	28.34
J-27	20	73.09	120.60	49.05	29.04
J-28	20	0.00	0.00	60.95	40.92
J-29	10	0.00	0.00	60.80	50.77
J-30	10	0.00	0.00	61.01	50.99
J-31	10	0.00	0.00	61.84	51.81
J-34	15	0.00	0.00	60.95	45.92
J-35	20	56.36	93.00	62.87	42.84
J-36	20	0.00	0.00	60.95	40.92
J-37	20	0.00	0.00	60.98	40.96
J-38	5	0.00	0.00	59.21	54.18
J-39	20	0.00	0.00	57.36	37.34
J-40	10	0.00	0.00	63.62	53.59
J-42	85	86.54	-86.54	46.55	-38.43
J-46	10	0.00	0.00	59.46	49.43
J-48	0	86.54	86.54	83.19	83.14
Kawit	2	25.51	25.51	42.08	40.06
Las Pinas 1	5	105.56	174.17	52.20	47.17
Las Pinas 2	10	105.56	174.17	54.04	44.02
lmus	10	33.65	33.65	42.61	32.59
Makati	30	73.09	120.60	57.36	27.35
Muntinlupa	10	0.60	0.99	58.21	48.19
New WTP	90	1,820.00	-1,820.00	89.01	-0.99
Noveleta	2	9.07	9.07	36.63	34.61
Paranaque 1	5	60.27	99.45	56.81	51.78
Paranaque 2	5	60.27	99.45	52.45	47.43
Paranaque 3	10	60.27	99.45	52.49	42.47
Paranaque 4	10	30.27	49.95	55.52	45.49
Paranaque 5	10	30.00	49.50	57.74	47.72
Pasay2	5	23.36	38.54	55.40	50.37
Pasig 1	20	188.51	311.05	60.37	40.35
Pasig 2	30	0.00	0.00	59.47	29.45
Pateros 1	20	11.32	18.67	60.53	40.51
Pateros 2	20	11.32	18.67	59.87	39.85
Rosario	2	27.13	27.13	30.13	28.12
Taguig 1	5	81.15	133.90	63.81	58.78
Taguig 2	15	81.15	133.90	58.02	43.00
Taytay	10	93.46	154.20	66.84	56.81

Table F4.4 Hydraulic Analysis Pipe Result at 9:00 (1,820 MLD) (1/2)

Label	From Node	To Node	Diameter (mm)	Length (m)	Hazen-Williams C	Discharge (Ml/d)	Velocity (m/s)	Headloss Gradient (m/km)
P-49e	Paranaque 2	J-15	1,100	3,100	100	18.297	0.22	0.08
P-51e	Paranaque 1	Paranaque 2	1,100	2,600	100	97.997	1.19	1.68
P-53e	J-20	J-19	500	700	100	-23.377	1.38	5.5
P-56e	J-17	J-20	600	3,900	100	-19.204	0.79	1.57
P-57e	J-19	Las Pinas 1	500	1,200	100	7.482	0.44	0.67
P-58e	J-20	Bacoor 1	400	1,000	100	4.173	0.38	0.67
P-59e	J-19	Las Pinas 2	500	1,200	100	-8.604	0.51	0.87
P-60e	J-17	Bacoor 2	600	1,000	100	-9.161	0.38	0.4
P-61e	Kawit	J-17	600	1,500	100	-11.617	0.48	0.62
P-62e	Paranaque 2	J-22	500	100	100	-11.609	0.68	1.51
P-63e	J-23	Paranaque 1	500	100	100	12.086	0.71	1.62
P-64e	J-22	J-23	500	2,900	100	-11.609	0.68	1.51
P-65e	J-24	J-25	450	4,500	100	3.817	0.28	0.32
P-66e	Taguig 2	J-24	450	1	110	3.817	0.28	0.27
P-67	Taytay	Taguig 1	3,400	7,500	110	974.009	1.24	0.4
P-67e	J-25	J-8	450	1	100	3.817	0.28	0.33
P-68e	J-26	J-6	400	2,500	100	-7.667	0.71	2.07
P-69e	J-27	J-26	600	1,500	100	9.915	0.41	0.46
P-70	Las Pinas 2	J-39	2,800	7,000	110	-637.297	1.2	0.47
P-70e	J-27	Makati	750	2,000	100	-58.407	1.53	4.16
P-71	J-39	Muntinlupa	2,800	1,800	110	-637.297	1.2	0.47
P-72	J-38	Muntinlupa	2,800	2,100	110	638.287	1.2	0.48
P-73	J-40	Taytay	3,400	3,500	110	-1,519.16	1.94	0.92
P-74	J-29	J-40	3,200	5,500	110	-945.354	1.36	0.51
P-74e	J-28	J-29	2,100	1,500	100	116.332	0.39	0.1
P-75	J-40	J-35	1,500	700	110	192.141	1.26	1.08
P-75e	J-29	J-30	1,050	2,000	100	-19.633	0.26	0.11
P-76	Cavite City	Noveleta	700	5,000	110	-34.14	1.03	1.81
P-76e	J-30	J-31	750	1,500	100	-19.633	0.51	0.55
P-77	Rosario	Noveleta	600	2,600	110	-27.13	1.11	2.5
P-77e	J-31	Taguig 1	600	1,200	100	-19.633	0.8	1.64
P-78	Noveleta	Kawit	1,000	4,500	110	-70.34	1.04	1.21
P-78e	Pasig 1	J-28	1,200	2,500	100	-41.98	0.43	0.23
P-79	Kawit	lmus	500	2,000	110	-5	0.29	0.27
P-80	J-15	Las Pinas 1	1,200	500	110	18.297	0.19	0.04
P-82	J-28	J-40	2,200	4,500	110	-381.665	1.16	0.59
P-84	Taguig 1	J-38	3,000	8,500	110	820.479	1.34	0.54
P-86	Paranaque 5	J-38	1,500	1,500	110	-182.192	1.19	0.98
P-87	Pasig 1	J-28	2,200	2,500	110	-227.722	0.69	0.23
P-88	Pateros 1	Pasig 1	2,200	2,000	110	127.854	0.39	0.08
P-89	Pateros 2	Pateros 1	2,600	1,200	110	-568.527	1.24	0.55
P-90	Taguig 2	Pateros 2	2,600	4,500	110	-485.361	1.06	0.41
P-91	J-23	Taguig 2	2,200	3,500	110	-263.398	0.8	0.3
P-92	Bacoor 2	Bacoor 1	1,350	2,000	110	-230.968	1.87	2.53
P-93	Bacoor 1	Las Pinas 2	1,350	1,500	110	-283.886	2.3	3.71
P-96	Paranaque 1	J-23	1,500	100	110	-239.703	1.57	1.62
P-97	Pateros 1	J-29	3,000	300	110	-1,072.60	1.76	0.89
P-98	J-26	J-6	900	2,500	110	-71.306	1.3	2.07
P-99	J-26	J-27	900	1,500	110	-31.714	0.58	0.46
P-100	New WTP	CWR	5,000	100	110	1,800.00	1.06	0.19
P-100e	J-34	J-28	2,100	1,100	100	4.37	0.01	2.28E-04
P-101	CWR	J-1	3,400	4,500	110	1,801.00	2.3	1.26
P-101e	J-34	Cainta	600	3,000	100	-1.981	0.08	0.02
P-102e	Cainta	J-35	600	1,200	100	-18.99	0.78	1.54
P-103e	J-36	J-34	2,200	1,500	100	0.75	2.28E-03	6.20E-06

