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TECHNICAL FEASIBILITY STUDY FOR PDAM KOTA BANDUNG

CIMENTENG WATER SUPPLY SYSTEM

DECEMBER 2006

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TECHNICAL FEASIBILITY STUDY FOR PDAM KOTA BANDUNG

CIMENTENG WATER SUPPLY SYSTEM

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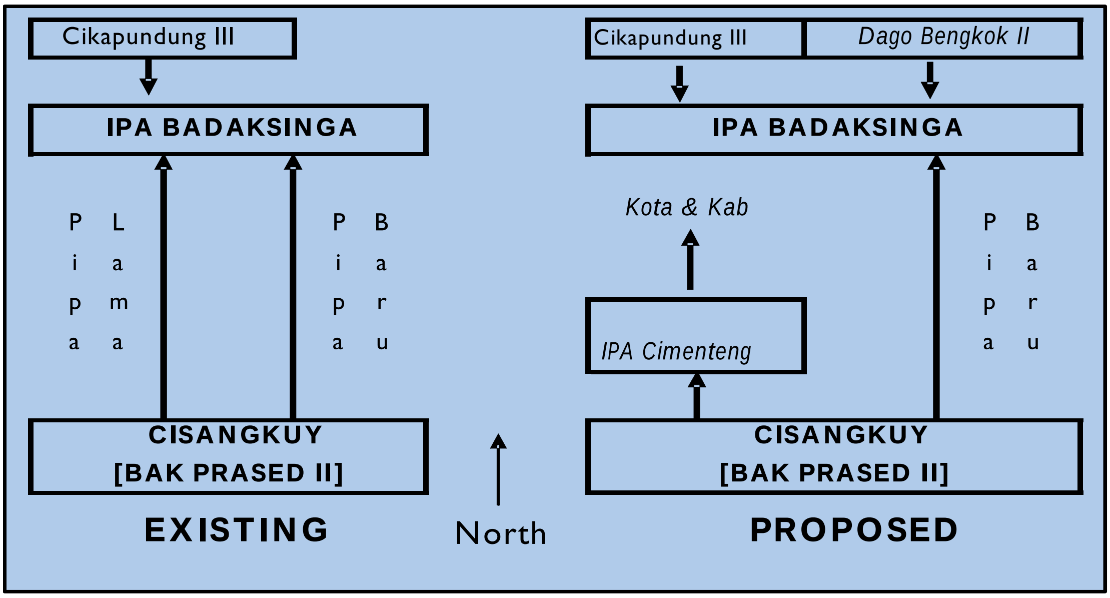
AMDAL	Analisa Mengenai Dampak Lingkungan (Environmental Impact Review)
ASL	Above Sea Level
BAPPEDA	Badan Perencanaan Pembangunan Daerah (Regional Planning Board)
BPS	Badan Pusat Statistik Statistics Bureau
DED	Detailed Engineering Design
EPANET	Computer software program for hydraulic analysis
FS	Feasibility Studies
HC	House Connection
IPA	Instalasi Pergolahan Air (Water Treatment Plant)
Kabupaten	District; administrative subdivision of a Province
Kecamatan	Administrative subdivision of a Kotamadya
Kelurahan	Administrative subdivision of a Kecamatan
km	Kilometer = 1000 meters = 0.6 mile
Kota	City; administrative subdivision of a Province
Kran Umum	Public Tap
L/sec	Liters per second
m	meter = 1000 millimeters (mm)
m^3	cubic meters = 1000 Liters (L)
Niaga	Commercial customer
O&M	Operations and Maintenance
PDAM	Perusahan Daerah Air Minum
PED	Preliminary Engineering Design
PSDA	Pengembangan Sumber Daya Air (Water Resources Development)
PLTA	Pembangkit Listrik Tenaga Air (Hydro-electric Power Plant)
PU	Pekerjaan Umum (Department of Public Works)
Rp	Rupiah (currency of Indonesia)
Wilayah	Region

EXECUTIVE SUMMARY

PDAM Kota Bandung proposes to reorganize the water supply system from Sungai Cisangkuy by changing the existing Pipa Lama 900 mm transmission pipeline to deliver water to the southern area of Kota Bandung (950 L/s) and to Kabupaten Bandung (150 L/s). The existing Pipa Baru 850 mm would remain unchanged and continue to deliver water to IPA Badaksinga.

Currently the Pipa Lama delivers water (estimated to be 660 L/s) to IPA Badaksinga where it is treated before distribution to the service area. Thus implementing this proposal would require a water treatment facility for the Cisangkuy water and a replacement water supply for IPA Badaksinga. Therefore the proposed project also includes:

1. Constructing IPA Cimenteng (1100 L/s) at a location about 4 kilometers from the water source (Sungai Cisangkuy) to treat the water
2. Constructing transmission pipelines from PLTA Dago Bengkok II to deliver 600 L/s from the Sungai Cikapundung to IPA Badaksinga.



To evaluate this proposal Consultant used EPANET computer software program for hydraulic analysis and results show the proposal to be technically feasible. Flow can be by gravity if the outlet of the clearwell of the new treatment plant is at or above elevation 790 meters. During Detailed Engineering Design data about flows and elevations should be verified and minor hydraulic losses estimated.

Risks include inability to deliver full volume of water to IPA Badaksinga from Pipa Baru due to water losses and reduced hydraulic capacity; and from Dago Bengkok because of water shortages during the dry season.

This scheme adds 1,000 L/s to the PDAM water supply, sufficient to serve 130,000 houses. However taking into consideration water lost (about 40%) and water to serve non-domestic customers, the number of houses that can be served is about 62,000.

1. INTRODUCTION

1.1. OBJECTIVES OF THIS STUDY

PDAM Kota Bandung requested assistance from the USAID Environmental Services Program (ESP) to do a technical study of a proposal to take water from the Cisangkuy River, treat it at a location in Cimenteng area; and send the water to the southern area of Kota Bandung between Jalan Tol Padalarang Cileunyi and Jalan Soekarno Hatta.

This Technical Study starts with a description of the proposed project including other facilities needed for implementation; next it analyzes the proposal in terms of hydraulics and water demand through year 2015; and then recommends a course of action for the PDAM.

Figure 1 Proposed Cimenteng Water Supply

1.2. METHODOLOGY

ESP-Jakarta provided a two-person-technical study team (International Water Supply Engineer and Local PDAM Water Supply Engineer) that mobilized 20 February 2006 to Kota Bandung. Based on discussion with PDAM staff the methodology shown below was used.

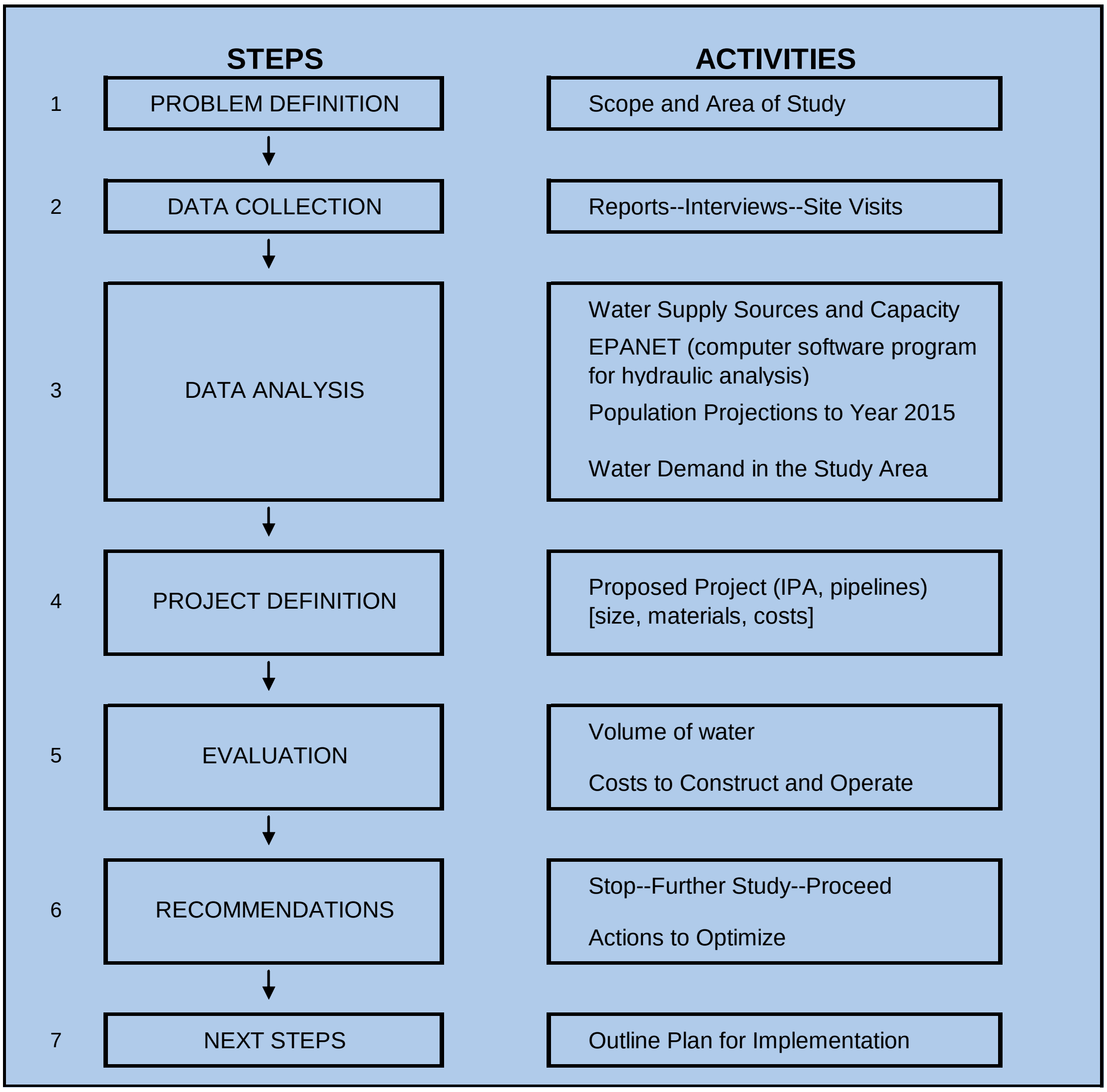


Figure 2 Study Methodology

2. PROPOSAL FOR EVALUATION

PDAM Kota Bandung withdraws water from the Sungai Cisangkuy at the PLN Hydroelectric Plant and transports it by gravity flow through two transmission pipelines (Pipa Baru and PIpa Lama) to IPA Badaksinga where it is blended with water from the Sungai Cikapundung, treated, then distributed to Service Zones designated West, Central-South, and East. PDAM has approval to extract 1,800 L/s from Sungai Cisangkuy.

<u>The specific proposal being evaluated is as follows:</u>
Change the Pipa Lama transmission pipeline to deliver source water to a new IPA named Cimenteng (1100 L/s) and then transport the treated water by pipeline from this new IPA to Kabupaten Bandung (150 L/s), and to the southern area of Kota Bandung (950 L/s) where some of the water (200 L/s) will be delivered to <u>Gedebage</u>, a planned development[1] by a private sector company as a Kota Mandiri (self-sufficient). Suggestions to PDAM about this service connection are in an Appendix to this Report.

Two important elements of the Cimenteng proposal are:

1. To make use of existing PDAM water sources, transmission pipelines, and treatment facilities, so certain elements of the project - elevations; pipe materials and diameters, source and volume of water supply - are already fixed; and
2. To maximize gravity delivery of the water supply.

> It is essential before undertaking any design and construction to confirm sufficient volumes of water are available and that a location can be found for the new IPA Cimenteng that is at an elevation to mimize pumping.

If this proposal is implemented then IPA Badaksinga will need another source of water. In 2003 KIMPRASWIL contracted with a local consultant to study[2] water supply from PLTA Dago Bengkok II on the Sungai Cikapundung. The Consultant studied two alternatives (300 L/s by 600 mm pipeline and 600 L/s by 700 mm pipeline) and found both to be technically feasible, i.e. adequate water supply and sufficient elevation difference for gravity flow to deliver water to IPA Badaksinga.

Previous studies[3, 4] have investigated modifications to the Pipa Lama transmission main from Cikalong to a proposed IPA located in Kunjangsari in the southern part of Kota Bandung. No action has been taken on these studies, perhaps because locating the IPA in Kujungsari requires pumping and because that destination limits service to the Kabupaten.

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[1] "Recana Induk Kawasan Gedebage", PT. Yodya Karya, 26 Dec 2005.

[2] "Laporan Akhir—Pekerjann: Bantuan Teknis Recana Peningkatan Kapasistas Air Baku Untuk Penyediaan Air Minum", PT. Ganesha Piramida (Bandung), 2003.

[3] "Bantuan Teknis Evaluasi Sistem Penyediaan Air Minum Kawasan Bandung Raya", PT. Imaya Consulting Engineers (Bandung), 2005.

[4] "Pekerjaan Penyiapan Studi Pra Kelayakan Investasi Penyediaan Air Bersih Dengan Peran Serta Swasta Di Bandung Timur dan Selatan" PT. Sehat Pratama Sejati, 1988 [copy from Ir. Kiki Rosjidi, KaBag Perencanaan, PDAM Kota Bandung.

