CHAPTER 4 Monitoring Plan

Groundwater monitoring is necessary for Groundwater conservation. Monitoring item should be groundwater level, yield of well and groundwater quality. Monitoring plan is summarized in Table-4.1. Monitoring wells should be selected following items below.

Table-4.1 Monitoring Plan

Item	Number of monitoring	Frequency of observation	Observation site	Purpose of Monitoring	Organization in charge
Groundwater level	12	Automatic recorder	Quaternary wells	- Long-term groundwater level fluctuation of Bogotá plain. - Result of artificial recharge in Bogotá Plain	EAAB
	10	Automatic recorder	Cretaceous wells	- Influence by groundwater development in Eastern Hills - Effect of artificial recharge in Eastern Hills	EAAB
	About 300	4 times/year	CAR monitoring wells	- Influence by artificial recharge in Bogotá plain - Groundwater level of Bogotá	CAR
	280	Once/month	Wells registered to DAMA	- Influence by groundwater development in Eastern Hills	DAMA
Yield	About 300	4 times/year	CAR monitoring wells	- Yield	CAR
	About 280	Once/month	Well registered to DAMA	- Yield	DAMA
Water quality	20	Twice/year	Sampling sites from 100 of JICA water quality analysis.	- Change of Water quality in Bogotá Plain	CAR
	10	Twice/year	-Wells near artificial recharge wells in Eastern Hills -Wells near artificial recharge wells in Bogotá Plain	- Change of water quality by artificial recharge	DAMA EAAB
Land Subsidence	12	Twice/year	12 Quaternary wells with JICA automatic recorders	-Land subsidence by lowering of groundwater level	CAR DAMA

(1) Groundwater level

Bogotá City Area

It is expected that groundwater level will go down by groundwater development of the Eastern Hills. Lowering of groundwater level, which will be observed by monitoring, should be compared with calculated one. Development plan should be examined based on this result.

Bogotá Plain

Groundwater level should be observed by monitoring wells that will be selected near artificial recharge wells in order to confirm effect of artificial recharge. For this monitoring, 12 wells with automatic recorders by JICA and regular monitoring wells registered to CAR should be used.

(2) Yield

DAMA implements monthly monitoring of wells registered to DAMA. This monitoring should be continued to confirm well yield. Yield of wells that are registered to CAR is not observed now. Instead, CAR should continue monitoring of yield of about 300 wells, which are regular monitoring wells of CAR.

(3) Water quality

Twenty wells should be selected from about 100 wells from which groundwater was sampled for this Study, and water quality analysis should be done for representative items twice a year. This analysis will give information on fluctuation of water quality of long period. Especially, it is necessary to analyze groundwater quality of wells near artificial recharge wells to identify influence by artificial recharge.

(4) Land subsidence

It is pointed out that land subsidence is taking place by over-pumping in the Study Area. However, currently there is no data that proves phenomena above. Purpose for monitoring of land subsidence is to evaluate relation between groundwater level and regional land subsidence. It is Quaternary Formations in the central and western part of Bogotá Plain that is target of this monitoring. Land subsidence, which is caused by lowering of groundwater level, must be examined relating to change of groundwater level. Consequently, altitudes of 12 sites of Quaternary wells with JICA automation recorders should be observed regularly. Altitude of leveling points, which will be installed near observation wells, should be measured from reference leveling points in mountain/hill (stable points against land subsidence) nearest to each observation wells. Monitoring should be carried out regularly twice a year. Relation between land-subsidence and groundwater level should be examined by use of the monitored result.

CHAPTER 5 Institution and Operation/Maintenanace

5.1 Institution for Water Resources and Groundwater Management

(1) Establishment of Joint Commission for Water Basin Management

Water resources in Bogotá Plain is managed by CAR and DAMA according to Law 99 of 1993. Regional Autonomous Corporation of Guavio also takes the charge in a quite limited area. Despite the concept of integrated water basin management, entities sometimes manages with their own standard and criteria, such as different levels of charges for water rights. As discussed in the meetings for problem identification, information on groundwater potential, water quality, volume of groundwater abstracted, etc., is scattered in various related organizations. No entity has good understandings on the whole conditions on groundwater. Organizations in charge of the management are quite reluctant to give permissions for new development. In some central parts of Bogotá Plain, groundwater resource has been exploited extensively and required measures for conservation of the resource have yet to be identified.

Establishment of a Joint Commission is required, as defined in Law 1604 of 2002. The

composition of the commission members will be directors, or their delegates of the following organizations.

1) CAR
2) DAMA
3) Regional Autonomous Corporation of Guavio
4) Regional office for management of the national park
5) Regional Autonomous Corporation of Magdalena River Basin

In the long term, however, members should be added by representative from other groups, including water users' associations, bulk water users such as water supply entities, municipalities and citizen groups such as NGO to realized social participation stipulated in the Law No. 2811 of 1974 (National Code for Renewable Natural Resources and Protection of Environment). At this stage, the Joint Commission will take full functions as a deliberative entity. Drafting policies, plans as well as norms/standards, however, should be carried out by the regulatory entities, such as CAR and DAMA, even at this stage. Typical or recommendable organization structure as well as functions of entities involved in the water resources administration are illustrated blow.