Table F4.4 Hydraulic Analysis Pipe Result at 9:00 (1,820 MLD) (2/2)

Label	From Node	To Node	Diameter (mm)	Length (m)	Hazen-Williams C	Discharge (Ml/d)	Velocity (m/s)	Headloss Gradient (m/km)
P-104	PMP-1	PSV-2	1,600	2,200	110	86.54	0.5	0.18
P-104e	J-36	J-37	400	1,100	100	-0.75	0.07	0.03
P-105	PSV-2	Antipolo SR	1,600	10	110	86.54	0.5	0.18
P-105e	J-37	Cainta	450	2,500	100	-0.75	0.05	0.02
P-106	Antipolo SR	Antipolo	1,000	1,700	110	142.791	2.1	4.49
P-107	J-1	FCV-1	3,400	5,500	110	1,711.79	2.18	1.15
P-108	FCV-1	PSV-1	3,400	40	110	1,711.79	2.18	1.15
P-109	PSV-1	Taytay SR	3,400	10	110	1,711.79	2.18	1.15
P-110	J-27	Makati	900	2,000	110	-103.824	1.89	4.16
P-111	Makati	Pateros 1	1,000	2,000	110	-81.354	1.2	1.58
P-112	Kawit	J-17	1,200	1,500	110	-79.234	0.81	0.62
P-113	J-17	Bacoor 2	1,200	1,000	110	-62.485	0.64	0.4
P-114	Paranaque 2	Paranaque 3	1,000	2,300	110	-7.328	0.11	0.02
P-115	Paranaque 3	Paranaque 4	1,000	3,000	110	-63.706	0.94	1.01
P-116	Paranaque 4	Paranaque 5	1,000	1,500	110	-78.567	1.16	1.49
P-117	PMP-1	J-42	2,000	6,800	110	-86.54	0.32	0.06
P-134	Las Pinas 2	J-19	1,500	1,200	110	170.642	1.12	0.87
P-135	J-19	Las Pinas 1	1,500	1,200	110	148.387	0.97	0.67
P-138	Bacoor 2	lmus	1,000	2,000	110	38.65	0.57	0.4
P-144e	Pasig 2	J-34	500	2,700	100	-6.72	0.4	0.55
P-145	J-34	Cainta	1,000	3,000	110	-8.359	0.12	0.02
P-146	J-35	Cainta	1,000	1,200	110	80.152	1.18	1.54
P-147	J-1	Teresa	300	500	110	2.67	0.44	1
P-148	J-48	J-1	2,000	2,200	110	-86.54	0.32	0.06
P-148e	Makati	J-46	1,200	2,000	100	-95.583	0.98	1.05
P-149e	J-46	Pasig 2	1,200	1,000	100	-6.72	0.07	0.01
P-150e	Pasig 1	J-46	1,200	1,000	100	88.862	0.91	0.92
P-201	Taytay SR	J-2	4,000	2,000	110	2,690.76	2.48	1.2
P-202	J-2	Taytay	4,000	1,200	110	2,647.37	2.44	1.16
P-209e	Pasig 1	Pateros 1	500	2,000	100	-2.352	0.14	0.08
P-210e	Pateros 1	Makati	1,500	2,000	100	215.047	1.41	1.58
P-211e	Makati	J-5	1,200	800	100	109.15	1.12	1.34
P-212e	J-5	J-6	1,300	2,700	100	116.201	1.01	1.02
P-213e	Pateros 1	Pateros 2	1,200	1,200	100	67.516	0.69	0.55
P-214e	Pateros 2	J-5	1,200	2,000	100	127.653	1.31	1.79
P-215e	Pateros 2	Taguig 2	450	4,500	100	4.359	0.32	0.41
P-216e	J-6	Taguig 2	900	2,000	100	-67.576	1.23	2.24
P-217e	Taguig 2	J-8	900	5,600	100	21.032	0.38	0.26
P-219e	Paranaque 5	Paranaque 4	900	1,500	100	54.125	0.98	1.49
P-220e	J-8	Paranaque 4	900	3,000	100	24.849	0.45	0.35
P-221e	Paranaque 4	Paranaque 3	900	3,000	100	43.887	0.8	1.01
P-222e	Paranaque 3	Paranaque 2	450	2,300	100	0.814	0.06	0.02
P-223e	J-6	Pasay2	650	2,500	100	-15.798	0.55	0.74
P-224e	Pasay2	Paranaque 1	1,050	2,000	100	-54.342	0.73	0.71
P-249e	J-29	Pateros 1	500	300	100	8.722	0.51	0.89
P-301	J-2	Angono	1,500	800	110	43.39	0.28	0.07
P-302	Angono	Binangonan	1,350	6,600	110	29.7	0.24	0.06