Details of the proposal are in Table 1 and Table 2 and illustrated in Figure 3 (existing) and 4 (proposed).

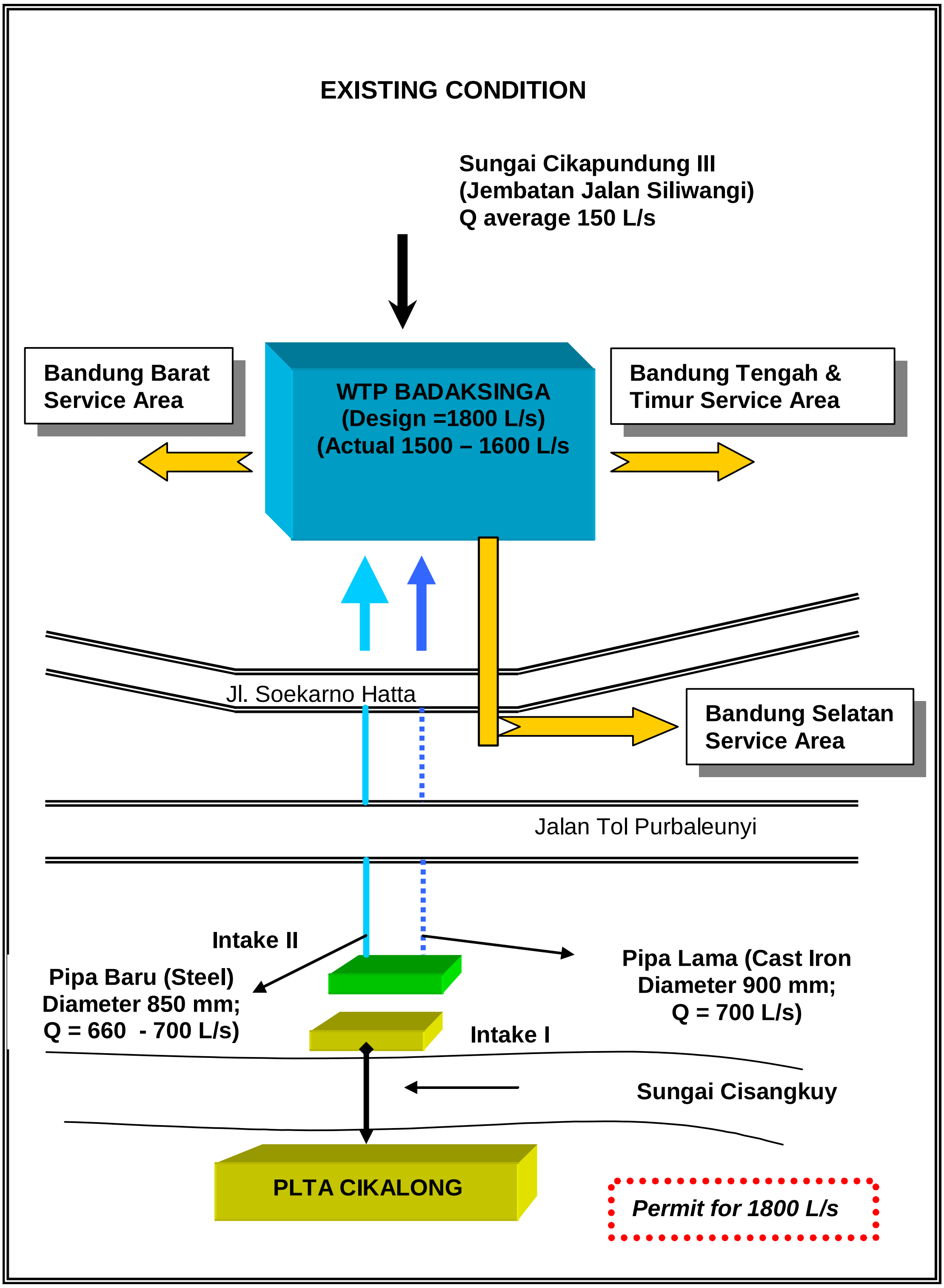

Figure 3 Sketch of Existing Cisangkuy Water Supply System

Table 1 Details of Proposed Cimenteng Project

STRUCTURE	PARAMETER	EXISTING	PROPOSED
SOURCE	Location	S. Cisangkuy	No Change
	Volume	1800 L/s	
PIPA BARU	Year Constructed	1988--1989	No Change
	Material	Steel with Cement Lining	
	Diameter	850 mm	
	Design Capacity	800 L/s	
	Current Capacity*	660 L/s	
	Length	31.25 km	
	Serves	IPA Badaksinga	
	Bulk Meter	None	Pitot Tube Meter
PIPA LAMA	Year Constructed	1956--1959	No Change
	Material	Grey Cast Iron	
	Diameter	800 mm (to km 14.2) 900 mm (17.0 km)	
	Design Capacity	1000 L/s	
	Current Capacity*	660 to 700 L/s	1100 L/s
	Length	31.25 km	Part I = ~4 km Part II = ~17 km
	Serves	IPA Badaksinga	South Kota (750 L/s) Gedebage (200 L/s) Kab. Bandung (150 L/s)
	Bulk Meter	None	Pitot Tube Meter
TREATMENT (design flow)	IPA	IPA Badaksinga (1800 L/s)	IPA Badaksinga and IPA Cimenteng (1100 L/s)

Data Sources : (1) PDAM Kota Bandung; (2) "Ringkasan Eksekutif, Bantuan Teknis Evaluasi Sistem Penyediaan Air Minum Kawasan Bandung Raya" by CV. Imaja, Bandung, 2005; and (3) "Bandung Water Supply Augmentation and Improvement—Phase 2, DED; Final Design Report, Vol. 3A: Cisangkuy Water Works Design Report" by DHV, IWACO, PT. Descerco, and PT. Waseco Tirta, Jan. 1988.

Table 2 Details of Proposed Transmission from Dago Bengkok II

STRUCTURE	PARAMETER	PROPOSED
SOURCE	Location	S. Cikapundung
	Volume	600 L/s
	Material	Steel with Cement Lining
	Diameter	700 mm
	Design Capacity	600 L/s
	Length	4.1 km
	Serves	IPA Badaksinga
	Bulk Meter	Pitot Tube Meter

Data Sources---(1) Bab. III, Bantuan Teknis Evaluasi Sistem Penyediaan Air Minum Kawasan Bandung Raya" by CV. Imaja, Bandung, 2005; and (2) "Laporan Akhir—Pekerjann: Bantuan Teknis Recana Peningkatan Kapasistas Air Baku Untuk Penyediaan Air Minum", PT. Ganesha Piramida (Bandung), 2003.

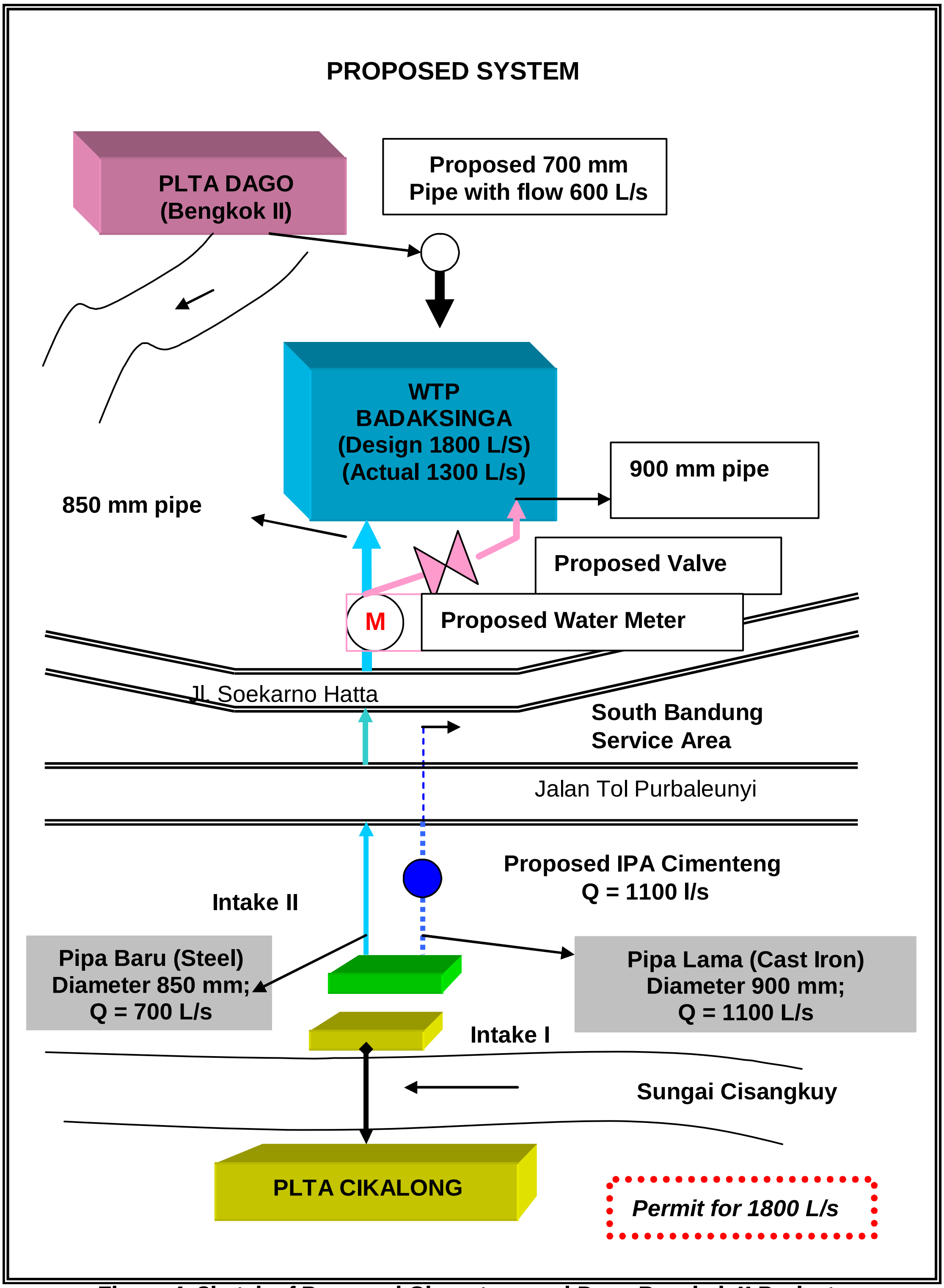

Figure 4 Sketch of Proposed Cimenteng and Dago Bengkok II Projects

[from Bantuan Teknis Evaluasi Sistem Penyediaan Air Minum Kawasan Bandung Raya" by CV. Imaja, Bandung, 2005]

3. ENGINEERING ANALYSIS OF PROPOSED PROJECT

The engineering analysis of this study focused on answering these questions:

1. What treatment is needed at the proposed IPA Cimenteng?
2. Can sufficient volume of water be transmitted by gravity from IPA Cimenteng to the Service Zone (southern part of Kota Bandung)?
3. Will the volume delivered to the Service Zone be adequate to serve the expected population in the year 2015?

This section describes approach, analysis, and results for the first two questions. Question #3--water Demand--is discussed in Section 4.

3.1. SOURCE WATER QUALITY AND TREATMENT

Sungai Cisangkuy is a major tributary of Sungai Citarum. The PDAM intake is about 150 meters downstream of the three PLN Cikalong Hydro-electric Power Plants (PLTA). There is sufficient quantity year-round and water quality is generally good. Cisangkuy water turbidity[5] is on the order of 20 NTU although in November 2005 it was reported to be over 6000 NTU.

Water from Cisangkuy goes to the IPA Badaksinga where it is blended with water from the Sungai Cikapundung. The combined waters are treated by coagulation with poly-aluminum chloride, flocculation, sedimentation, filtration, and disinfection (chlorine gas).

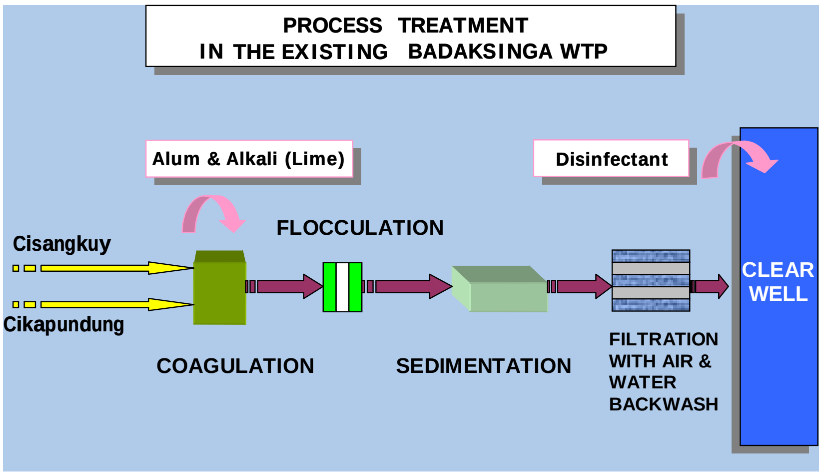

Figure 5 Sketch of IPA Badaksinga Water Treatment Process

[5] Interview with Agus Wahyu, Supervisor, IPA Badaksinga, 16 March 2006

Filters are backwashed by air and water every 24 hours. Sedimentation basin residuals and filter backwash water are discharged to the Sungai Cikapundung. The plant operates 24 hours a day with two shifts, each with 12 operators and one supervisor. There is a water quality laboratory.