Concept to be applied for water resources management is a coordinated one among interests of stakeholders such as governmental managing entities, users, and environmental organizations, rather than the one with restriction-education by the government and with obedience by the users or people. For the coordination norms/standards/guidelines, such as water pricing, as recommended in the section below are instruments to be prepared by specialists or experts and to be approved by the Joint Commission composed various types of stakeholders.

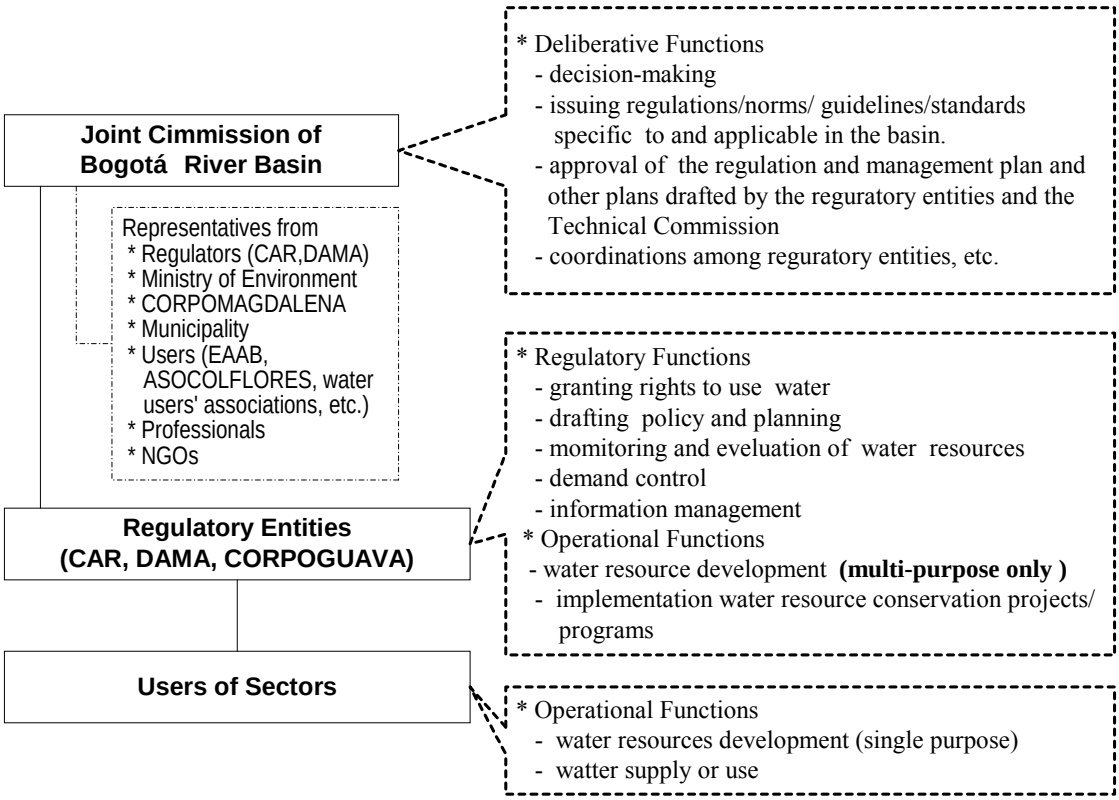

Figure 5.1 Recommendable Organization Structure of Water Resource Management of the Bogotá River Basin

(2) Establishment of Technical Commission for Groundwater Management

Establishment of a Technical Commission under and to support to Joint is also recommendable. The Technical Commission will be in charge of the followings:

- To integrate monitoring (volume of abstracted water, water level and quality) activities e and valuation on groundwater potential and availability
- To collect, analyze information on and to estimate the present and future demands for groundwater
- To make drafts of technical standards/guidelines for groundwater management
- To make investigations and recommendations on measures for groundwater protection, conservation and sustainable development
- Activities for technical upgrade of the relevant organizations and persons

Members of the Technical Commission would be representatives or staff specialized for hydrogeology from groundwater management entities, professional group, users and drillers in charge of sustainable development, as shown below.

1) CAR
2) DAMA
3) IDEAM
4) INGEOMINAS
5) Major Users (EAAB, ASOCOLFLORES, etc.)
6) Colombian Association of Hydrogeologists
7) Drilling companies

Since establishment of Joint Commission may take a long time, the Technical Commission should immediately be established as a technical group or a task force.

(3) Operation for Monitoring and Evaluation

Measurement and monitoring activities should be implemented by the CAR, DAMA and EAAB who manages monitoring wells. The Technical Commission, or the Group before the establishment of the Joint Commission, should carry out analysis and evaluation of the data obtained from the monitoring by various organizations.

The important thing is to prepare a common information system or a database to be shared by all environmental authorities. The Technical Commission, or the Group should prepare the information system based on the results of the Study.

As for data on volume of abstracted, it would better to compile data submitted from users into monitoring system. There are nearly 1,000 wells registered to CAR other than those designated as monitoring wells for the purpose. It is necessary to encourage for these well users to install meters and to submit the data on volume of abstracted water.

(4) Zoning and Tariff Setting for Demand Control and Saving of Groundwater

As stipulated in the Law No. 2811 of 1974 (National Code for Renewable Natural Resources and Protection of Environment), Decree No. 1729 of 2002, or other laws and decrees, zoning is a basic tool for the management of environment and renewable natural resources.