Note: Pipe lavel with e represents the existing primary main

Table F4.5 Hydraulic Analysis Jubction Result at 9:00 (3,640 MLD)

Label	Elevation (m)	Demand (Ml/d)	Demand (Calculated) (Ml/d)	Calculated Hydraulic Grade (m)	Pressure (m)
Angono	10	51.01	51.01	67.43	57.40
Antipolo	200	684.25	1,129.01	255.62	55.59
Bacoor 1	5	73.14	120.67	30.83	25.81
Baras	5	7.65	7.65	45.27	40.24
Binangonan	10	89.59	89.59	58.76	48.73
Cainta	20	125.17	206.52	58.35	38.33
Cardona	20	7.97	7.97	51.99	31.98
Cavite City	2	33.06	33.06	9.91	7.91
J-1	60	0.00	0.00	83.20	23.19
J-2	5	0.00	0.00	68.47	63.44
J-5	20	85.29	140.73	51.58	31.57
J-6	20	85.29	140.73	47.47	27.46
J-8	10	0.00	0.00	46.14	36.12
J-15	2	0.00	0.00	33.46	31.44
J-17	2	0.00	0.00	27.07	25.06
J-19	5	0.00	0.00	34.28	29.26
J-20	5	0.00	0.00	31.43	26.41
J-22	5	0.00	0.00	39.10	34.09
J-23	5	0.00	0.00	50.78	45.76
J-24	10	0.00	0.00	52.40	42.38
J-25	10	0.00	0.00	46.14	36.12
J-26	20	85.29	140.73	40.77	20.76
J-27	20	85.29	140.73	41.74	21.73
J-28	20	0.00	0.00	59.34	39.32
J-29	10	0.00	0.00	59.11	49.09
J-30	10	0.00	0.00	59.09	49.06
J-31	10	0.00	0.00	59.00	48.97
J-34	15	0.00	0.00	59.31	44.29
J-35	20	125.17	206.52	62.89	42.87
J-36	20	0.00	0.00	59.31	39.29
J-37	20	0.00	0.00	58.89	38.87
J-38	5	46.66	76.99	46.70	41.68
J-39	20	46.67	77.01	42.22	22.21
J-40	10	0.00	0.00	65.40	55.37
J-42	85	684.25	-684.25	75.42	-9.58
J-46	10	0.00	0.00	53.62	43.60
J-48	0	684.25	684.25	77.08	77.04
Jala-Jala	5	6.06	6.06	16.32	11.32
Kawit	2	27.21	27.21	25.79	23.78
Las Pinas 1	5	181.58	299.61	32.99	27.98
Las Pinas 2	10	181.58	299.61	35.81	25.80
lmus	10	57.31	57.31	25.92	15.91
Makati	30	85.29	140.73	52.95	22.94
Morong	10	8.61	8.61	47.16	37.14
Muntinlupa	10	46.67	77.01	44.14	34.12
New WTP	90	3,640.00	-3,640.00	88.96	-1.04
Noveleta	2	13.82	13.82	18.42	16.41
Paranaque 1	5	58.58	96.65	50.53	45.51
Paranaque 2	5	58.58	96.65	38.70	33.68
Paranaque 3	10	58.58	96.65	38.74	28.72
Paranaque 4	10	58.58	96.65	41.57	31.55
Paranaque 5	10	58.58	96.65	44.22	34.20
Pasay2	5	19.87	32.79	49.38	44.35
Pasig 1	20	216.69	357.53	58.25	38.23
Pasig 2	30	108.34	178.77	50.86	20.85
Pateros 1	20	11.52	19.01	58.56	38.54
Pateros 2	20	11.52	19.01	57.07	37.05
Pililla	5	11.80	11.80	39.39	34.38
Rosario	2	35.98	35.98	7.46	5.46
Taguig 1	5	211.35	348.72	58.78	53.75
Taguig 2	15	211.35	348.72	52.40	37.38
Tanay	5	30.29	30.29	42.62	37.60
Taytay	10	116.76	192.65	67.51	57.48
Teresa	60	8.93	8.93	78.52	18.51

Table F4.6 Hydraulic Analysis Pipe Result at 9:00 (3,640 MLD) (1/2)