IPA Badaksinga design was based on maximum influent turbidity of 200 NTU. With the majority of water from Cisangkuy, the high turbidity of Cikapundung is diluted. However Dago Bengkok connection increases Cikapundung water and disconnecting Pipa Lama decreases Cisangkuy water so the IPA Badaksinga needs modification of the chemical dosing system to treat the increased turbidity; and increased supply from the Sungai Cikapundung requires inlet pipe modifications and a Venturi meter to measure flow.

As soon as possible, PDAM should conduct pilot studies to determine the most cost effective treatment process for Cisangkuy water. The process now used at IPA Badaksinga will work; chemical dosages should be less since the water quality of Cisangkuy is better than that of water from Cikapundung. However there may be differences in chemical composition (alkalinity, hardness); different physical settling characteristics of solids (turbidity); and there may be other suitable treatment methods. All these can be measured by pilot testing. The DED engineer will use results from the pilot studies to specify the treatment process and estimate operating costs, so these studies should start soon.

The exact area of land needed for a water treatment plant depends on the design capacity and the treatment processes. For purposes of locating a suitable site now, it would be reasonable to assume four hectares of land.

3.2. HYDRAULIC ANALYSIS

The purpose of this analysis is to determine elevations needed for gravity flow and to confirm delivery of required volumes of water to IPA Badaksinga.

Flows in the transmission pipeline were simulated using EPANET, a computer software program for analyzing the hydraulic and water quality behavior of pressurized pipe networks. EPANET was developed by the United States Environmental Protection Agency (USEPA) National Risk Management Research Laboratory. It is public domain software that may be freely copied and distributed. EPANET Version 2 is designed to run under the Windows 95/98/NT operating system of an IBM/Intel-compatible personal computer. The software program and Users Manual can be downloaded at no cost from:
http://www.epa.gov/nrmrl/wswrd/epanet.html

Figure 6 is the EPANET network diagram for the existing system. The diagram starts on the left side with the Cisangkuy source and moves to the right to the IPA Badaksinga. The top line is the Pipa Baru which will continue to transmit water from Cisangkuy to IPA Badaksinga. The bottom line is the Pipa Lama. Valves with short sections of pipe are a fiction created to simulate limitations in water availability, i.e. maximum water from Cisangkuy is 1,800 L/s and maximum water into IPA Badaksinga is 1,400 L/s.

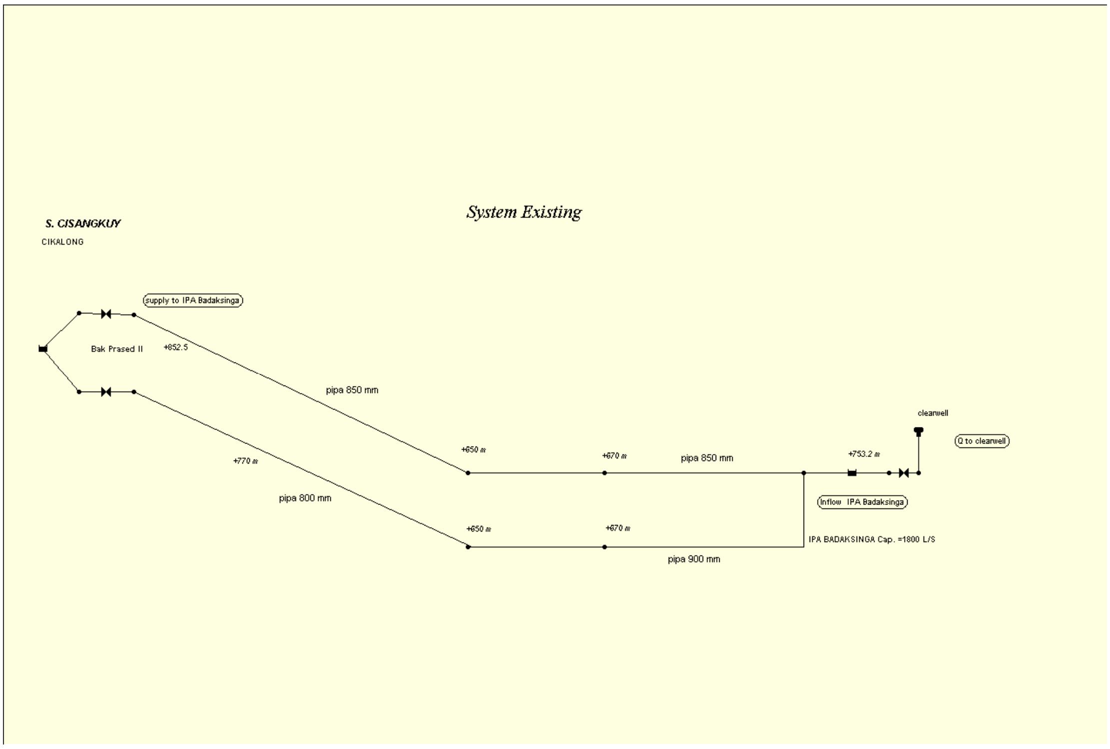

Figure 6 EPANET Network Diagram for Existing System

Figure 7 is the diagram used for a computer simulation to determine flows from and elevation of IPA Cimenteng. In this figure the bottom line is the Pipa Lama that is proposed to serve IPA Cimenteng and then transmit water to Kabupaten Bandung and Kota Bandung

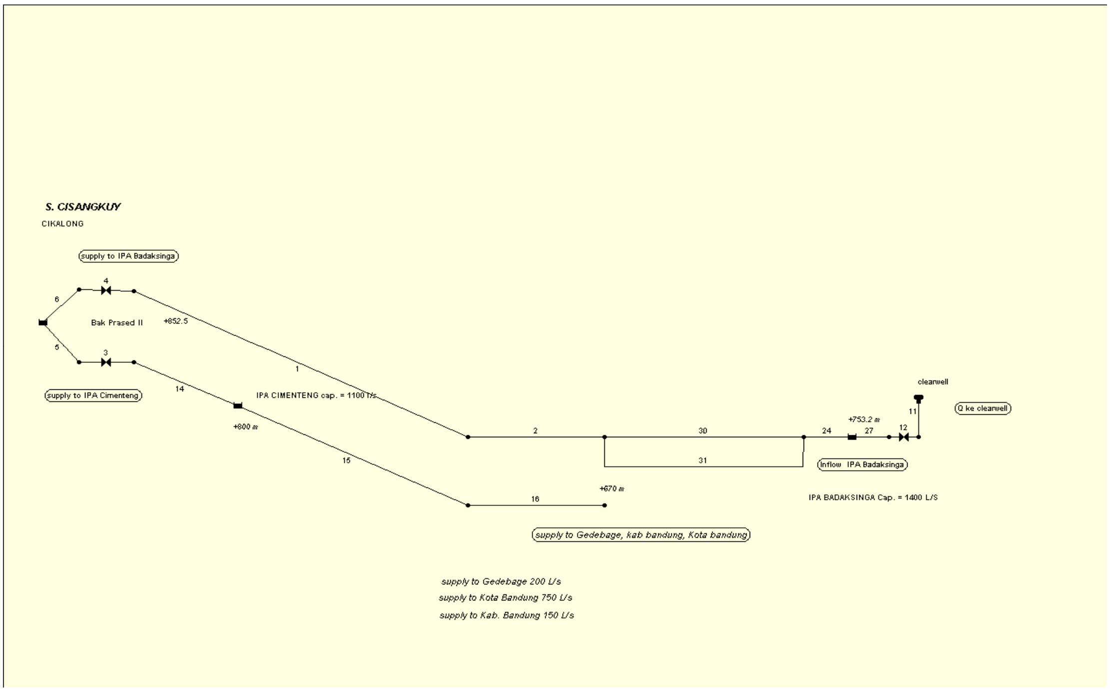

Figure 7 EPANET Network Diagram for IPA Cimenteng Analysis

Input data for the EPANET analysis is shown in the following tables:

Table 3 EPANET Input Data - Nodes

ITEM	NAME	Input to EPANET	Units	Quantity
Reservoir	Bak Prased II	elevation	Meters	847.9
	IPA Badaksinga			753.2
	IPA Cimenteng			**varies**
	Dago Bengkok II			787.5
Tank	Clearwell of IPA Badaksinga	Bottom elevation	Meters	745.0
		Diameter	Meters	43.7
		Initial Water Level	Meters	1.0
		Min Water Level	Meters	0.4
		Max Water Level	Meters	3.33
Junction	Supply Gedebage, Kab & Kota	Elevation	Meters	670

Table 4 EPANET Input Data - Pipelines

Description	Material	Diameter (mm)	Length (m)	Roughness Coefficient	Initial Status
Pipa Baru	Steel	850 without lining; actual = 829	31,257	C = 120	open
Pipa Lama Existing	Gray Cast Iron	800	14,200	C = 100	open
		900	17,057	C = 100	open
Pipa Lama Modified to IPA Cimenteng		800	~4000	C = 100	open
Pipa Lama Modified from IPA Cimenteng		800	~10,000		
		900	~7,000		
Dago Bengkok	Steel	700	4,032	C = 140	open

Hydraulic losses in pipelines result from (1) friction of water against the pipe surface and (2) components such as valves, bends, and meters. Pipe friction is function of the interior surface of the pipe and for the Hazen-Williams formula used by EPANET this is expressed as a Roughness Coefficient (C). The higher the value of C, the faster the flow. Pipe interiors deteriorate over time, the C factor decreases, and the volume of water transmitted decreases. C factor can be improved by replacing the pipe or by relining the pipe interior. For this EPANET analysis we assumed old pipe for Pipa Lama and Pipa Baru. Dago Bengkok is a new pipeline so it has a higher value for C.

Friction losses from components are referred to as Minor Hydraulic Losses, and the magnitude depends primarily on the geometrical construction of the component and the impact the construction has on the fluid flow due to change in velocity and cross flow fluid accelerations. The type, size, and location of these components will be determined during DED. So for this EPANET analysis, we used for Pipa Baru the same value (C or K = 48) established during design[6]. For Pipa Lama we assumed the same K factor adjusted for pipe length, i.e. (21 km / 31 km) x 48 = 33.

NOTE: Data inputs for EPANET analysis - flow rates, pipe diameters, and elevations - need to be confirmed by physical measurement before undertaking detailed engineering design.

[6] "Final Design Report. Vol. 3A: Cisangkuy Water Works Design Report", by DHV and IWACO, Jan. 1988

Various elevations for water supply from IPA Cimenteng were modeled to determine the minimum elevation that provides the specified volume of water by gravity flow at Kilometer 21.2, at the Jalan Tol which is the southern boundary of the proposed Service Zone. Results of this hydraulic analysis show that the elevation for the outlet from IPA Cimenteng clearwell should be close to 790 m. Less than this elevation will require pumping.

Table 5 EPANET Results from Various IPA Cimenteng Elevations

IPA Cimenteng Elevation (m ASL)	Distance from Bak Prased (m)	At Km 21.2 (Jl. Tol) Head (m) (m ASL)	At Km 21.2 (Jl. Tol) Pressure (m)
770	3.700	657	-13
780	3.600	666	-4
790	3.400	675	+5
800	2.400	677	+7

Negative pressure means pumping is required

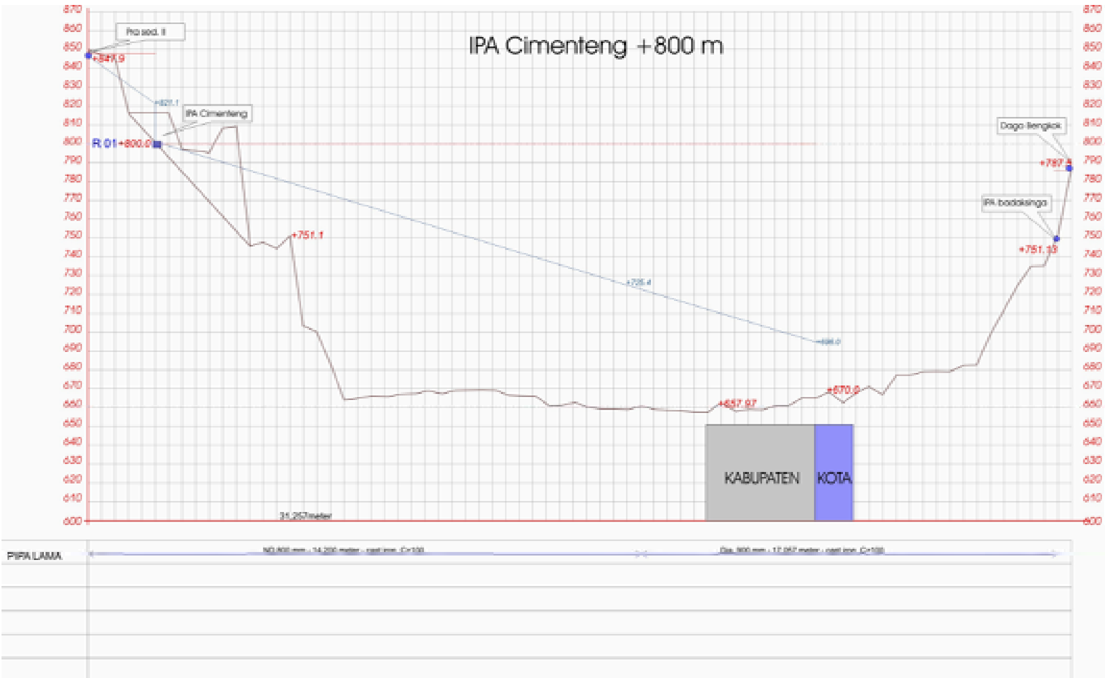

Figure 8 Hydraulic Grade Line with IPA Cimenteng at 800 m ASL

The difference in head (m ASL) at Kilometer 21.2 between Figure 8 (696m) and Table 5 (677m) illustrates the impact of minor hydraulic losses.