Currently Accord of CAR No. 8 of 2000 defines water charge according to the portion of individual volume of abstraction rather than total volume of used in some zone. For effective demand control and the resource conservation by promotion of saving water use, water pricing should take account of conditions of demand-supply. The Technical

Commission or Group should prepare the draft of zoning and tariff setting based on the results of the Study and the monitoring and evaluation for the approval of the managing entity.

(5) Promotion of Well Registration and Establishment of Registration of Drillers

Nearly 6,000 unregistered wells are estimated there in the Study Area. In case these wells are used, the use may be illegal. It is pointed out in the discussion meetings that there are many abandoned wells that may be contaminant source of aquifers. It is necessary to carry out investigation of unregistered wells and to let the users or owners to register in case in use or to scrap adequately in case out of use. For the investigation and execution, it is necessary to define legal procedures as well as to carry out legal arrangement to give staff of CAR and DAMA, or contractors, legal status, such as rights to pass to private lands and buildings.

For wells to be drilled, a system for registration of well drillers is recommendable in order to realize adequate applications for well drilling, construction works, pumping tests, applications for groundwater water abstraction. Since system of permissions for drilling might be strongly opposed by the existing drillers or might be recognized as deprivation of freedom to choose profession that is secured by the constitution, registration system is recommended without rejection of registration to any application. Every person who wants to do drilling business has to apply for registration with information of representative of the company, list of engineers and available equipment and financial status. In case some illegal actions, such as drilling without application or permission, construction works disaccording to the permitted design, manipulation of data of pumping tests, are detected, the registration will be revoked and the person cannot drill for a certain period.

(6) Water Rights Application for Artificial Recharge

In Colombia, there is no experience of artificial recharge projects same or similar as proposed in the plan, and no legal provisions are stipulated so far. Artificial recharge will involve the three type of water as shown below.

a: Water to be taken from a river (surface water) for recharge

b: Water charged in an aquifer

c: Water to be abstracted (groundwater) from the aquifer and to be used

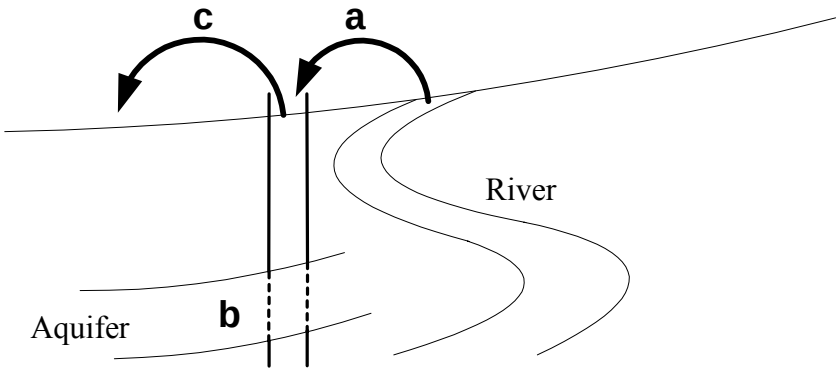

Figure 5.2 Types of Water Involved in Artificial Recharge

There may be two options for application for water rights in artificial projects. It is necessary to get permissions by managing entities for implementation of the projects despite whichever options of water rights application are taken.

A: Water rights application is not to be done at times of surface water (a of the above figure) intake but at times of groundwater (c) abstraction according to the volume abstracted. Artificial projects are not regarded as those to use water but those to

conserve groundwater or to increase the availability of groundwater resources (b) in this option.

B: The application is to be done at times of surface water (a) intake and not application at times of groundwater abstraction (b). Recharged water (b) is regarded as that stored in the ground by the surface water rights holders.

Since artificial recharge projects proposed in the plan have a nature of conservation of groundwater or amplification of groundwater availability for the times of emergency and dry seasons, option A would be recommendable for the projects of eastern hills and of the western plain. For the western plain project, entities managing of groundwater resource will implement the project by itself and it will be quite natural for option A to be applied and for users to applied water rights when they abstract groundwater.

5.2 Operation for Research and Development for Technology on Efficient Groundwater Use.

(1) Establishment of Project Implementation Unit

As proposed in the groundwater development and conservation plan, the project of technical research and development (R&D) are to be implemented to minimize groundwater use in the area of extensive use of the resource. Since the nature of project includes two major elements, i.e., water use for irrigation and the groundwater resource conservation, the project should be implemented by the organizations for the two sectors. CAR represents the organization of the resource conservation, while ASOCOLFLORES is the one of the resource use for development of the regional economy. The two organizations should establish a joint implementation unit for the project implementation.

Use of consultants is recommendable for the feasibility study of the project. In case international consultants are required, the Ministry should preferably apply technical assistance to foreign or international organizations. The Technical Commission or Group can work as internal consultants for advisor for the matter of the resource management. Participation of institutes for irrigation or agriculture should be encouraged especially for the component of the efficient irrigation with less groundwater.

(2) Financial Sources of the R&D Project

As stipulated in Law No. 99 of 1993 as well as Decree No. 1729 of 2002, water right charges as well as surtax in immobile property destined to environmental and renewable natural resources conservation to be collected by the users should be used for the investment of the resource conservation.