Label	From Node	To Node	Diameter (mm)	Length (m)	Hazen-Williams C	Discharge (Ml/d)	Velocity (m/s)	Headloss Gradient (m/km)
P-49e	Paranaque 2	J-15	1,100	3,100	100	98.48	1.20	1.69
P-51e	Paranaque 1	Paranaque 2	1,100	2,600	100	168.14	2.05	4.55
P-53e	J-20	J-19	500	700	100	-19.87	1.17	4.07
P-56e	J-17	J-20	600	3,900	100	-15.95	0.65	1.12
P-57e	J-19	Las Pinas 1	500	1,200	100	9.66	0.57	1.07
P-58e	J-20	Bacoor 1	400	1,000	100	3.92	0.36	0.60
P-59e	J-19	Las Pinas 2	500	1,200	100	-10.61	0.63	1.28
P-60e	J-17	Bacoor 2	600	1,000	100	-11.74	0.48	0.63
P-61e	Kawit	J-17	600	1,500	100	-13.78	0.56	0.85
P-62e	Paranaque 2	J-22	500	100	100	-19.75	1.16	4.03
P-63e	J-23	Paranaque 1	500	100	100	15.05	0.89	2.44
P-64e	J-22	J-23	500	2,900	100	-19.75	1.16	4.03
P-65e	J-24	J-25	450	4,500	100	8.43	0.61	1.39
P-66e	Taguig 2	J-24	450	1	110	8.43	0.61	1.17
P-67	Taytay	Taguig 1	3,400	7,500	110	1,725.57	2.20	1.16
P-67e	J-25	J-8	450	1	100	8.43	0.61	1.40
P-68e	J-26	J-6	400	2,500	100	-8.81	0.81	2.68
P-69e	J-27	J-26	600	1,500	100	11.90	0.49	0.65
P-70	Las Pinas 2	J-39	2,800	7,000	110	-909.47	1.71	0.92
P-70e	J-27	Makati	750	2,000	100	-68.65	1.80	5.60
P-71	J-39	Muntinlupa	2,800	1,800	110	-986.47	1.85	1.06
P-72	J-38	Muntinlupa	2,800	2,100	110	1,063.48	2.00	1.22
P-73	J-40	Taytay	3,400	3,500	110	-1,208.92	1.54	0.60
P-74	J-29	J-40	3,200	5,500	110	-1,456.84	2.10	1.14
P-74e	J-28	J-29	2,100	1,500	100	148.09	0.49	0.15
P-75	J-40	J-35	1,500	700	110	367.60	2.41	3.58
P-75e	J-29	J-30	1,050	2,000	100	5.97	0.08	0.01
P-76	Cavite City	Noveleta	700	5,000	110	-33.06	0.99	1.70
P-76e	J-30	J-31	750	1,500	100	5.97	0.16	0.06
P-77	Rosario	Noveleta	600	2,600	110	-35.98	1.47	4.22
P-77e	J-31	Taguig 1	600	1,200	100	5.97	0.24	0.18
P-78	Noveleta	Kawit	1,000	4,500	110	-82.86	1.22	1.64
P-78e	Pasig 1	J-28	1,200	2,500	100	-59.56	0.61	0.44
P-79	Kawit	lmus	500	2,000	110	-2.31	0.14	0.06
P-80	J-15	Las Pinas 1	1,200	500	110	98.48	1.01	0.93
P-82	J-28	J-40	2,200	4,500	110	-593.39	1.81	1.35
P-84	Taguig 1	J-38	3,000	8,500	110	1,382.81	2.26	1.42
P-86	Paranaque 5	J-38	1,500	1,500	110	-242.35	1.59	1.66
P-87	Pasig 1	J-28	2,200	2,500	110	-323.06	0.98	0.44
P-88	Pateros 1	Pasig 1	2,200	2,000	110	184.88	0.56	0.16
P-89	Pateros 2	Pateros 1	2,600	1,200	110	-882.96	1.92	1.24
P-90	Taguig 2	Pateros 2	2,600	4,500	110	-800.82	1.75	1.04
P-91	J-23	Taguig 2	2,200	3,500	110	-333.33	1.01	0.46
P-92	Bacoor 2	Bacoor 1	1,350	2,000	110	-177.82	1.44	1.56
P-93	Bacoor 1	Las Pinas 2	1,350	1,500	110	-267.47	2.16	3.32
P-96	Paranaque 1	J-23	1,500	100	110	-298.53	1.96	2.44
P-97	Pateros 1	J-29	3,000	300	110	-1,586.08	2.60	1.83
P-98	J-26	J-6	900	2,500	110	-81.96	1.49	2.68
P-99	J-26	J-27	900	1,500	110	-38.05	0.69	0.65
P-100	New WTP	CWR	5,000	100	110	3,600.00	2.12	0.69
P-100e	J-34	J-28	2,100	1,100	100	-62.68	0.21	0.03
P-101	CWR	J-1	3,400	4,500	110	1,804.47	2.30	1.26
P-101e	J-34	Cainta	600	3,000	100	8.12	0.33	0.32
P-102e	Cainta	J-35	600	1,200	100	-30.85	1.26	3.78
P-103e	J-36	J-34	2,200	1,500	100	-3.07	0.01	0.00
P-104	PMP-1	PSV-2	1,600	2,200	110	342.70	1.97	2.30
P-104e	J-36	J-37	400	1,100	100	3.07	0.28	0.38
P-105	PSV-2	Antipolo SR	1,600	10	110	342.70	1.97	2.30
P-105e	J-37	Cainta	450	2,500	100	3.07	0.22	0.22
P-106	Antipolo SR	Antipolo	1,000	1,700	110	91.57	1.35	1.97
P-107	J-1	FCV-1	3,400	5,500	110	1,457.88	1.86	0.85
P-108	FCV-1	PSV-1	3,400	40	110	1,457.88	1.86	0.85
P-109	PSV-1	Taytay SR	3,400	10	110	1,457.88	1.86	0.85
P-110	J-27	Makati	900	2,000	110	-122.03	2.22	5.60

Table F4.6 Hydraulic Analysis Pipe Result at 9:00 (3,640 MLD) (2/2)