Figure 9 illustrates the EPANET analysis for water supply to IPA Badaksinga from Cisangkuy via the Pipa Baru and from the proposed Dago Bengkok II. Results of this analysis show that the treatment plant can be supplied from both water sources by gravity flow.

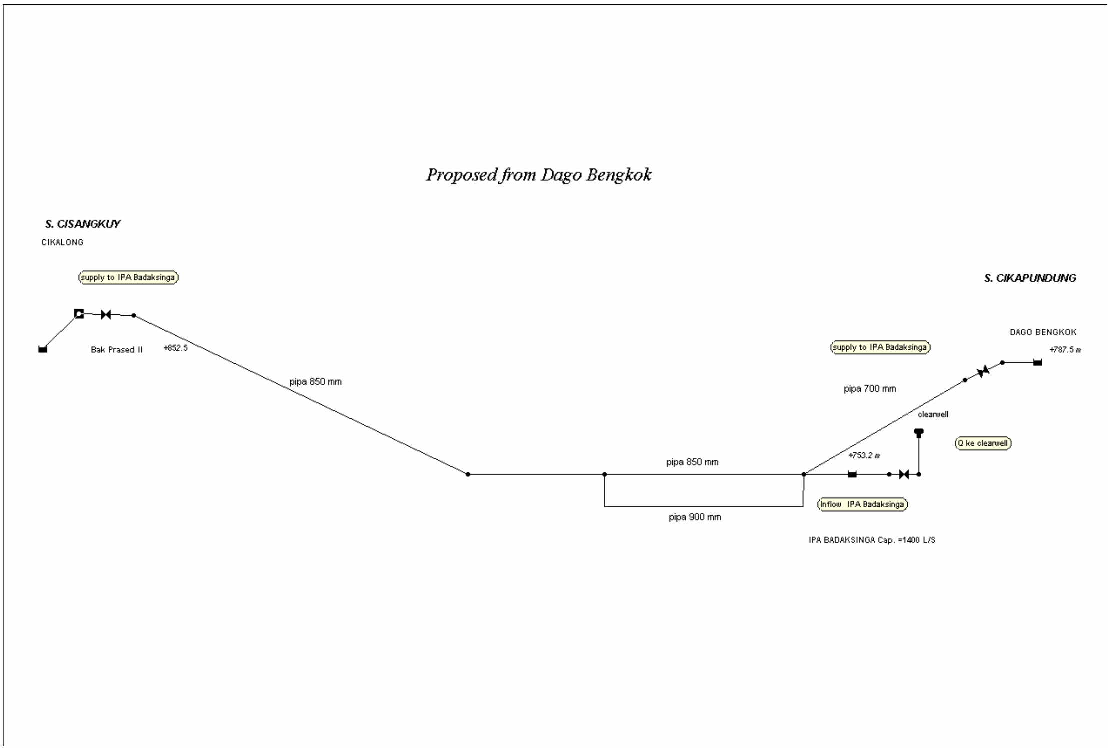

Figure 9 EPANET Network Diagram for IPA Badaksinga

3.3. ENVIRONMENTAL ANALYSIS

The Government of Indonesia requires all development projects be studied to determine potential environmental impacts and to establish suitable mitigating measures. The scope of analysis depends on size and location of the project as shown in the table below. In Indonesia the required documents before a project begins are:

1. AMDAL = Analisis Mengenai Dampak Lingkungan (Environmental Impact Assessment)
2. UKL = Upaya Pengelolaan [Kelola] Lingkungan Hidup (Environmental Management Plan)
3. UPL = Upaya Pemantauan Lingkungan Hidup (Environmental Monitoring Plan)

Table 6 Threshold Criteria for Projects Requiring Environmental Review

WATER SUPPLY	SCALE	AMDAL	UKL / UPL
Water Intake from Surface Sources (River, Lake) or Springs	Debit	≥ 250 L/sec	50 – 250 L/sec
Piped Transmission Line	Length	≥ 10 km	2 – 10 km
Water Treatment Plant	Production	-	> 50 L/sec
Distribution Network	Area served	≥ 500 Ha	100 – 500 Ha

References: Decree of the State Minister of the Environment No. 17/2001, dated 22 May 2001 and No. 86/2002, dated 28 October 2002; and Decree of the Minister of Settlements and Regional Infrastructure No. 17/KPTS/2003, dated 3 February 2003.
Ha = Hectares; km = kilometers; L/sec = Liters per second

The proposed Cimenteng project involves modifying existing structures and constructing a new IPA. From the table above it appears UKL / UPL for IPA and pipelines will be sufficient. In 2004 PDAM completed UKL / UPL for Dago Bengkok transmission pipeline of capacity 300 L/s.

3.4. CONSTRUCTION SEQUENCE

To do this work the Contractor will cut the existing Pipa Lama transmission pipeline in three different locations and reconnect to the new IPA Cimenteng at two of those locations. This will disrupt flow to IPA Badaksinga that can be replaced by supply from Dago Bengkok II via new transmission pipelines that must be connected to the IPA Badaksinga.

To assure success and minimize disruptions, it is important that PDAM review in detail the sequence of activities; to schedule these disconnections and connections at a time of low water use; and to inform the public when to expect water outages and for what duration.

Terms of Reference for the Contractor should include requirements to present in advance a schedule for this particular activity to be reviewed and approved before commencement. The schedule should show in detail day, time, work crews, equipment, and contingency plans.

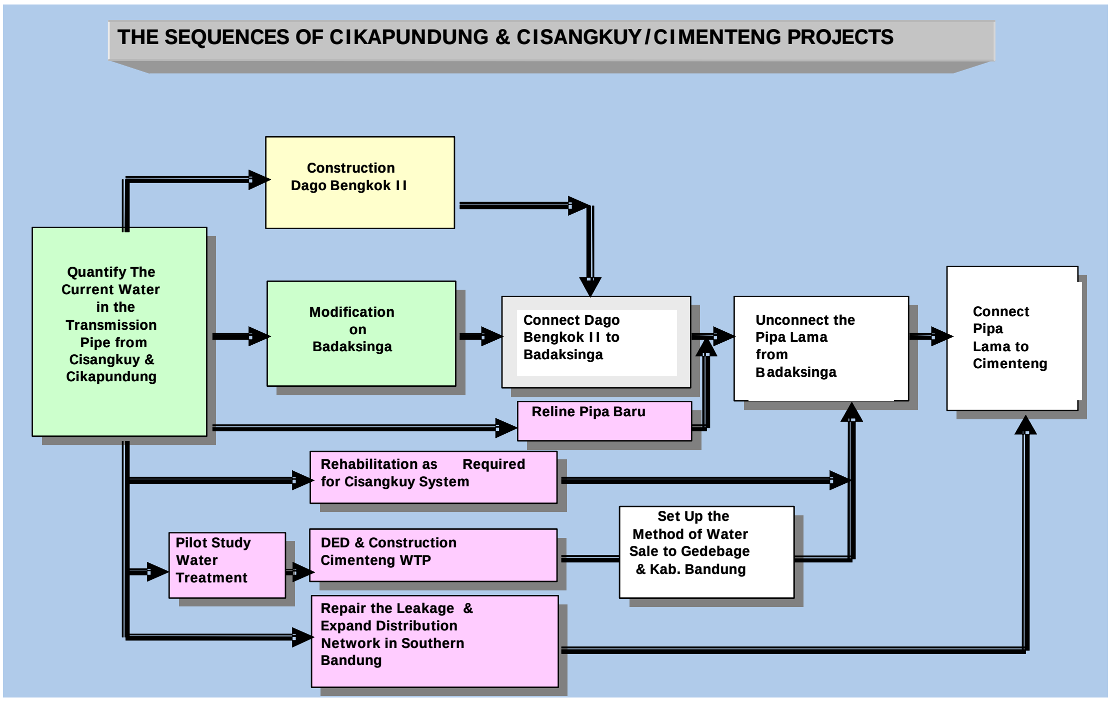

Figure 10 Sequence of Construction Activities

3.5. INCREASE IN WATER SUPPLY

The following table shows the total gain in PDAM water supply by implementing this project. See Figure 11 for details.

Table 7 Changes (L/s) in PDAM Water Supply

WATER SOURCE	TRANSMISSION PIPELINE	Liters Per Second (L/s)	
		Now	Future
Cisangkuy	Pipa Baru	700	700
	Pipa Lama	700	1100
Cikapundung	Cikapundung III	200	200
	Dago Bengkok	0	600
2	4	1600	2600
		GAIN OF	1000

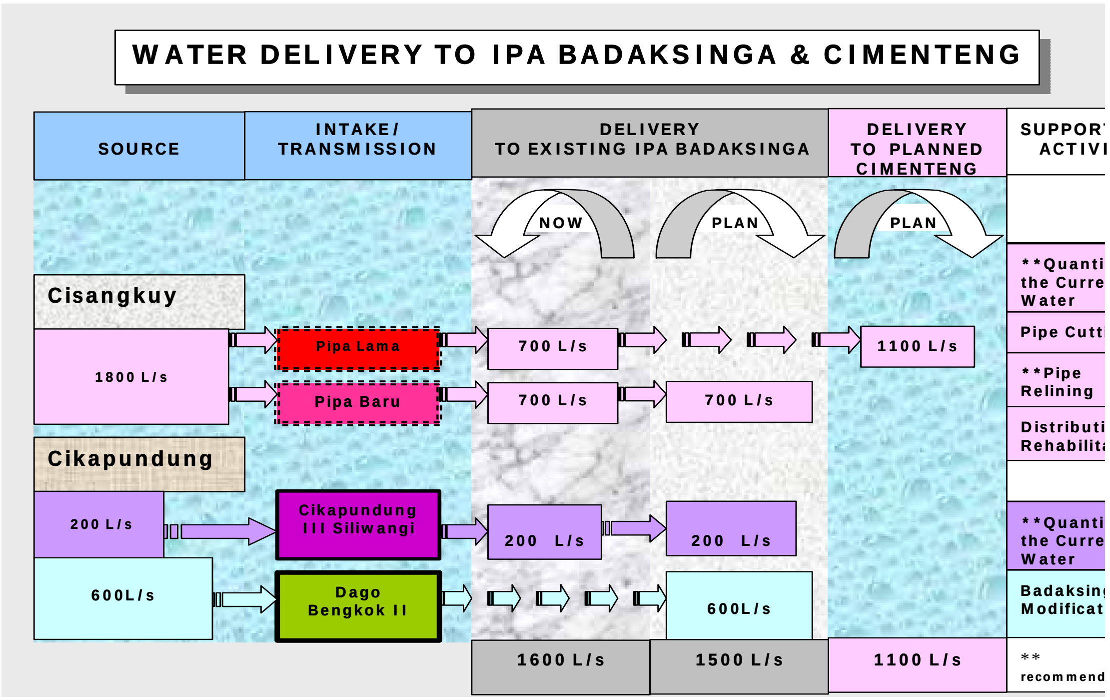

Figure 11 Summary of Changes in Water Supply

4. POPULATION AND WATER DEMAND IN YEAR 2015

This section explains the methodology and results for estimating population and water demand in year 2015 for the area in southern Bandung that will be supplied by the proposed IPA Cimenteng system. The procedure used involved a multi-step process. Table 8 lists the steps.