When all water charges for the estimated groundwater use ($1m^3$/second) farmers of floriculture are supposed to be paid and average rate of Col.\$15/ m^3 is assumed, the collected annual charges would reach to nearly half of the annual cost of the R&D project. Annual surtax on the property of those farmers would account for considerable portion of the project cost. For the implementation period of the R&D project, these resources should be allotted to the project with high priority. Additional funds should be complementally raised by the two organizations.

5.3 Human Resource Development

To upgrade technical level of the staff engaged in groundwater management and development, the followings are recommendable.

(1) Technical Transfer through this Study and the Feasibility Study and by applying JICA Training Schemes

Methodology adopted in and results of this Study should further studied by the counterparts. Through the feasibility study applied to the Government of Japan, entities in charge of groundwater management and development should take the opportunity for technical transfer from experts to be dispatched. Since JICA has prepared various training courses, entities in charge of groundwater management and development can utilized them for technical transfer.

(2) Mutual Edification through Activities in the Technical Commission

Technical upgrade can be realized through activities in the Technical Commission recommended above by exchanging information and mutual edification among the commission members. One of the major reasons for the proposal for the establishment is technical level up of the staff. Seminars for the drillers by the Technical Commission may contribute not only to technical upgrade but also to sound groundwater development.

(3) Scholarship

For upgrade of technical level to higher level in the field of hydrogeology, scholarship can be recommended for the young staff of CAR, DAMA, etc., to study in Colombian or foreign universities. It is recommendable that one or two staff, such as hydrologists or civil engineer, in every year from the two organization to take lectures on groundwater in Andes University or the National University in parallel with the jobs in each organization.

It can be proposed for IDEAM to give opportunity for the staff all over the country in charge of groundwater management by preparing a scheme for scholarship especially those who want to study in master courses or Ph. D. courses abroad. Scholarship should be repaid when the person will leave public entities or for water resources management within a certain period, say five to ten years after the persons finish the study.

CHAPTER 6 Design and Cost Estimate

6.1 Design

Design Criteria

In Colombia, according to the well drilling work, the civil work, concrete structure work and the electric installation work, next design criteria are allowed. These criteria depend on the criteria of USA so that it is based on these criteria the designs of the Master Plan Study on "Groundwater Development for Bogotá Plain".

(a) Well drilling work: AWWA-100(1997)

(b) Civil work:

Road construction work: Normas Invias
Installation of pipe work Reglamento Técnico del sector de Agua Potable y Saneamiento Básico RAS – 2000

(c) Concrete structure work:

Normas Colombianas de Diseño y Construcción Sismoresistente NSR – 98

(d) Electric work: Código Eléctrico Nacional Colombiano CEC

Installation of power supply work
Installation of electric facilities

Capacity of well

Arrangement of production and recharge wells is designed based on size and capacity of standard well as shown in Table-6.1

Table-6.1 Standard Capacity of Wells

Tyep of well	Aqifer	Length of well	Diameter of well	Specific/injection Capacity
Production well	Quaternary	200-300m	8 inch	1,500m^3/day
	Cretaceus	300m	10 inch	3,000m^3/day
Recharge well	Quaternary	200-300m	10 inch	1,500m^3/day
	Cretaceous	300m		10 inch

(2-1) Production Well Capacity

Quaternary well

From the result of Study, average specific capacity of Quaternary well is 60m2/day. This value can be used for yield of 500 to 1,500m3/day. Depth of well depends on thickness of Quaternary aquifer in place by place. In this Study, representative depth of Quaternary well is assumed 200 to 300m.

Cretaceous well

From result of exploratory drilling by EAAB, specific yield of Cretaceous is 34m2/day for yield of 3,000m3/day. Specific yield depends on yield of well. Above specific yield was estimated from result of step-draw down test of Suba and La Salle well and Vietnam pimping test. Well depth depends on thickness of Labor and Tierna Formation in place by place. Other than these formations, Dura Formation and part of Chipaque Formation also can be aquifer. Accordingly, 4 formations above is considered aquifer in this Study and well depth of 300m is proposed to pump up from these aquifers.

(2-2) Recharge well Capacity

Quaternary well

From assumption that recharge capacity is same as pumping capacity, specific injection of Quaternary well is set 60m2/day. This value can be used for water injection of 500 to 1,500m3/day. This value is valid under condition that maintenance of recharge well is usually carried out.

Cretaceous well

From assumption that recharge capacity is same as pumping capacity, specific injection of Cretaceous well is set 34m2/day for injection rate of 3,000m3/day. This value is based on result of Pilot Study for artificial recharge in Vitelma site. This value is valid under condition that maintenance of recharge well is usually carried out.

(3) Design of Facilities

The principal facilities for proposed two projects: groundwater development and conservation in Easter Hills of Bogotá Plain and groundwater conservation project in western part of Bogotá Plain are shown in Table-6.2 and Table-6.3.