Label	From Node	To Node	Diameter (mm)	Length (m)	Hazen-Williams C	Discharge (Ml/d)	Velocity (m/s)	Headloss Gradient (m/km)
P-111	Makati	Pateros 1	1,000	2,000	110	-110.85	1.63	2.81
P-112	Kawit	J-17	1,200	1,500	110	-93.98	0.96	0.85
P-113	J-17	Bacoor 2	1,200	1,000	110	-80.07	0.82	0.63
P-114	Paranaque 2	Paranaque 3	1,000	2,300	110	-6.52	0.10	0.01
P-115	Paranaque 3	Paranaque 4	1,000	3,000	110	-61.52	0.91	0.94
P-116	Paranaque 4	Paranaque 5	1,000	1,500	110	-86.27	1.27	1.77
P-117	PMP-1	J-42	2,000	6,800	110	-342.70	1.26	0.77
P-118a	CWR	J-1	3,400	4,500	110	1,804.47	2.30	1.26
P-119a	Taytay SR	J-2	4,000	2,000	110	2,274.52	2.09	0.88
P-120a	J-1	FCV-2	3,400	5,500	110	1,457.88	1.86	0.85
P-121a	FCV-2	PSV-3	3,400	40	110	1,457.88	1.86	0.85
P-122a	PSV-3	Taytay SR	3,400	10	110	1,457.88	1.86	0.85
P-123a	J-2	Taytay	4,000	1,200	110	2,168.03	2.00	0.80
P-124a	Taytay	J-40	3,400	3,500	110	1,208.92	1.54	0.60
P-134	Las Pinas 2	J-19	1,500	1,200	110	210.40	1.38	1.28
P-135	J-19	Las Pinas 1	1,500	1,200	110	191.48	1.25	1.07
P-136a	Las Pinas 2	Bacoor 1	1,000	1,500	110	121.39	1.79	3.32
P-137a	Bacoor 1	Bacoor 2	1,000	1,500	110	94.28	1.39	2.08
P-138	Bacoor 2	lmus	1,000	2,000	110	59.62	0.88	0.89
P-141a	J-42	PMP-2	2,000	6,800	110	341.55	1.26	0.77
P-142a	PMP-2	PSV-4	1,600	2,200	110	341.55	1.97	2.28
P-143a	PSV-4	Antipolo SR	1,600	10	110	341.55	1.97	2.28
P-144a	Antipolo SR	Antipolo	2,600	2,000	110	1,037.45	2.26	1.68
P-144e	Pasig 2	J-34	500	2,700	100	-17.24	1.02	3.13
P-145	J-34	Cainta	1,000	3,000	110	34.25	0.50	0.32
P-146	J-35	Cainta	1,000	1,200	110	130.23	1.92	3.78
P-147	J-1	Teresa	300	500	110	8.93	1.46	9.36
P-148	J-48	J-1	2,000	2,200	110	-684.25	2.52	2.78
P-148e	Makati	J-46	1,200	2,000	100	-51.84	0.53	0.34
P-149e	J-46	Pasig 2	1,200	1,000	100	161.53	1.65	2.77
P-150e	Pasig 1	J-46	1,200	1,000	100	213.37	2.18	4.63
P-201	Taytay SR	J-2	4,000	2,000	110	2,274.52	2.09	0.88
P-202	J-2	Taytay	4,000	1,200	110	2,168.03	2.00	0.80
P-209e	Pasig 1	Pateros 1	500	2,000	100	-3.40	0.20	0.16
P-210e	Pateros 1	Makati	1,500	2,000	100	293.01	1.92	2.81
P-211e	Makati	J-5	1,200	800	100	124.30	1.27	1.70
P-212e	J-5	J-6	1,300	2,700	100	144.37	1.26	1.52
P-213e	Pateros 1	Pateros 2	1,200	1,200	100	104.86	1.07	1.24
P-214e	Pateros 2	J-5	1,200	2,000	100	160.80	1.65	2.74
P-215e	Pateros 2	Taguig 2	450	4,500	100	7.19	0.52	1.04
P-216e	J-6	Taguig 2	900	2,000	100	-71.12	1.29	2.46
P-217e	Taguig 2	J-8	900	5,600	100	46.42	0.84	1.12
P-219e	Paranaque 5	Paranaque 4	900	1,500	100	59.43	1.08	1.77
P-220e	J-8	Paranaque 4	900	3,000	100	54.85	1.00	1.52
P-221e	Paranaque 4	Paranaque 3	900	3,000	100	42.38	0.77	0.94
P-222e	Paranaque 3	Paranaque 2	450	2,300	100	0.72	0.05	0.01
P-223e	J-6	Pasay2	650	2,500	100	-16.01	0.56	0.76
P-224e	Pasay2	Paranaque 1	1,050	2,000	100	-48.79	0.65	0.58
P-249e	J-29	Pateros 1	500	300	100	12.90	0.76	1.83
P-301	J-2	Angono	1,500	800	110	212.98	1.39	1.30
P-302	Angono	Binangonan	1,350	6,600	110	161.97	1.31	1.31
P-303	Binangonan	Cardona	1,000	5,300	110	72.38	1.07	1.28
P-304	Cardona	Morong	1,000	4,700	110	64.41	0.95	1.03
P-305	Morong	Baras	1,000	2,400	110	55.80	0.82	0.79
P-306	Baras	Tanay	1,000	4,400	110	48.15	0.71	0.60
P-307	Tanay	Pililla	600	2,800	110	17.86	0.73	1.15
P-308	Pililla	Jala-Jala	350	10,700	110	6.06	0.73	2.16

Note: Pipe lavel with e and a represents the existing and additional primary main, respectively.

Table F4.7 Staged Implementation Plan of Primary Distribution Main

Pipe Diameter (mm)	1st Stage (for 900 MLD)		2nd Stage (for 1,800 MLD)		3rd Stage (for 3,600 MLD)		Total	
	Length (m)	Cost (x 1,000 Pesos)	Length (m)	Cost (x 1,000 Pesos)	Length (m)	Cost (x 1,000 Pesos)	Length (m)	Cost (x 1,000 Pesos)
4,000	3,200	732,800		0	3,200	732,800	6,400	1,465,600
3,400	11,000	1,980,000		0	13,500	2,430,000	24,500	4,410,000
3,200	5,500	907,500		0		0	5,500	907,500
3,000	8,800	1,240,800		0		0	8,800	1,240,800
2,800	10,900	1,308,000		0		0	10,900	1,308,000
2,600	5,700	615,600		0		0	5,700	615,600
2,400		0		0		0	0	0
2,200	8,000	640,000	4,500	360,000		0	12,500	1,000,000
2,000		0		0		0	0	0
1,500	4,700	225,600	2,400	115,200	800	38,400	7,900	379,200
1,350	3,500	143,500		0	6,600	270,600	10,100	414,100
1,200		0	2,500	87,500		0	2,500	87,500
1,000	8,500	221,000	11,000	286,000	19,800	514,800	39,300	1,021,800
900		0	6,000	138,000		0	6,000	138,000
800		0		0		0	0	0
700	5,000	85,000		0		0	5,000	85,000
600	2,600	31,200		0	2,800	33,600	5,400	64,800
500	4,700	47,000		0		0	4,700	47,000
250		0		0		0	0	0
Total	82,100	8,178,000	26,400	986,700	46,700	4,020,200	155,200	13,184,900

Note: Cost of pipelaying includes material, laying and cutting/breaking/restoration of of concrete pavement (250 mm of thickness).