Table 8 Procedure to Estimate Water Demand in Year 2015

Step	Activity	Source or Formula
1	Define Zone of Service	Ask PSAM ti mark map
2	Estimate Population in the Zone of Service	Pop in Zone = (Total Pop. In Kec.) × (% of Kec. In Zone)
2.1	Review map to estimate % land area in the zone	
2.2	Get population for each Kelurahan in the zone	BPS year 2004
2.3	Calculate population in each Kecamatan	BPS (year 2004) for Kelurahan × % land area in Service Zone
3	Estimate Number of House Connections (HC)	
3.1	Number of connections by customer category for each Wilayah	Data from PDAM
3.2	Calculate HC connections	(Total PDAM connections) × (HC as % of Total)
4	Estimate Current Level by of Coverage by PDAM	
4.1	Number of people per House Connections (HC)	Per PDAM, use 5
4.2	Calculate % Coverage	% Coverage = [(PDAM HC) × (# people/HC)]/ [(Kec. Pop.)]
4.3	Evaluation % Coverage to determine if PDAM goal possible	
5	Estimate Demand per HC for each Wilayah	Data from PDAM
5.1	Evaluate data to establish single value to use	m^3/ month/ connection converted to L/S Demand
6	Forecast Future Population and Water Demand	
6.1	Estimate future population	Pop. In year #2 = (Pop. In year #1) × (1+ Growth Rate)
6.2	Estimate # HC per year by based on different scenarios	(Population / 5) × % HC Coverage
6.3	Estimate domestic (HC) water demand	Water Demand = (#HC × m^3 / connection / month)
6.4	Estimate total water demand (L/s)	(HC Water Demand)/ (% Water Used by HC)
6.5	Estimate amount of loss water	
6.6	Calculate Required Water Production (L/s)	(Total Water Demand) × (1+% Water Loss)

STEP #1—DEFINE THE SERVICE ZONE

The area in Kota Bandung to be served is between Jalan Tol Purbaleunyi and Jalan Soekarno Hatta

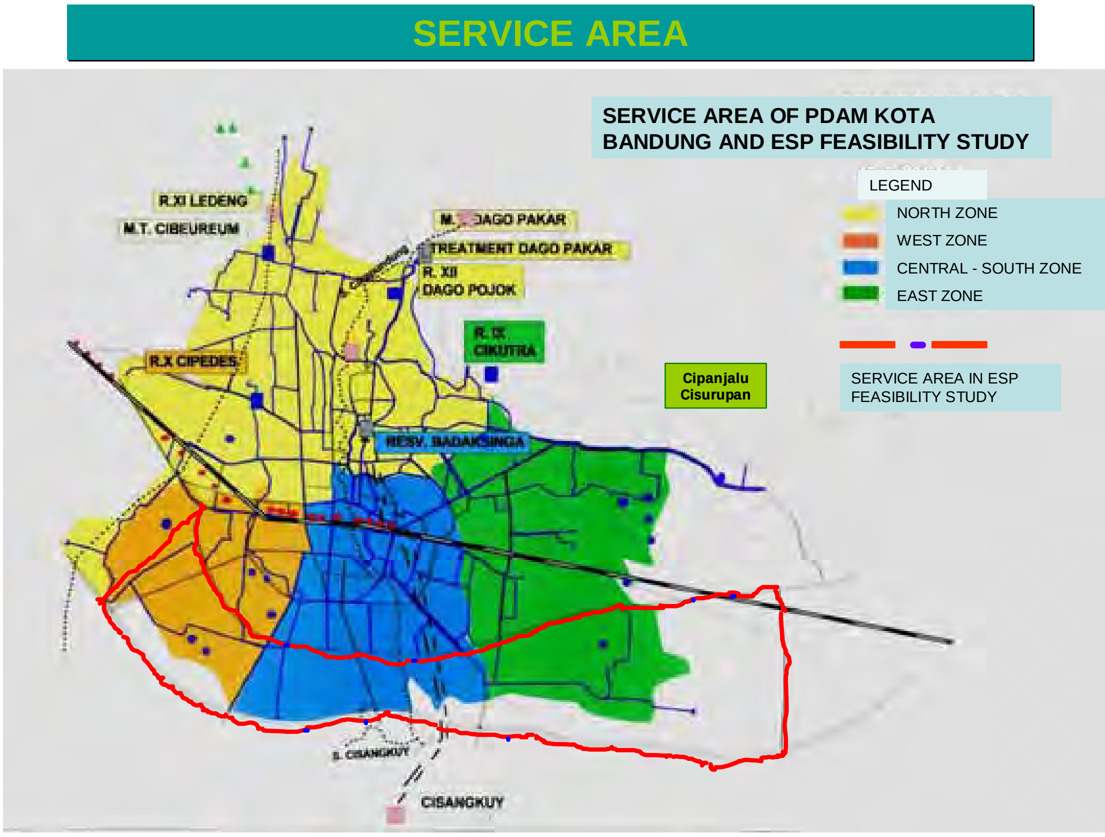

Figure 12 Area in Kota Bandung Served by IPA Cimenteng
[southern Bandung; marked in red outline]

STEP #2—ESTIMATE POPULATION IN THE SERVICE ZONE

Population for Base Year

Population data for this study was collected from the Badan Pusat Statistik, (BPS) Kota Bandung. BPS Population for Year 1990 and Year 2000 is from the Government of Indonesia census and population for intermediate years is compiled from data submitted by the kecamatans.

Population Growth Rate

BPS uses an average population growth rate of 1.5% per annum to forecast population growth in Kota Bandung. However BPS data for years 2000--05 show a growth rate of only 0.9% per year.

Rencana Tata Ruang Wilayah (RTRW) Kota Bandung uses a growth rate of 2.5% and it appears from their report that they assume expansion of land area from the current 167 km2 to 198 km2 in year 2013, i.e. annexing land from the Kabupaten. At a meeting[7] with

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[7] Ibu Heni Kusmin, Kepala Data & Statistik, BAPPEDA Kota Bandung, 14 March 2006.

BAPPEDA, they explained their population growth rate considers economic factors and the 2.5% growth rate is based on expected development of Gedebage.

PLN no longer uses population to forecast electricity demand. The PLN is based on the following three factors[8]

1. economy (if good, then electricity consumption higher)
2. statistical analysis for past 5 years of natural growth of electricity usage based on customers having more electric appliances
3. regional development in Propinsi Jawa Barat and Propinsi Banten)

PLN does not distinguish between Kota Bandung and Kabupaten Bandung; its service area is "Bandung Raya" (i.e. Greater Bandung).

Based on discussions with PDAM, we used 1.5% for this study.

Population in Future Years

Population for each Kecamatan was calculated according to this formula:

$$\text{Population Year (N)} = \text{Population Year (N-1)} \times (1 + \text{Growth Rate})$$

$$\text{Population Year (2015)} = \text{Population Year (2004)} \times (1 + 1.5\%)^{11}$$

Table 9 lists the administrative areas (Kecamatan and Kelurahan) in the Zone of Service and the estimated Year 2004 population. Percent Land Area is based on a visual estimate of a paper map.

Table 9 Estimated Year 2004 Population in Zone of Service

Population in Service Zone				Year 2004 Population		
WILAYAH	KECAMATAN	KELURAAN	% AREA	TOTAL	SERVICE ZONE	KEC.
KAREES	Regol	Ciseureuh	100 %	14,745	14,745	28547
		Pasirluyu	100 %	13,802	13,802	
TEGALEGA	Bojongloa Kaler	Kopo	10 %	26,756	2,676	2,676
	Bojongloa Kidul	Cibaduyut Kidul	100 %	7,781	7,781	76,008
		Cibaduyut Wetan	100 %	4,426	4,426	
		Mekarwangi	100 %	9,157	9,157	
		Cibaduyut	100 %	9,722	9,722	
		Kebon Lega	100 %	23,433	23,433	
		Situ Saeur	100 %	21,489	21,489	
	Babakan Ciparay	Margasuka	100 %	11,344	11,344	79,607
		Cirangsang	100 %	9,864	9,864	
		Margahayu Utara	100 %	20,219	20,219	
		Babakan Ciparay	80 %	29,987	23,990	
		Babakan	50 %	28,380	14,190	
		Sukahaji	0 %	26,582	0	
	Bandung Kulon	Gempolsari	0 %	18,010	0	44,925
		Cigondewah Kaler	100 %	19,347	19,347	
		Cigondewah Kidul	100 %	6,954	6,954	
		Cigondewah Rahayu	100 %	8,507	8,507	
		Caringin	100 %	9,867	9,867	
		Warung Muncang	0 %	20,973	0	
		Cibuntu	0 %	18,450	0	
		Cijerah	1%	24,971	250	

[8] Ir. Kriswanto, Manager Perencanaan Sistem Kelistrikan, PLN Distribusi Jawa Barat dan Banten, 14 March 2006.

Population in Service Zone				Year 2004 Population		
WILAYAH	KECAMATAN	KELURAAN	% AREA	TOTAL	SERVICE ZONE	KEC.
GEDE BAGE	Rancasari	Darwati	100 %	15,655	15,655	53,884
		Cisaranten Kidul	95 %	19,541	18,564	
		Cipamokolan	75 %	20,181	15,136	
		Mekarmulya	50 %	9,058	4,529	
	Margacinta	Margasenang	100 %	29,103	29,103	106,259
		Margasari	100 %	30,582	30,582	
		Sekejati	100 %	46,574	46,574	
	Bandung Kidul	Wates	100 %	8,601	8,601	44,600
		Mengger	100 %	5,558	5,558	
		Kujangsari	100 %	14,667	14,667	
		Batununggal	100 %	15,774	15,774	
UJUNG BERUNG	Arcamanik	Cisaranten Kulon	1 %	19,163	192	192
	Ujungberung	Cisaranten Wetan	40 %	7,887	3,155	3,155
	Cibiru	Pasir Baru	20 %	11,186	2,237	8,086
		Cipadung	30 %	19495	5,849	

STEP #3—ESTIMATE NUMBER OF HOUSE CONNECTIONS

Household Connections (HC)

Table 10 PDAM House Connections in Service Zone

Wilayah	Total Connections	Rumah Tangga	% RT
Karees	33,370	27,034	81 %
Tegalega	28,379	23,806	84 %
Gede Bage	12,226	11,477	94 %
Ujung Berung	13,047	12,182	93 %

Since 2002 PDAM has been doing “sweeping surveys” [door-to-door interviews about water connections; evaluation of customer category; number of people per house, etc.] which examine 100% of all buildings in a specific neighborhood. By the end of year 2005 PDAM had surveyed 256,295 buildings in 73 Kelurahans in 16 Kecamatan. During this survey they identified 106,398 PDAM customers. One result of these surveys is reclassification of customers as shown in the following table.

Table 11 Change in PDAM Customers Oct-05 to Jan-06

Customer Class	October 2005	January 2006	% Change
Social	2,242	2,023	- 10 %
Non-Niaga	126,182	119,749	- 5 %
Niaga (Commercial)	12,781	17,805	39 %
Industry	502	616	23 %
	141,707	140,193	- 1 %

Household customers decrease due to reclassification (e.g. to commercial) or shut-off for non-payment. The immediate impact to PDAM is improved revenues because commercial and industrial customers pay higher water rates than domestic customers. For this Study the impact of decreasing domestic connections is expected to be minimal because of the large number of new service connections that will be installed.

STEP #4—ESTIMATE CURRENT LEVEL OF COVERAGE BY PDAM

Number of People Per House Connection

PDAM Sweeping Survey data indicate an average of 5 people per service connection, but according to BPS there are on average 3.6 people per house.

Table 12 Number of People per House in Kota Bandung

Year	Rumah Tangga	# People per House
1980	274,401	5,3
1990	433,283	4,8
1995	559,360	3,2
2000	595,408	3,6
2005	Not available	

Hasil pengelolahan Sensus 2000, BPS Propinsi Jawa Barat

This difference between BPS and PDAM data results from different methods of counting the number of people per house. BPS counts number of "family cards" per address while PDAM counts number of people physically living in the dwelling. Consider for example one house with husband and wife who have a family card and the wife's mother who has her own family card. For BPS census, there are 1.5 people per house, but for PDAM water supply, there are three. Based on discussion with PDAM, we assume 5 people per house connection.

Coverage in the Entire Kotamadya

Analysis of PDAM Customer Data for January 2006 shows about 118,000 house connections in the Service Area. Assuming 5 people per connection, this means 590,000 people have direct piped water service, about 26% of the population in the Kotamadya. Data in the following table shows there are plenty of potential customers in south Bandung.

Table 13 Estimated Year 2004 PDAM Coverage Zone of Service

Wilayah	House Connections as % of Total Connections	Kecamatan	Total Kec. Pop. 2004	Total PDAM Customers	% Coverage
Karees	81 %	Regol	77,298	8,035	42 %
Tegalega	84 %	Bojongloa Kaler	115,830	6,046	22 %
		Bojongloa Kidul	76,008	4,350	24 %
		Babakan Ciparay	126,376	3,517	12 %
		Bandung Kulon	127,079	6,704	22 %
Gede Bage	94 %	Rancasari	64,435	2,070	15 %
		Margacinta	106,259	7,895	35 %
		Bandung Kidul	44,600	2,261	24 %
Ujung Berung	93 %	Arcamanik	62,512	2,172	16 %
		Ujung Berung	76,825	1,401	9 %
		Cibiru	79,350	83	0 %
4		11	956,572	44,534	

% Coverage = [(Total PDAM Customers) × (HC as % of Total) × (5 people/ HC)] / (Kec. Pop.)

PDAM believes the major factor limiting service connections is the availability of water and that they could install as many as 1,000 new service connections per month.

STEP #5—ESTIMATE DEMAND PER HC FOR EACH WILAYAH

Water Consumption per Domestic Service Connection

PDAM data for October 2005 shows water consumption averages 20 m^3 per month for all service connections and 19 m^3/month/HC. This is supported by results from the Real Demand Survey (RDS) conducted in year 1999 that found a rate of 140 liters per person per day, which at 5 people per service connection is equivalent to 21 m^3/connection/month. PDAM data allowed analysis of consumption data specific to the Service Zone and the results are shown in the following table.