Table-6.2 Facility Design － Groundwater Development and Conservation Project in Eastern Hills of Bogotá plain

Location	Facilities	Size	Unit	No
Soacha	Production well	Diameter/length: 10inch/150m+8inch/150m (300m)	No	8
	Submersible Pump	For 10inch well-75KV, H=150m, Q=4,500m^3/day	No	8
	Electric Facilities	Incoming line	m	3,200
	Pipeline	Diameter: 150mm	m	2,400
	Purification facilities	Aeration＋settling pond＋Chlorination Maximum capacity：18,000m^3/day	No	2
Vitelma (San Cristobal River)	Production well	Diameter/length: 10inch/150m+8inch/150m (300m)	No	10
	Production/recharge well	Diameter/length: 10inch/150m+8inch/150m (300m)	No	10
	Submersible Pump	For 10inch well-75KV, H=150m, Q=4,500m^3/day	No	20
	Electric Facilities	Incoming line	No	3,200
	Pipeline	Diameter: 150mm	m	2,400
	Settling pond	Capacity: 30,000m^3/day	No	1
	Purification facilities	Aeration＋settling pond＋Chlorination Maximum capacity：90,000m^3/day	No	1
San Diego (San Francisco River)	Production well	Diameter/length : 10inch/150m+8inch/150m (300m)	No	3
	Production/recharge well	Diameter/length : 10inch/150m+8inch/150m (300m)	No	3
	Submersible Pump	For 10inch well-75KV, H=150m,Q=4,500m^3/day	No	6
	Electric Facilities	Incoming line	m	250
	Pipeline	Diameter：150mm, 250mm, 300mm (Total)	No	900
	Purification facilities	Aeration＋settling pond＋Chlorination Maximum capacity：27,000m^3/day	No	1
Santa Ana ＆ Chico	Production well	Diameter/length : 10inch/150m+8inch/150m (300m)	No	4
	Submersible Pump	For 10inch well-75KV, H=150m,Q=4,500m^3/day	No	4
	Electric Facilities	Incoming line	m	900
	Pipeline	Diameter: 150mm	m	800
	Purification facilities	Aeration＋settling pond＋Chlorination Maximum capacity：18,000m^3/day	No	1
Cerros Norte	Production well	Diameter/length : 10inch/150m+8inch/150m (300m)	No	6
	Submersible Pump	For 10inch well-75KV, H=150m, Q=4,500m^3/day	No	6
	Production well	Incoming line	m	2,450
	Pipeline	Diameter: 150mm	m	1,750
	Purification facilities	Aeration＋settling pond＋Chlorination Maximum capacity：27,000m^3/day	No	1
	Access road	4m width	m	200

Table-6.3 Facility Design—Groundwater Development and Conservation Project in Eastern Hills of Bogotá Plain (continued)

Location	Facilities	Size	Unit	No
Suba	Production well	Diameter/Length: 10inch/150m+8inch/150m (300m)	No	2
	Submersible Pump	For 10inch well-75KV, H=150m, Q=4,500m^3/day	No	2
	Electric Facilities	Incoming line	m	200
	Pipeline	Diameter: 150mm	m	600
	Purification facilities	Aeration＋settling pond＋Chlorination Maximum capacity：9,000m^3/day	No	1
Yenoba Bueno	Production well	Diameter/length: 10inch/150m+8inch/150m (300m)	No	30
	Submersible Pump	For 10inchwell-75KV, H=150m, Q=4,500m^3/day	No	30
	Electric Facilities	Incoming line	m	20,000
	Pipeline	Diameter: 150mm, 250mm, 300mm (Total)	m	20,500
	Purification facilities	Aeration＋settling pond＋Chlorination Maximum capacity：45,000m^3/day	No	3
	Acess road	4m width	m	17,100
	Site (well)	30m x 30m	No	30
	Site (Purification)	30m x 30m	No	3
Total	Production well	Diameter/Length: 10inch/150m+8inch/150m (300m)	No	63
	Production/Recharge well	Diameter/Length: 10inch/150m+8inch/150m (300m)	No	13
	Purification facilities	Aeration＋settling pond＋Chlorination Maximum capacity：45,000m^3/day	No	10

Table-6.4 Facility Design—Groundwater Conservation Project in Western Part of Bogotá Plain

Location	Facilities	Size	Unit	No
<Torrent Recharge project>				
Chic Basin (5 sites) Frio Basin (5 sites) Subachoque Basin (4 sites) Total：14sites	Weir	Size 2x4x1m, Intake0.3x1m	No	14
	Channel	0.3x0.3x10m	m	14
	Settling Pond	Capacity 30,000m^3(100mx100mx3m)	No	14
	Purification	Purification instrument 3units	No	14
	Regulation tank	Capacity 20m^3	No	14
	Recharge well	Diameter/length: 10inch/150m+8inch/150m (300m)	No	28
	Submersible pump	For 10inchwell-7.5HP, H=150m, Q=500m^3/day	No	28
	Site	10,900m^3	No	14

6.2 Cost Estimate

Cost of the two projects proposed in the Master Plan, i.e., 1) Groundwater Development and Conservation in Eastern Hills of Bogotá Plain, 2) Groundwater Conservation in Western Part of Bogotá Plain, are roughly estimated as follows:

* Cost Estimate Standards: CONSTRUDATA CIELOS RASOS 124 SEPTIEMBRE NOVIEMBRE 2002, PUBLI LEGIS
* Unit Cost: As in July
* Exchange Rate: US$ 1 = Col.$ 2,700 (reference JPY 1 = Col.$ 20

Project costs are comprised of the following. Tax (IVA) is included in each element.

* Construction Cost: Cost for construction of main facilities and auxiliary Facilities including preparatory works and installation of equipment (Cost for; Materials + Equipment + Labor + Administration + Profits).
* Land Acquisition Cost: Cost for acquisition of land required for facility construction, including compensation cost.
* Engineering Fee: Fee to be paid to consultants required for tendering, detail design and cost estimate. 10% of the construction cost.