Figures

Summary of Development Scenarios

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

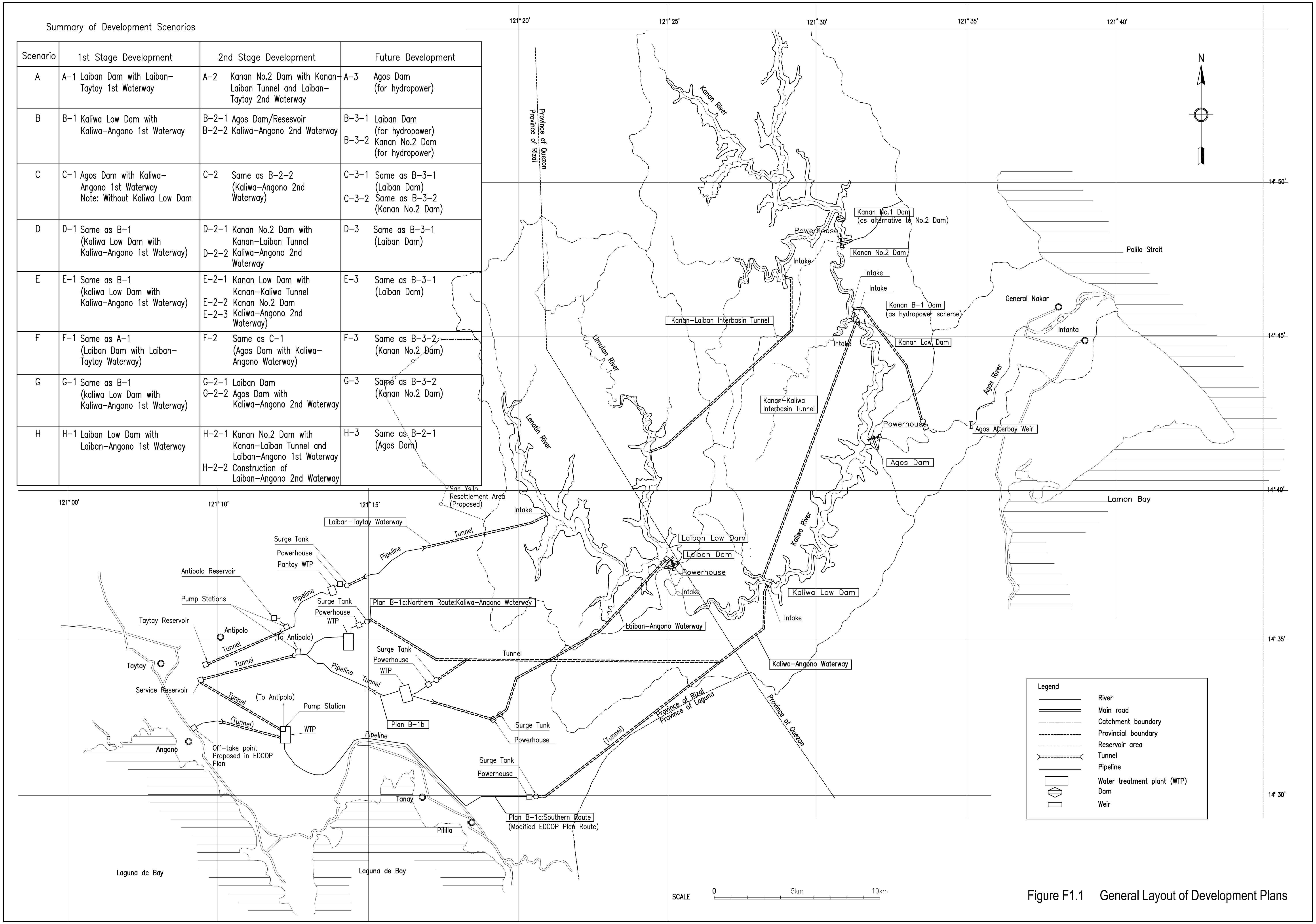
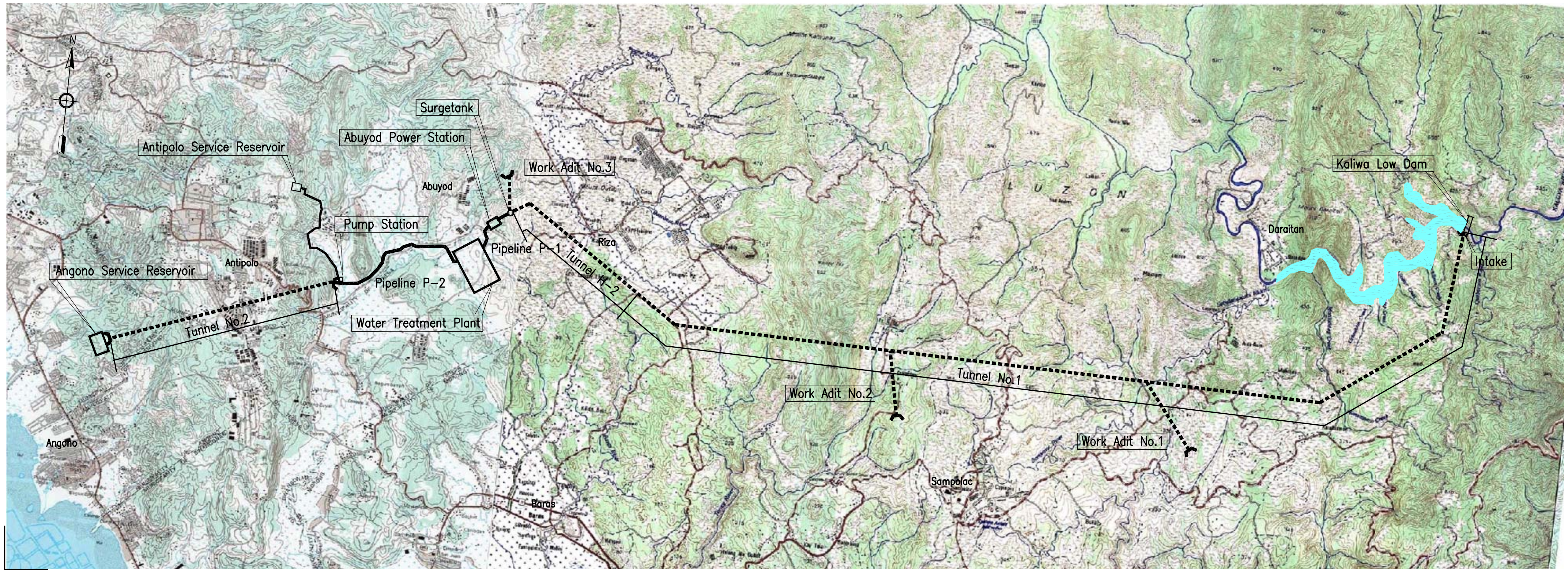
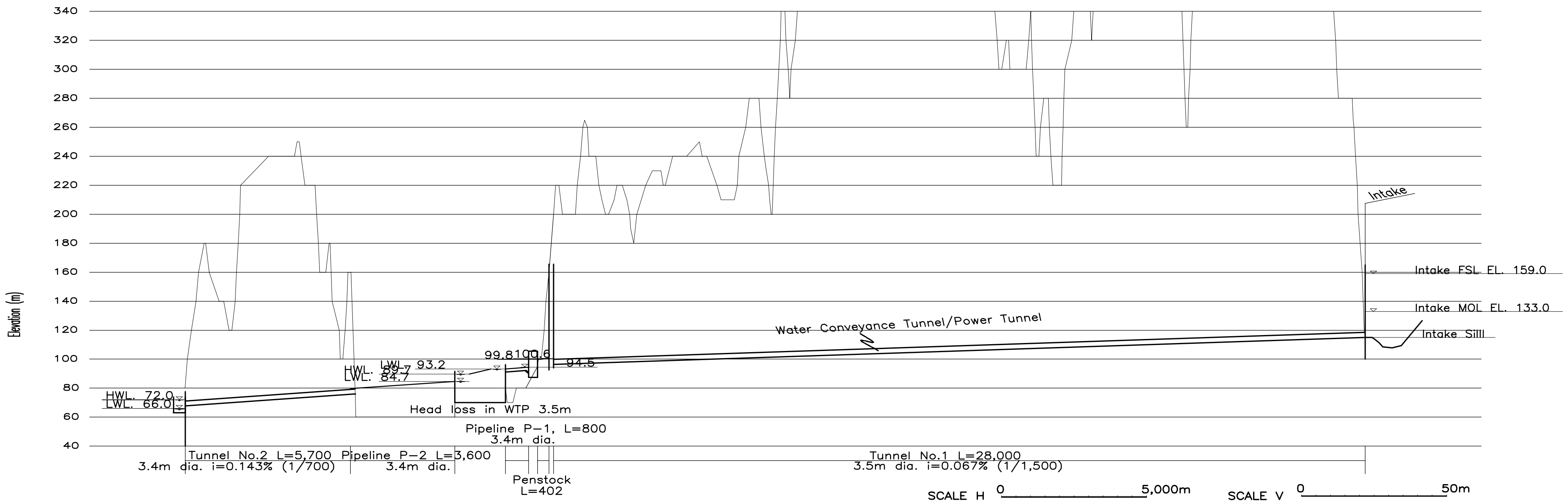