Table 14 Water Consumption in the Service Zone

Rumah Tangga (House) Customer Data			
Wilayah	**Number of ustomers**	**Consumption (m^3/month)**	**Rumah Tangga m^3/ month/RT**
Karees	27,034	422,425	16
Tegalega	23,806	356,424	15
Gede Bage	11,477	196,392	17
Ujung Berung	12,182	210,070	17

There is no reason to assume individual household water consumption will change significantly in the future because:

1. high costs of electricity are likely to preclude use of dishwashers
2. changes in bathing and toilet are more influenced by culture than product availability
3. density of housing limits size of outdoor landscaping.

Therefore assuming a demand of 20 m^3/month/house allows for increased use over time.

STEP #6—ESTIMATE POPULATION AND WATER DEMAND TO YEAR 2015

To serve 80% of the population by House Connection by Year 2012 requires 8.1% annual average growth rate of HC. This is on the order of 700 new connections installed per month.

Based on PDAM data we estimate 80% of the water supply is used for HC and the remainder for social, commercial, and industrial customers. So the total water demand is increased.

Water Production depends on amount of water lost and we assumed Annual Reduction in Water Loss of 2% per year. Table 15 summarizes results.

Table 15 Estimated Population and Average Water Production Required By South Bandung to Year 2015

FORECAST POPULATION AND WATER DEMAND TO YEAR 2015							
	2005	**2007**	**2008**	**2010**	**2012**	**2014**	**2015**
POPULATION	455,000	469,000	476,000	490,000	505,000	520,000	528,000
Annual Increase of HC	8,1 %						
% HC Coverage	23 %	39 %	47 %	64 %	**80 %**	96 %	100 %
House Connections (HC)	20,900	36,800	45,000	62,200	80,500	99,700	105,600
#HC To Install Per Month	-	700	700	700	800	800	700
HC Water Demand (L/s)		280	350	480	620	770	810
Total Water Demand (L/s)		350	440	600	780	960	1,010
Annual Reduction in Water Loss	2 %						
Estimated Water Losses	40 %	36 %	34 %	30 %	26 %	22 %	20 %
Required Water Production (L/s)		550	670	860	1,050	1,230	1,260
Annual Increase of HC	4,0 %						
% HC Coverage	23 %	31 %	35 %	43 %	51 %	59 %	63 %
House Connections (HC)	20,900	29,100	33,300	42,100	51,500	61,400	66,500
#HC To Install Per Month	-	300	300	400	400	400	400
HC Water Demand (L/s)		220	260	320	400	470	510
Total Water Demand (L/s)		280	330	400	500	590	640
Annual Reduction in Water Loss	2 %						
Estimated Water Losses	40 %	36 %	34 %	30 %	26 %	22 %	20 %
Required Water Production (L/s)		440	500	570	680	**760**	800

Formulas Used in Table Above

House Connections (HC) =	(Population / 5) x % HC Coverage
#HC to Install per Month =	HC / (12 x number of years)
HC Water Demand (L/s) =	HC x (m^3/month/house connection)
Total Water Demand (L/s) =	Sosial + HC + Niaga + Industri
Total Water Demand (L/s) =	(HC Water Demand) / (% Water Used by HC)
Required Water Production (L/s) =	(Total Water Demand) / (1 + %Water Loss)

Assumptions Used in the Table Above

Population growth rate	1.5%
People per House Connection	5
m^3/month/house connection	20
% of Total Water Supply Used by HC	80%

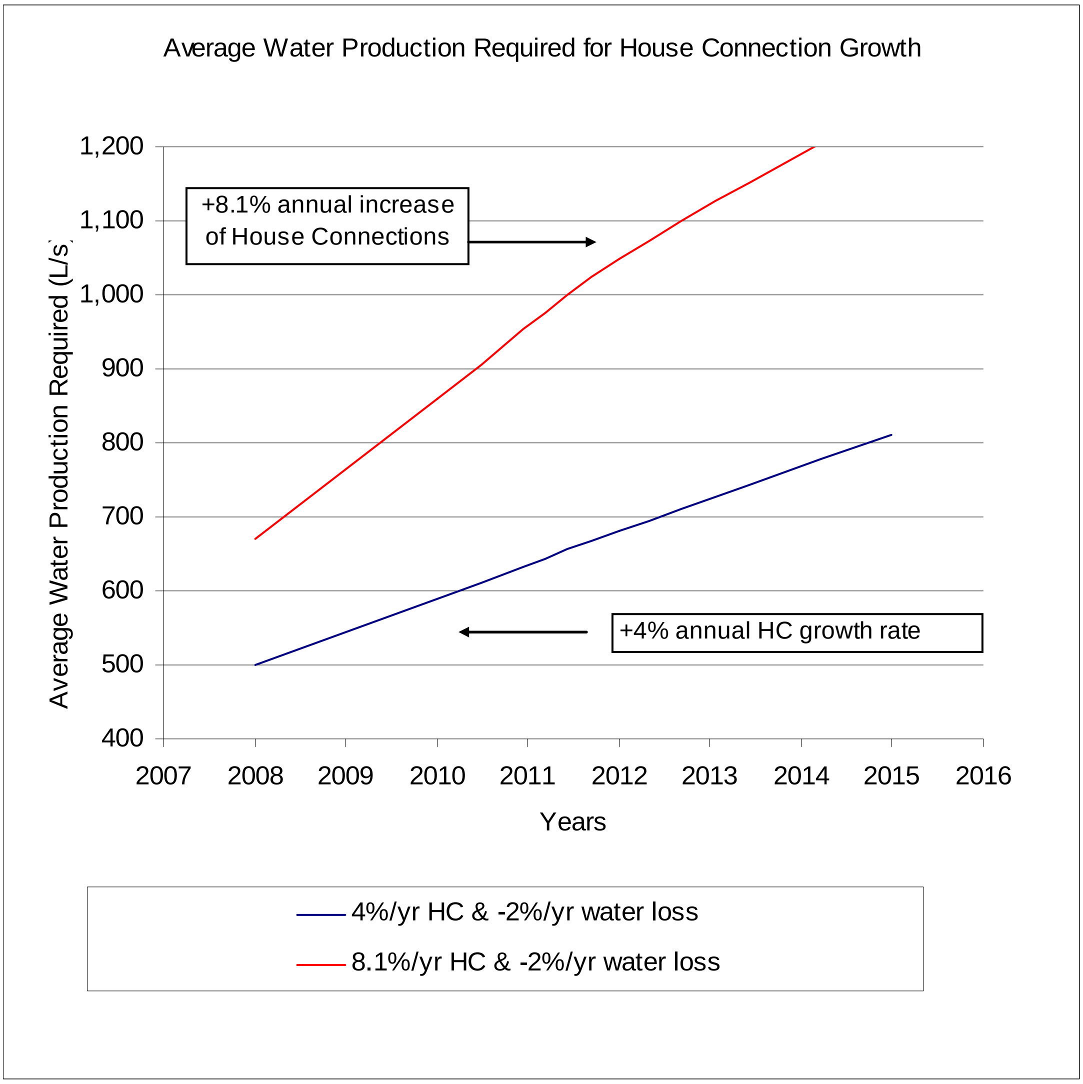

Figure 13 Graph of Average Water Production Required for south Bandung through Year 2015

The top line in this graph is based on an annual growth of House Connections of 8.1% to provide 80% service area coverage in Year 2012. With annual water loss reduction 2% a water production of 1050 L/s is needed in Year 2012. The bottom line in the graph shows that a slower increase in HC (4%) with same reduction of water losses that a production of 750 L/s is adequate through year 2014.

Forecasting Water Demand depends on estimates of population growth, water consumption, service area coverage, and distribution system water losses. Overestimating results in excess construction and underutilized facilities; underestimating in unsatisfactory service due to water shortages. PDAM needs to accurately measure water production and consumption;; develop its own data for forecasting population growth; and continue to implement water loss reduction programs.

5. CONCLUSIONS

1. Based on data available, the proposed project to transmit water from Cisangkuy via IPA Cimenteng is technically feasible in terms of delivering sufficient water by gravity flow if the clearwell outlet of the IPA is at or above elevation 790 meters. Lower elevations will require pumping.
2. The number of customers PDAM can serve with this water depends on the number of service connections installed and the control of water losses.
    a. 750 L/s could serve almost 60% of possible house customers in southern Kota Bandung through year 2014 if the annual rate of customer growth does not exceed 4% and if the PDAM can reduce water losses at least 2% per year.
    b. To provide 80% of population with house connection by year 2012 requires water production of 1050 L/s.
3. This analysis assumes that the Pipa Baru pipeline, which will not be changed, can deliver at least 700 L/s to IPA Badaksinga. PDAM currently estimates flow in this pipeline to be about 660 L/s but this should be verified by an alternate measurement.
4. Essential to implementing this project is replacing the water supply to IPA Badaksinga. Detailed Engineering Design and Environmental Analysis have been completed for the proposed Dago Bengkok II supply and construction is estimated to take one year. However the source water is not a year-round supply, so a study should be done to determine location and size of a reservoir to serve as a water source during the dry season.
5. Volume from water sources is limited so raw water supply should be monitored. PDAM needs to install equipment at enough locations to measure and record source water flow. Accuracy of 5% is sufficient.
6. PDAM cannot always rely on data and methods of other organizations to estimate population and should collect its own numbers for planning and estimating purposes.

6. RECOMMENDATIONS

1. MEASURE
   a. Calibrate existing flow meters at IPA Badaksinga to confirm flows from Cisangkuy and Cikapundung
   b. Install flow meters at other locations in the transmission system. To reduce costs, use portable, insertion flow meters with accuracy ±5%. This data establishes a baseline for measuring water losses.
   c. Conduct topographic surveys to accurately measure or confirm ground and pipe elevations.
2. STUDY
   a. Conduct pilot studies for treatment of Cisangkuy water. Results will be used in designing IPA Cimenteng. Studies should cover both wet and dry season.
   b. Investigate conditions and costs for pipe relining. Relining Pipa Baru could restore the original carrying capacity of 800 L/s.
3. OPTIMIZE
   a. Continue efforts to reduce water losses in the distribution network. Reducing physical ("wet") water losses makes more water available. Reducing commercial ("dry") losses increases revenues.
   b. Identify, inspect, and maintain valves. For transmission pipelines this should be done once a year. Water flow is restricted when valves are not in their proper position (open, closed). It commonly happens in large networks that valves get into the wrong position during repairs and installations.
4. DESIGN
   a. Begin Preliminary Engineering Design (PED) of the modified Pipa Lama transmission pipeline to identify size and number of bends, valves, and fittings to include as minor losses in the hydraulic analysis
   b. Schedule PED of IPA Cimenteng after pilot studies completed
5. PLAN
   Sequence of activities as illustrated in Figure 10.
6. CONSIDER
   a. Kabupaten Bandung has approval from Pengembangan Sumber Daya Air (PSDA) to withdraw 400 L/s from Cisangkuy. It would be reasonable for PDAM Kota Bandung to include this volume of water in the design of its treatment plant and transmission system, then deliver this volume to the Kabupaten via one or two metered connections. The Kabupaten would be bulk water customer.
   b. The advantages of this proposal are economy of scale for infrastructure; Kabupaten gets its water supply; PDAM Kota Bandung gets a large customer; PDAM can use the water when the Kabupaten cannot.

7. APPENDICES

APPENDIX A
INTERVIEWS AND REPORTS USED IN THIS TECHNICAL STUDY

APPENDIX B
DETAILS ABOUT PDAM KOTA BANDUNG

APPENDIX C
NOTES ON WATER SERVICE TO GEDEBAGE

APPENDIX D
OUTLINE IMPLEMENTATION PLAN

APPENDIX E
NOTES FOR MEETING (10 MARCH 2006) PDAM KOTA BANDUNG, USAID, and ESP-Jakarta

APPENDIX F
ESTIMATED PROJECT COSTS

APPENDIX A
INTERVIEWS AND REPORTS USED IN THIS TECHNICAL STUDY

INTERVIEWS

PDAM KOTA BANDUNG

1. Ir. Agung Sugianto, Bidang Penelitian Tehnik
2. Mohammad Moeslim, Ka. Sie. Perencanaan
3. Ir. H. Kiki Moch. Rosjidi, KaBag Perencanaan,
4. Hadi Pratama, Bidang Operasional
5. Dra. Titi Rachmawati, Kepala IPA Badaksinga
6. Agus Wahyu, Supervisor, IPA Badaksinga
7. Jhoni Wahdanu, Bagian Produksi Air Permukaan

OTHER AGENCIES

1. Staff Badan Pusat Statistik, Kota Bandung,
2. Ir. Kriswanto, Manager Perencanaan Sistem Kelistrikan, PLN Distribusi Jawa Barat dan Banten, 14 March 2006.
3. Ibu Heni Kusmin, Kepala Data & Statistik, BAPPEDA Kota Bandung, 14 March 2006.