*	Administration Cost:	Cost for project owner to administer the project. 1% of costs for construction, land acquisition, and engineering.
*	Contingency:	10% of costs for construction, land acquisition, engineering, and administration.

Project cost of two projects that was estimated under above condition is shown as follows. See Table-6.5.

- Groundwater development and conservation project in eastern hills of Bogotá plain
  Project cost: 75.43 billion Colombian pesos
- Groundwater conservation project in western part of Bogotá Plain
  Project cost：40.48 billion Colombian pesos

Table-6.5 Rough Cost Estimate—Groundwater development and Conservation in Plain

Item	Groundwater development and conservation project in Eastern hills	Groundwater conservation project in western area	Total
1. Construction cost	60.36	25.60	85.96
2. Research	-	9.00	9.00
3. Land Acquisition cost / compensation	1.65	0.20	1.85
4. Engineering fee	6.04	2.56	8.60
5. Administration cost	0.67	0.28	0.95
6. Contingency	6.71	2.84	9.55
＜Total＞	75.43	40.48	115.91
	27.9 Million US$	15.0 Million US$	42.9 Million US$
	3,770 million Japanese yen	2,030 million Japanese yen	6,900 million Japanese yen

Note) IVA is included in each item. unit：billion Col$

CHAPTER 7 Implementation Program

(1) Organization for Implementation and Preparation of Fund

Implementation organization and preparation of funds for two projects that were proposed by Master Plan: ①Groundwater development project in Eastern Hills of Bogotá Plain, ② Groundwater conservation project in western part of Bogotá Plain, were proposed as shown below.

Groundwater development and conservation project of Eastern Hills of Bogotá Plain

Ministry of Environment should supervise and manage this project, because this is an integrated environmental project that is planed in two administrative areas (Cundinamarca Department and Bogotá City). Organization in charge of this project should be Bogotá City that will receive direct benefit (water supply for Bogotá City) from this project. Implementation organization should be Water Supply and Sewerage Company of Bogotá (EAAB) that is invested 100% of its capital by Bogotá City.

Funds for implementation (75 Billion Pesos) should be from environmental investment of Bogotá City, and it should be taken into account to use foreign funds (soft roan) for most part of implementation.

Groundwater conservation project in western part of Bogotá Plain

Ministry Environment should supervise and manage this project as well as above mentioned project. CAR, which takes responsibility of environmental projects in Cundinamarca Department, is suitable for organization in charge of this project. Implementation organization should be joint implementation unit (CAR and ASOCOLFLORES: Organizations to receive

benefit from this project) that will be newly organized.

Funds for implementation (40 Billion Pesos) should be from environmental investment of CAR, and it should be taken into account to use investment fund of ASOCOLFLORES and foreign funds (soft roan) for considerable part of implementation.

(2) Implementation Schedule

Implementation schedule of groundwater development/conservation project and institutional project on groundwater management and etc is proposed as shown in Table-7.1. Before implementation of two environmental projects: ① groundwater development and conservation project and ②groundwater conservation project in western part of Bogotá Plain, 2 to 3 years are necessary for preparation works (F/S and procurement of consultant/construction company).

Table-7.1 Rough Estimate of Project Cost – Groundwater Development and Conservation of Bogotá Plain

Item \ Year	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
1	**Project in Eastern**															
1-1	Preparation															
A	M/P and F/S	X	XX	XX	XX	XX										
B	Procurement															
	- Consultant						X									
	- Construction company						X									
1-2	Consultant Service															
A	Survey/Design/Cost Estimate						X									
B	Supervising of construction							XX	XX	XX	XX					
1-3	Construction (76wells)															
2	**Project in Western**															
1-1	Preparation															
A	M/P and F/S	X	XX	XX	XX	XX										
B	Procurement															
	- Consultant						X									
	- Construction company						X									
1-2	Consultant Service															
A	Survey/Design/Cost Estimate						X									
B	Supervising of construction							XX	XX	XX	XX	XX	XX	XX		
1-3	Construction															
	Project of Torrent Recharge (14 sites)							XX	XX	XX	XX	XX	XX	XX		
3	**Institutional Projects**															
3-1	Preparation (F/S)	X	XX	XX												
3-3	Groundwater monitoring				XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
3-3	Establishment of technical commission for groundwater management				XX	XX										
3-4	Activity of technical commission						XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX

CHAPTER 8 Initial Environmental Examination

Table-8.1 Checklist for Screening

No.	Environmental Item	Description	Evaluation	Remarks (Reason)
Social Environment				
1.	Resettlement	Resettlement due to land occupancy (transfer of rights of residence/land ownership	[Y][N][?]	N
2.	Economic Activity	Loss of base of economic activities on the land and water	[Y][N][?]	N
3.	Traffic and public facilities	Impacts on schools, hospitals and present traffic conditions, such as the increase of traffic congestion and accidents	[Y][N][?]	N
4.	Split of Communities	Community split due to interruption of area traffic	[Y][N][?]t	N
5.	Cultural Property	Damage to or loss of value of churches, temples, shrines, archaeological remains or other cultural assets	[Y][N][?]	N
6.	Water Rights and Rights of Common	Obstruction of fishing rights, water rights, rights of common	[Y][N][?]	N
7.	Public Health Condition	Worsening of public health and sanitation conditions due to the generation of garbage and the increase of vermin	[Y][N][?]	N
8.	Waste	Generation of construction waste, debris and logs	[Y][N][?]	N
9.	Hazards(Risk)	Increase in danger from ground failure, cave-ins, etc.	[Y][N][?]	N
Natural Environment				
10.	Topography and Geology	Changes of valuable topography and geology due to excavation or filling work	[Y][N][?]	N
11.	Soil Erosion	Topsoil erosion by rainfall after reclamation and deforestation	[Y][N][?]	N
12.	Groundwater	Lowering of the groundwater table due to over pumping and turbid water caused by construction work	[Y][N][?]	N
13.	Hydrological Situation	Lowering of river discharge and wetland surface water	[Y][N][?]	?
14.	Coastal zone	Coastal erosion and change of vegetation due to coastal reclamation and coastal changes	[Y][N][?]	N
15.	Fauna and Flora	Construction of breeding and extinction of species due to changes of habitat conditions	[Y][N][?]	N
16.	Meteorology	Changes of temperature, rainfall, wind, etc. due to large-scale reclamation and building construction	[Y][N][?]	N
17.	Landscape	Change of topography and vegetation due to reclamation. Deterioration of aesthetic harmony by structures	[Y][N][?]	N
Pollution				
18.	Air Pollution	Pollution caused by exhaust gas from vehicles or factories	[Y][N][?]	N
19.	Water Pollution	Groundwater pollution caused by an artificial recharges, etc.	[Y][N][?]	**?**
20.	Soil Contamination	Contamination caused by discharge or diffusion of sewage or toxic substances	[Y][N][?]	N
21.	Noise and Vibration	Noise and vibrations generated by vehicles and pumping operation	[Y][N][?]	N
22.	Land Subsidence	Deformation of the land and land subsidence due to lowering of groundwater table	[Y][N][?]	?
23.	Offensive Odor	Generation of exhaust gas and offensive odor by facility construction and operation	[Y][N][?]	N
Overall Evaluation: Project EIA is necessary for the project implementation			[Y][N][?]	Y

Table-8.2 Checklist for Scoping

Environmental Item			Evaluation	Reason
Social Environment	1	Resettlement	D	A wide area is not needed
	2	Economic Activities	D	ditto
	3	Traffic/Public Facilities	D	In rural
	4	Split of Communities	D	Hold only small spots
	5	Cultural Property	D	ditto
	6	Water rights & Rights of Common	C	Water right is not certain
	7	Public Health	D	Improve
	8	Waste	D	Avoidable by control
	9	Hazard(risk)	D	
Natural Environment	10	Topography & Geology	D	Small construction work only
	11	Soil Erosion	D	ditto
	12	Groundwater	C	Interference with exist. Wells.
	13	Hydrological Situation	D	Water intake when a high water season
	14	Coastal zone	D	Inland
	15	Fauna& Flora	D	Work not in forest or wetland
	16	Meteorology	D	Small scale construction and operation
	17	Landscape	D	ditto
	18	Air Pollution	D	Small construction work
	19	Water Pollution	D	Perfect prevention by control
	20	Soil Contamination	D	ditto
	21	Noise& Vibration	D	ditto
	22	Subsidence	C	Depend on geology and withdrawal quantity of groundwater
	23	Offensive Odor	D	Few exhaust gas in construction

Note: Evaluation Category

A : Serious impact is expected

B : Some impact is expected

C : Extent of impact is unknown(Examination is needed. Impact may become clear as study progresses

D : No impact is expected. IEE/EIA ia not necessary

CHAPTER 9 Project Evaluation

9.1 Economic Evaluation

Economic evaluation means the analysis of a project from the point of view of development planning or the country as a whole to judge whether an investment will generate worthwhile public benefit. In economic evaluation, financial cash inflow and outflow should be adjusted according to the principle of cost-benefit analysis. After adjustments of cash flow, Economic Internal Rate of Return (EIRR), Net Present Value (NPV) and Benefit-Cost Ratio (B/C) are calculated. From those figures, it becomes evident whether this project is meaningful or not from the point of view of a country.

9.1.1 Principal Assumptions

On estimating the economic cost and benefit, the following conditions and assumptions are applied. Assumptions in detail are given in Table-9.1.

(1) Price Level

For economic evaluation, the basic price level for cost and benefit estimates is set at prices of July 2002. Foreign exchange rate is set at Col$ 2,700 to US$ 1.00 based on the official exchange rate at the time.

(2) Opportunity Cost of Capital

Opportunity cost of capital represents the permissible economic rate of return for development projects. In this study 13% of opportunity cost of capital (the same as adopted in the study by World Bank in Colombia) is applied from the viewpoint of needs for emergency water development and groundwater conservation.

(3) Economic Value

In economic analysis, all goods and services applied in the project cost and benefits should be estimated on the basis of real economic value. In this report, local financial cost are converted into economic cost applying standard conversion factor of 96% calculated from the external trade of Colombia from 1996 to 2002.

(4) Economic Life

Various components with different specifics are used for construction. The economic life of each component is hard to define correctly because it varies depending on the conditions such as maintenance and weather. In this analysis, the economic life of the facilities and equipment is set principally based on the EAAB accounting standards as shown in Table-9.1. However, pumping motor is separately estimated at 8 years of economic life; to be replaced periodically in 8 years.