Figure F1.1 General Layout of Development Plans



General Layout of Selected Kaliwa–Angono Water Conveyance Route



Profile of Selected Kaliwa–Angono Water Conveyance Route

Figure F2.1 General Layout and Profile of Selected Kaliwa-Angono Water Conveyance Route

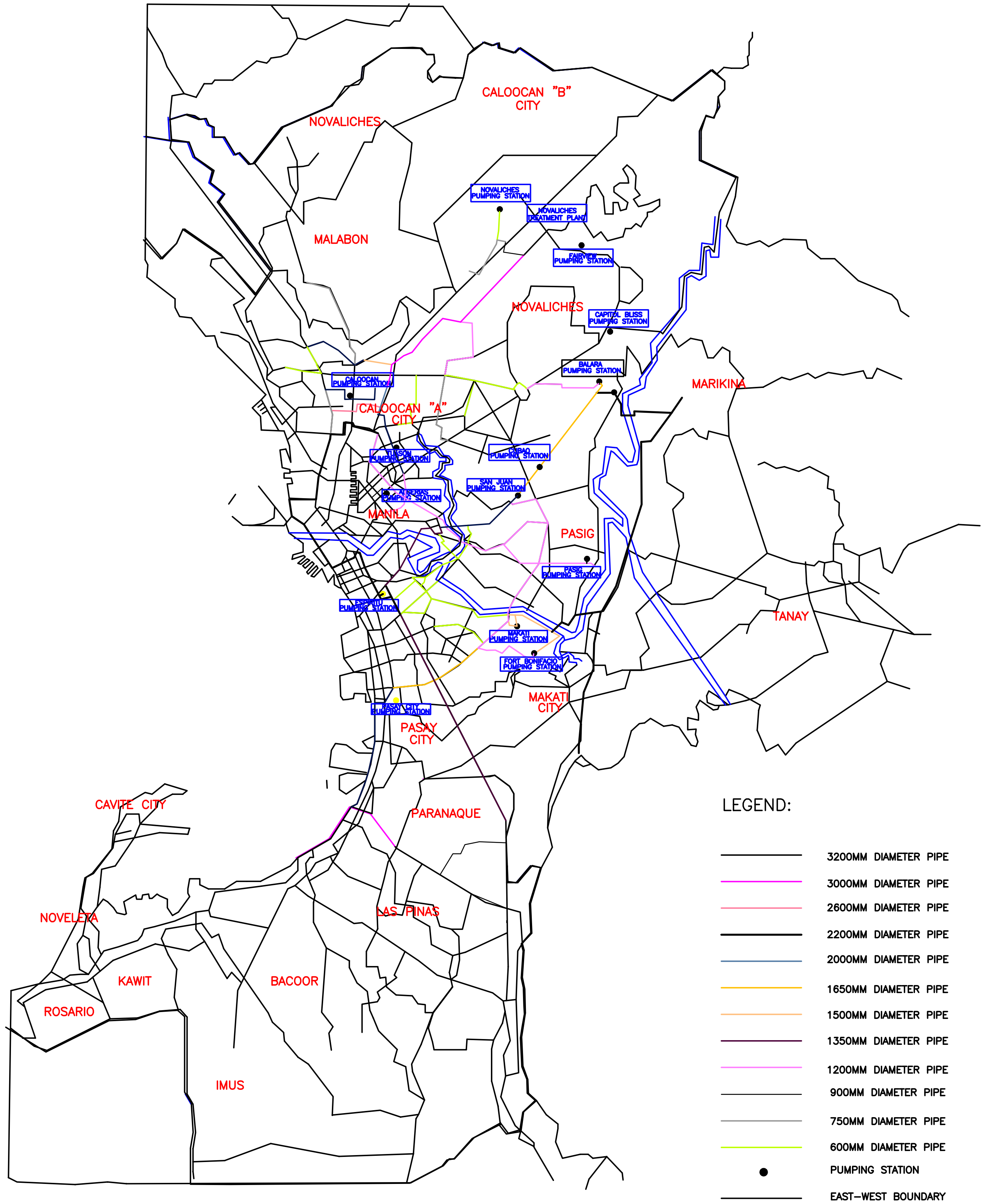


Figure F4.1 Existing Distribution Primary Main

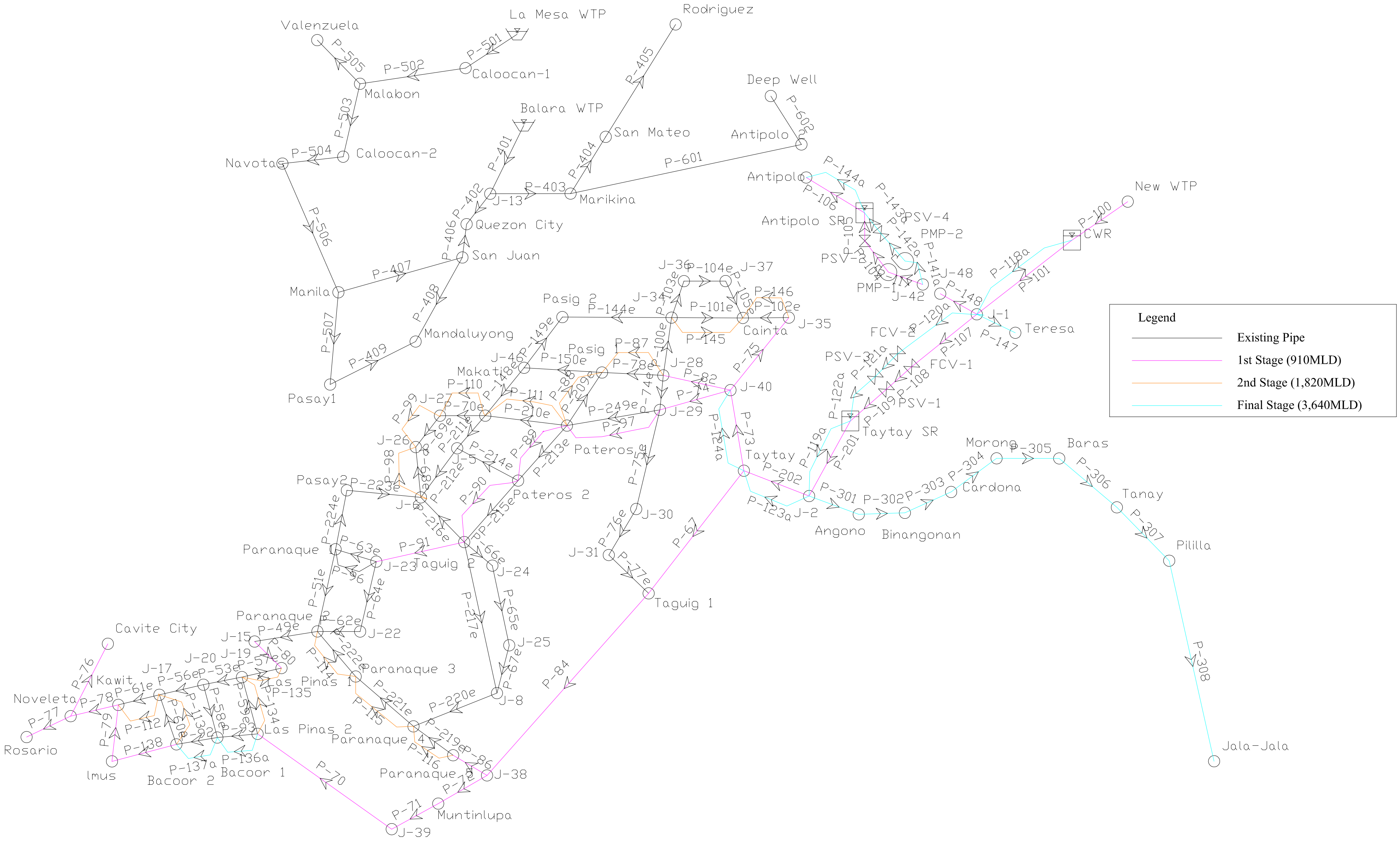


Figure F4.2 Staged Layout Plan of Distribution Primary Mains