REPORTS

1. Selamatkan Air Kita--31 Tahun PDAM Kota Bandung, PDAM Kota Bandung, Jl. Badaksinga No. 10, Bandung 40132, Indonesia
2. Bandung Dalam Angka 2004, Badan Pusat Statistik, Kota Bandung
3. "Laporan Kegiatan Tim S/d Akhir Tahun 2005 & Rencana Kerja Tahun 2006", TIM Pemutakhiran Data Kepelanggenan, PDAM Kota Bandung, Jan-06
4. "Bantuan Teknis Evaluasi Sistem Penyediaan Air Minum Kawasan Bandung Raya", PT. Imaya Consulting Engineers (Bandung), 2005.
5. "Laporan Akhir—Pekerjann: Bantuan Teknis Recana Peningkatan Kapasistas Air Baku Untuk Penyediaan Air Minum", PT. Ganesha Piramida (Bandung), 2003.
6. "Bandung Water Supply Augmentation and Improvement—Phase 2, DED; Final Design Report, Vol. 3A: Cisangkuy Water Works Design Report" by DHV, IWACO, PT. Descerco, and PT. Waseco Tirta, Jan. 1988.
7. "Pekerjaan Penyiapan Studi Pra Kelayakan Investasi Penyediaan Air Bersih Dengan Peran Serta Swasta Di Bandung Timur dan Selatan" PT. Sehat Pratama Sejati, 1988 [copy from Ir. Kiki Rosjidi, KaBag Perencanaan, PDAM Kota Bandung].
8. "Recana Induk Kawasan Gedebage", PT. Yodya Karya, 26 Dec 2005.
9. "Final Design Report. Vol. 3A: Cisangkuy Water Works Design Report", by DHV and IWACO, Jan. 1988
10. As-built Drawings for IPA Badaksinga prepared by DHV & IWACO, 1989.

APPENDIX B
DETAILS ABOUT PDAM KOTA BANDUNG

The PDAM provides treated water and collects and treats wastewater for Kota Bandung; and produces bottled water.

SERVICE AREA – KOTA BANDUNG

Kota Bandung, the capital of Propinsi Jawa Barat, is located in the Priangan highlands about 190 kilometers southeast of Jakarta. The Kota consists of 26 Kecamatans sub-divided into 139 Kelurahans. It has a land area of 167 square kilometers (km^2) and a population of 2.23 million (year 2004). This is a population density of 134 people per hectare, however taking into consideration that only 60% of the land is occupied by housing, the density is actually about 220.

Topographically the northern part of the Kota is mountainous and the southern part relatively flat. Elevations of the Kota range from 1050 meters above sea level (ASL) in the north to 675 meters ASL in the south. The city center is about 770 m ASL.

PRESSURE AT SERVICE CONNECTION

PDAM goal is a pressure at the tap of 1 to 2 bars (10 to 20 meters) but due ot low volume of water available and high demand the actual pressure is 0.1 bar.

NUMBER OF CUSTOMERS AND LEVEL OF COVERAGE

PDAM serves customers through piped water connections, public taps and hydrants, and trucked water services.

Table 16 PDAM Customers and Water Usage (Oct-05)

Customer Classification	Number of Customers (Oct-05)	% of Total	Water Usage Oct-05 (m^3)	% of Total	L/ connection/ day
Sosial – Kran Umum	2,090	1,5 %	113,488	4,0 %	1750
Sosial	152	0,1 %	28,388	1,0 %	6020
Non – Niaga/ Rumah Tinggal	126,182	89,0 %	2,367,133	82,5 %	610
Niaga Kecil	4,847	3,4 %	102,662	3,6 %	680
Niaga Besar	7,934	5,6 %	244,092	8,5 %	990
Industri Kecil	267	0,2 %	4,938	0,2 %	600
Industri Bersar	235	0,2 %	9,495	0,3 %	1300
	141,707	100 %	2,870,196	100 %	

PDAM estimates 50 people per public tap (Kran Umum) and 5 people per domestic service connection. Thus PDAM is estimated to serve **735,000** people, about **32%**[9] of the estimated population of 2.28 million (year 2005).

[9] PDAM reports that it serves 55% of the population.

Major reasons why coverage is low are:

1. PDAM does not have sufficient water supply
2. Ground water is easily available
3. Large number of public taps and hydrants to serve small commercial establishments such as kiosks and warungs.

FACILITIES FOR SOURCE, TREATMENT, AND TRANSMISSION

Kota Bandung has numerous rivers and tributaries flowing through it but most are polluted because many industries and houses are not connected to the sewer system. PDAM prefers to use water from sources outside its boundary, i.e. Kabupten Bandung, which are at a higher elevation (thus can be delivered by gravity), and because the water quality is good. Sungai Cisangkuy (1600 L/s) and Sungai Cikapundung (600 L/s) provide about 85% of the water supply.

Table 17 PDAM Water Sources (2005)

Water Sources	Number	Maximum Production (L/s)	Year 2005 Production (L/s)	% of Total Production
Air Permukaan (River Water)	5	2770	2230	87 %
Air Tanah (Ground Water)	32	180	164	6 %
Mata Air (Water Springs)	16	170	177	7 %
	53	3120	2571	100 %

The PDAM operates 6 treatment plants The only treatment needed is removing turbidity according to the process pre-sedimentation → coagulation (using poly aluminum chloride)→ flocculation → sedimentation→ filtration→ disinfection (by chlorine gas).

Table 18 PDAM IPA (2005)

Sumber Air	Instalasi Pengolahan Air	Kapasitas Desain (l/dt)	Kapasitas Produksi (l/dt)	Prosentase (%)	Pemakaian Air Instalasi (%)
Mata Air	Bandung Utara – Lembang	170	93	55 %	
Air Tanah	Air Tanah (Sumur Artesis)	530	209	39 %	-
Air Permukaan	Pengolahan Badaksinga dari S. Cisangkuy dan S. Cikapundung	1800	1503	84 %	5
	Pengolahan Pakar dari S. Cikapundung	600	596	99 %	3,34
	IPA Mini Dago Pakar	60	42	70 %	2,89
	IPA Mini Cibeureum	40	40	100 %	2,50
	IPA Mini Cipanjalu	20	14	70 %	3,62
	IPA Mini Cirateun	5	3	60 %	2,50
3	Jumlah	3225	*2500*	78 %	5

Sumber: Bagian Produksi Air Permukaan PDAM Kota Bandung, 2005

The water distribution system has four zones (Bandung Utara, Bandung Timur, Bandung Barat, and Bandung Tengah Selatan) served by six major reservoirs. See Table 19.

Ujung Berung in northeast Bandung is operated as a separate zone. Water comes from three sources: springs, the Sungai Cipanjalu (20 L/s), and local wells. There are no PDAM water storage facilities for this zone.

Table 19 PDAM Distribution System Reservoirs (2005)

Reservoir	Volume (m^3)	Elevation (m)	Water Source	Serves
R. IX Cikutra	11,000	747,4	Air Tanah	Timur
R. X Cipedes	11,000	748,7	Air Tanah	Barat
R. XI Ledeng	3,000	924,15	Mata Air Ledeng	Utara
IPA Ledeng	100		Mata Air Ledeng	Utara
R. XII	7,500	845	S. Cikapundung	Utara
R. Badak Singa	10,000	744,5	S. Cikapundung S. Cisangkuy	Tengah Selatan
6	42,600			

Table 20 Service Connections and Water Consumption (October 2005) by Kecamatan

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
		Population			Water	(3)/(4)	(5)/(4)	(6)/(4)	(6)/(5)
No	Kecamatan	(People)	Connection	Consumption	Sold	Pop/Connect	m3/connect.	Rp/connect.	Rp/Consump.
			(unit)	(m3)	(Rp)	(Pop/Unit)	(m3/unit)	(Rp/unit)	Rp/m3
1	Bandung Kulon	130,256	6,825	102,982	232,269,260	19.09	15	34,032	2,255
2	Babakan Ciparay	129,535	3,582	49,765	118,926,090	36.16	14	33,201	2,390
3	Bojongloa Kaler	118,726	6,109	91,199	205,636,575	19.43	15	33,661	2,255
4	Bojongloa Kidul	77,908	4,387	86,794	207,754,695	17.76	20	47,357	2,394
5	Astanaanyar	73,777	7,771	148,238	361,880,035	9.49	19	46,568	2,441
6	Regol	79,230	8,049	147,754	390,855,810	9.84	18	48,560	2,645
7	Lengkong	75,122	10,550	228,842	655,721,360	7.12	22	62,154	2,865
8	Bandung Kidul	45,715	2,241	50,585	116,191,685	20.40	23	51,848	2,297
9	Margacinta	108,915	8,017	127,245	308,474,250	13.59	16	38,478	2,424
10	Rancasari	66,046	2,070	28,466	68,088,490	31.91	14	32,893	2,392
11	Cibiru	81,334	82	1,498	3,847,960	991.88	18	46,926	2,569
12	Ujungberung	78,746	1,394	22,928	49,947,440	56.49	16	35,830	2,178
13	Arcamanik	64,075	2,181	38,247	87,185,710	29.38	18	39,975	2,280
14	Cicadas	101,076	9,396	151,103	341,074,555	10.76	16	36,300	2,257
15	Kiaracondong	128,111	8,511	124,374	286,003,925	15.05	15	33,604	2,300
16	Batununggal	122,437	6,554	107,945	266,967,935	18.68	16	40,734	2,473
17	Sumur Bandung	39,269	4,446	147,258	442,381,375	8.83	33	99,501	3,004
18	Andir	102,716	5,036	77,316	202,304,315	20.40	15	40,172	2,617
19	Cicendo	92,867	5,676	128,722	342,508,925	16.36	23	60,343	2,661
20	Bandung Wetan	37,670	4,089	117,258	351,181,160	9.21	29	85,884	2,995
21	Cibeunying Kidul	111,582	6,743	92,581	214,618,360	16.55	14	31,828	2,318
22	Cibeunying Kaler	71,712	4,918	125,189	329,861,390	14.58	25	67,072	2,635
23	Coblong	120,773	8,860	307,334	863,706,040	13.63	35	97,484	2,810
24	Sukajadi	102,522	5,851	154,951	391,177,140	17.52	26	66,856	2,525
25	Sukasari	78,402	5,641	126,451	337,614,185	13.90	22	59,850	2,670
26	Cidadap	49,918	2,295	66,061	191,698,385	21.75	29	83,529	2,902
Wilayah Kota Bandung		**2,288,440**	**141,274**	**2,851,086**	**7,367,877,050**	**16.20**	20	52,153	2,584

APPENDIX C
NOTES ON WATER SERVICE TO GEDEBAGE

Gedebage is a planned development[10] of 526 hectares (ha) that includes residential housing (100 ha) and apartments (4 ha); commercial facilities (20 ha); hospital; train station; stadium; hotel; and retention pond (160 ha) for storm water. It is proposed by a private sector company as a Kota Mandiri (self-sufficient) and will be located in the southeast of the Kota. PDAM is planning on providing water supply of 200 Liters per Second (equivalent to 12,000 L/minute or 720 m^3/hour). Following are some ideas for PDAM to consider about providing this volume of water.

1. Pipeline---this volume can be provided by a steel pipeline with lining of coal tar or cement, 400 mm internal diameter, Hazen-Williams C factor of 140. Expected flow velocity would be about 1.2 meter per second
2. Single Customer---it will be easier for PDAM to enter into a contract with the Property Manager so there is only one customer and one invoice.
3. Customer Service Meter to measure flow
   a. should be smaller than the pipe diameter. For example a Magnetic Flow meter manufactured by Badger Meter (USA) size 150 mm (6 inch) has a flow range up to 12700 L/minute while a 200 mm (8 inch) has a range to 22600 L/minute. Accuracy is $\pm$0.5%, probably more than the PDAM needs. The advantage of smaller size is lower cost to purchase and install.
   b. Needs a certain minimum distance of straight length unobstructed pipe upstream and downstream of the meter to ensure uniform, non-turbulent flow. Turbulent flow is created by bends, valves, and other fittings and causes incorrect meter readings. The minimum distance varies and is meter specific but in general is on the order of 5 to 10 times the meter diameter.
   c. Could be two meters installed in series, one owned by PDAM and the other owned by the Customer. When the difference between the two meters is x%, the meters should be recalibrated. The value of x can be agreed during negotiations for contract for water supply and would be based on the sale price of the water. For example over a 24 hour period, a 6% difference could amount to slightly over 1000 cubic meters.
4. Water Storage---periodically PDAM will have to shut off flow for maintenance and repair; also there will be peak periods of higher water usage. Thus the Kota Mandiri should have its own water storage reservoir. A reasonable size would be 20% of average daily demand which at 200 L/s is about 3500 cubic meters, about 4.5 hours supply.

[10] "Recana Induk Kawasan Gedebage", PT. Yodya Karya, 26 Dec 2005.

APPENDIX D
OUTLINE IMPLEMENTATION PLAN

NO.	PROGRAM ACTIVITY	YEAR
I.	**THE EXISTING IPA BADAKSINGA**	
1.1.	Calibrate existing flow meters at Badaksinga to confirm flows from Cisangkuy and Cikapundung	2006 - 2007
1.2.	Modify IPA Badaksinga to receive water from Dago Bengkok II	2006 - 2007
II.	**SOURCE OF DAGO BENGKOK II**	
2.1.	Construct Dago Bengkok II	2006 - 2007
2.2.	Install flow meters (use portable and insertion flow meters to reduce costs with accuracy ± 5%) in the transmission system, as a baseline for measuring water loses.	2006 - 2007
2.3.	Connect Dago Bengkok II to Badaksinga	2006 - 2007
III.	**SOURCE OF CISANGKUY**	
3.1.	Conduct topographic surveys to accurately measure or confirm ground and pipe elevations.	2006 - 2007
3.2.	Install flow meters (use portable and insertion flow meters to reduce costs with accuracy ±5%) in the transmission system, as a baseline for measuring water loses.	2006 - 2007
3.3.	Reline Pipa Baru	2008 – 2009
3.4.	Rehabilitation as required for Cisangkuy system.	2008 – 2009
3.5.	Disconnect the Pipa Lama from Badaksinga	2009
IV.	**NEW IPA CIMENTENG**	
4.1.	Pilot study water treatment	2006 - 2007
4.2.	Detailed Engineering Design and Construction of IPA Cimenteng	
4.3.	Connect Pipa Lama to IPA Cimenteng	2009
V.	**SERVICE AREA IN SOUTHERN BANDUNG** (Between Jalan Tol Padalarang – Cileunyi And Jalan Soekarno-Hatta)	
5.1.	Repair leakage & expand distribution network in southern Bandung	2006 - 2007
5.2.	Setup the method of water sale to Gedebage and Kabupaten Bandung (recommend PDAM install one bulk meter and establish one customer account for each)	2009

APPENDIX E
NOTES FOR MEETING (10 MARCH 2006) PDAM KOTA BANDUNG, USAID, AND ESP-JAKARTA

PREPARED BY SHER SINGH, ESP-JAKARTA

INTRODUCTION

Discussions with various PDAM staff identified issues of concern that can be grouped according to technical, financial, and human resources. Related to this project are issues concerning source water quantity and quality; non-revenue water; and reliability of data. Specifically

1. Problems with water sources (pollution, access, decreasing in volume)
2. Large volume of Non-Revenue Water (defined as the difference between water produced and water sold).
3. Inconsistent data from other government agencies

This memo provides some ideas about actions the PDAM can take toward these issues.

PUBLICIZE THE PROBLEM

Problems of water quantity and water quality are beyond the control of the PDAM and are the responsibility of Central and Province (Jawa Barat) governments. The PDAM can publicize the issue through newspaper articles; letters to customers (e.g. as an attachment to the customer invoice); participation in forums and conferences; and organizing groups of citizens to investigate and advise.

Concerning groundwater, it might be useful to prepare an analysis comparing cost of pumping one cubic meter from various depths to the cost of one cubic meter from PDAM. The idea is to show it is more economical to connect to PDAM than to rely on a deep well and suffer increasing electricity costs.

MEASURE VOLUME OF SOURCE WATER

PDAM Kota Bandung transports its surface and spring water source long distances before treatment. Considering the shortage of source water quantity it is important for PDAM to minimize losses. Therefore we recommend the PDAM measure and record the volume of water it withdraws from river, spring, and ground sources and compare it to the water produced to identify lost water.

An expensive, highly accurate meter can not be justified financially because monitoring source water does not have an impact on revenues from water sales and in the case of gravity flow has little impact on delivery costs.

For source water systems it would be appropriate to use insertion flow meters that do not have to be left in place. For example for pipes 50 mm to 300 mm (12 inches) an insertion magmeter has an accuracy of 2% of flow rate; costs about half the amount of a full bore (i.e.

in-place) magmeter, and can be installed on existing pipe without having to remove a section of pipe or shutting it down. Installation is done via a ball valve or a mounting system to make a pressure tap while the pipeline is still under pressure ("hot-tap").

A pitot tube is a device which converts the velocity head in a flow stream to a pressure head. Two connections, 90 degrees apart, either flanged or threaded, are needed per pipe. Installation is similar to insertion magmeter described above. Accuracy can be 1% of flow.

It is possible to install permanent fittings so that the insertion meter can be moved from one location to another to make measurements. This minimizes procurement costs. The length and weight of the insertion meter depend on pipe size and for large diameter pipe may be so long and heavy that two people are needed to place and insert.

Portable ultrasonic flowmeters can be used but require direct contact with the pipe surface (i.e. remove paint and other protective coatings) and results may be influenced by pipe interior lining.

RELINE PIPELINES TO IMPROVE CARRYING CAPACITY

Actual carrying capacity of a pipeline decreases over time due to deterioration of the inner lining. There are techniques to reline a pipe in-place with minimal excavation and practically no replacement. [Contact Aart Merkelijin, ESP-Aceh WATSAN Advisor] . This can be an economical way to increase water volume.

WALK THE TRANSMISSION LINE TO IDENTIFY LEAKS

Walking along the transmission line is a fast, inexpensive method to identify major leaks, malfunctioning air valves, encroachments and endangerments. Such a walk does not have to be completed in one day. Best time would be during the dry season where leaks and lush green vegetation (an indicator of a possible leak) can be more easily identified.

MAINTAIN PIPELINE VALVES

A transmission pipeline typically has air valves at high points; wash-outs at low points, shut off valves to isolate sections for repair, sometimes flow control valves (e.g. butterfly valve). All these items need inspection and maintenance that includes "valve exercise" (closing and opening to assure movement). This requires a trained work crew with specific equipment and a documented maintenance plan to schedule and record work.

USE REPRESENTATIVE SAMPLE OF CUSTOMER WATER METERS

Reducing Non-Revenue Water (NRW) increases revenues, reduces operating costs, and makes more water available. You cannot control what you cannot measure. Thus to control NRW requires accurately measuring the volume of water entering the distribution system, e.g. the effluent from water treatment plants and reservoirs, and the amount of water withdrawn as measured by customer water meters.

PDAM Kota Bandung has about 140,000 connections of which 126,000 (90%) are classified as household (domestic). PDAM schedules monthly meter reading but with that many meters in place it is likely some meters cannot be accessed or are out-of-order or are incorrectly read or inaccurately reported.

It is possible to measure a smaller, representative sample of meters and calculate average water consumption that will be close to actual consumption as measured by 100% of the meters. Applying principles of statistics, a sample size of 384 can provide data with 95% confidence the results will be within 5% of the average. For PDAM the estimated average is 20 cubic meters per connection per month, so $\pm$5% would be 19 to 21 m^3/con/mo. As shown in the following table, increasing sample size provides increased confidence and closer interval to average.

Sample Size	Error in Interval Estimate	Confidence Level
96	10 %	95 %
384	5 %	95 %
666	5 %	99 %
9604	1 %	95 %
16641	1 %	99 %

Thus the PDAM could install 400 new, accurate meters at representative households, measure monthly, and have adequate confidence the results are within 5% of the actual average. With this number the PDAM can have a better idea about actual water loss and can identify household customers whose consumption is significantly lower (indicating a meter may not be working) or higher (indicating a problem; perhaps misuse of water).

PDAM should have no difficulty finding locations for these meters. With about 1000 employees the PDAM could do this program without having to go outside their own organization.

CONSIDER PERFORMANCE BASED CONTRACT FOR NRW REDUCTION

After installing bulk meters to measure water entering the distribution system and installing a small sample of meters at households, the PDAM can make a better estimate of water loss. After establishing this baseline, the PDAM could tender a performance-based contract for NRW reduction where compensation for work accomplished is based on level of reduction achieved. For example, if the contractor succeeds in reducing NRW from 40% to 32%, then payment would be based on that 8% reduction. To do this successfully requires that the PDAM establish a baseline and be able to measure contractor's accomplishments.
Based on experience elsewhere this type of contract works best when

1. Compensation is a combination of a subsistence rate (e.g. travel expenses, salary, housing allowance) and a rate based on performance; and
2. The agency commits money for capital improvements such as installation of zone meters in the distribution system; replacement of leaking valves and pipes.

DEVELOP PDAM NUMBERS TO ESTIMATE WATER DEMAND

During data collection we found

1. Three different rates for future population growth:
    a. % from Kota BAPEDA
    b. 1.5% from Kota Badan Pusat Statistik (BPS)
    c. 0.9% from analysis of Kota BPS data for 2000—2004.

2. Two different numbers for number of people per household
   a. from Kota BPS
   b. 5 from PDAM data
      This difference between BPS and PDAM data results from different methods of counting the number of people per house. BPS counts number of "family cards" per address while PDAM counts number of people physically living in the dwelling. Consider for example one house with husband and wife who have a family card and the wife's mother who has her own family card. For BPS census, there are 1.5 people per house, but for PDAM water supply, there are three.

We conclude that PDAM cannot always rely on data from outside agencies and recommend the PDAM establish a Planning Committee that would meet once or twice a year to agree relevant numbers to be used for planning and estimating purposes.

We suggest PDAM meet with other agencies providing public services such as PLN (electricity) and Dinas Kebersihan (trash collection and disposal) to learn how they forecast population and service demand. It may be useful for these agencies to meet once or twice a year to discuss this matter and mutually agree numbers for the year.

During the meeting the subject of energy efficiency was discussed. Electricity is not a significant cost item for the PDAM, nevertheless PDAM should

1. Perform an Energy Efficiency Assessment to identify major power uses and demand profile[11] with emphasis on pumps and motors
2. Ask PLN about possible cost savings by controlling Power Factor[12].

Conduct pump efficiency tests that compare the relationship between energy consumed (kWh) and water flow (L/s) at a given pumping head (m) to determine overall system efficiency, electrical motor performance, and pump hydraulics. If performance is below standards then repair, replace, or upgrade. This activity could be contracted out to the private sector.

11 Power Demand Profile identifies quantities and when power is used according to time-of-day, day of week, season, or other factors

12 Motors for intake and discharge pumps have high electrical load consumption, especially at start-up. This electrical load is described by the Power Factor (PF). Electricity Providers often invoice commercial and industrial customers for this type of electricity demand.

APPENDIX F
ESTIMATED PROJECT COSTS

CAPITAL COSTS

The following table summarizes infrastructure projects and estimated costs that do NOT include

1. Land Acquisition
2. Detailed Engineering Design, Environmental Impact Assessments, Construction Management (typically 12.5% of construction cost)
3. Commercial Contingencies (inflation, currency exchange)
4. Physical Contingencies (changes to quantities or unit costs)
5. Value Added Tax (*Pajak Pertambahan Nilai*, 10%)

Costs are based on estimates prepared for similar for other PDAM

Table 21 Estimate of Capital Costs for Proposed Projects

Infrastructure	Components & Tasks	Quantities	Estimated Cost (Billion Rp)
Dago Bengkok Transmission Pipeline	Construct Intake Procure and Install Pipe Install Valves & Fittings Connect to IPA Badaksinga	Intake = 600 L/s Spiral Steel Pipeline, D=700mm, L=4200m Shut off Valves, Air Valves, Washout Bulk Water Meter	50
Pipa Baru Pipeline	Repair Valves Shutdown, Dewater & Inspect Install Measuring Devices	Inter-connecting Water Control Valves (6); Over Speed Valves (OSV), Air Valves, etc. Steel Pipeline D= 850mm, L=32,00m cement lining	60
IPA Cimenteng	Design and Construct	1100 L/s Coagulation (alum); filtration; disinfection (Cl_2 gas); bulk meter	110
Pipa Lama Pipeline (Existing)	Repair Valves Shutdown, Dewater & Inspect Repair, rehabilitate	Gray Cast Iron Pipe 800mm (14000m) and 900mm (17000); valve similar to Pipa Baru	40
Pipa Lama (Modified)	Cut and connect to IPA influent Cut and Connect to IPA Effluent Make connection to serve Kabupaten Cut and make connection to serve Kota	Pipe to be cut is 800 to 900 mm Section to be removed (or left buried in place) is on the order of 200 meters	40 300

PDAM proposes to use HDPE instead of spiral steel pipe for Dago Bengkok transmission pipeline which will reduce the cost by about 50%.

It is recommended PDAM investigate relining the interior portions of the Pipa Baru and Pipa Lama in order to improve flow capacity. The cost for this depends very much on specific site conditions so it is not possible to estimate costs for this without getting an expert to inspect and estimate.

OPERATION AND MAINTENANCE EXPENSES

Since the water flow in the transmission pipelines is by gravity, the principal operation and maintenance expenses are staff wages and annual costs for replacement and repair of pipeline and equipment.

Using data from a recent study[13], staff wages are based on a full time operation and maintenance staff of two work crews, each consisting of 1 foreman and three skilled laborers. Assume monthly salary for one work crew = 6 Million Rp. Thus annual cost for two work crews is 144 M Rp. So for this analysis use 150 M Rp.

Maintenance and repair expenses for the pipeline, valves, and other appurtenances are assumed at the annual rate of 1% of the cost for valves and appurtenances which are about 20% of the pipeline costs in Table 1 above. Thus 1% x (20% x 160 B Rp) = 320 M Rp. So for this analysis use 300 M Rp.

Table 22 summarizes the estimated operation and maintenance expenses for the Cisangkuy and Dago Bengkok Transmission Pipelines assuming inflation rate of 7% per year.

Table 22 Estimate of Capital Costs for Proposed Projects Million Rupiah

YEAR	Labor	Maintenance & Repairs	Total
2006	150	300	0
2007	161	321	0
2008	172	343	515
2009	184	368	551
2010	197	393	590
2011	210	421	631
2012	225	450	675
2013	241	482	723
2014	258	515	773
2015	276	552	827

Years 2006 and 2007 are shown at zero because the pipelines are not completed until year 2008

[13] Phase II Feasibility Analysis For the Proposed Subang Water Source and Water Transmission Main Project, T. Stephen Jones, ESP-Jakarta, 2006

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