(5) Time Horizon for Evaluation

The economic evaluation period is set at 20 years in this analysis taking into account economic life of well that is considered generally 15-20 years in the Central and South America.

Table-9.1 Principal Assumptions

Items	Assumptions	
1.Prices	As of July 2002	
2.Exchange Rate of Colombian Peso	Col$ 2,700 = US$ 1.00	
3.Opportunity Cost of Capital	13 % (Based on the study by World Bank in Colombia)	
4.Standard Conversion Factor	96 % (Based on the external trade of Colombia from 1996 to 2002)	
5.Time Horizon for Evaluation	20 years	
6.Economic Life (Principally based on EAAB Accounting Standards)	1) Weir: 50 years	2) Sedimentation Pond: 50 years
	3) Well: 20 years	4) Treatment Facilities: 50 years
	5) Canal: 50 years	6) Electric Facilities: 20 years
	7) Pumping Motor: 8 years (to be replaced periodically in 8 years)	

9.1.2 Cost

The project costs are estimated in Chapter 6. The financial costs are converted to economic costs by applying economic value as mentioned above as shown in Table-9.2.

Table-9.2 Economic Project Cost

Project	Economic Project Cost	(Financial Project Cost)
1. Eastern Hill Project	Col$ 72.9 billion	(Col$ 75.4 billion)
2. Western Plain Project	Col$ 40.1billion	(Col$ 40.5 billion)

<Bogota Western Plain Project>

Besides, as for Western Plain Project, green house construction cost and related cost in line with cultivated area expansion are considered and then added to total cost of the Project. These costs are estimated based on the assumptions in Table-9.3, mostly according to the data from Instituto de Alta Direccion Empresarial.

Table-9.3 Green House Construction and Running Cost

Items	Assumptions
<Cost other than Project Cost>	Source: Instituto de Alta Direccion Empresarial
	1) Green House Construction - 4 US$/$m^2$ - Infrastructure cost: 28% of construction cost
	2) Replacement of Plastic Material: 15% of construction cost in every 24 months
	3) Running Cost: 18,000 US$/ha

<O&M Cost>

O&M (Operation and Maintenance Cost) of 2 projects is estimated based on the assumptions in Table-9.4.

Table-9.4 O&M Cost

Project	Assumptions
1) Bogota Eastern Hill Project	1) Electricity - Consumption: 74 kwh/day/well - Price: Col$87kwh (same as price of Viterma in 2000)
	2) Chlorine - Consumption: 70% of Wiesner (0.00229/m^3) - Price: Col$1,094/kg
	3) Groundwater Charge: Col$15/$m^3$
	4) Maintenance: 2% of 1)+2)
2) Bogota Western Plain Project	2% of project cost

9.1.3 Benefit

(1) Bogota Eastern Hill Project

(a) Municipal Water Supply

< Emergency Water Supply>

Benefit; groundwater supply amount in emergency

When the latest large collapse occurred at Chingaza in 1997, the water conducting from Chuza to Wiesner Plant stopped for 9 months. Therefore, water supply was covered

principally by San Rafael Reservoir water intake at Wiesner Plant and full operation of Tibitoc Plant.

In order to estimate the benefit, the same kind of large accidents or disasters is assumed to occur in every 15 years and then the water supply is also assumed to stop for 6 months considering 3-month stock of San Rafael Reservoir as shown in Table-9.5.

<Regular Water Supply>

Benefit; groundwater supply amount developed by the Project

Groundwater would be supplied routinely after development. However, the benefit could not be generated while current EAAB supply capacity exceeds the demand.

The supply shortage against demand is foreseen from 2018 judging from the report 'Actualización de la Proyección de la Demanda de Agua' of EAAB, assuming the operation as follows; continuous operation rate of 90% at Wiesner and El Dorado Plant, 2.0m^3/second of groundwater production and the rest of production by Tibitoc Plant. Accordingly the benefit can be counted from 2018. The base assumptions are presented in Table-9.5.

(b) Dissolved Oxygen Increase in Bogota River

Benefit; the reduction effect of Biological Oxygen Demand (BOD) in the Bogota River Basin after the location of the Tibitoc Plant

Most of the process at water treatment plant involves in the reduction of BOD. Hence, reduction of BOD in the river leads to the reduction of treatment cost at treatment plant. Increased volume of flow rate indicates an increase of dissolved oxygen in water and this brings effects on decrease of the concentration of BOD. The methodology of the estimation in the Bogota River is as the followings.

Reduction of BOD = Present BOD – 50% of Increased Oxygen × Coefficient of River Basin ($1/2^x$)
Benefit (year) = Reduction of BOD × Unit cost of BOD Treatment (per 1mg BOD)

Present BOD and dissolved oxygen concentration (Source: University of Andes, 2002) is modified depending upon the contamination condition at each locations. Coefficient of River Basin decreases with the square of the number of the basin from Tibitoc Plant due to decrease of intake oxygen. The actual unit cost of Salitre Waste Water Treatment Plant that is 0.005 Col$/mg BOD is applied herein. The base assumptions are presented in Table-9.5.

(c) Incremental Electric Generation at Bogota River

Groundwater development will decrease Tibitoc Plant intake from Bogota River. The decreased amount could be discharged into Bogota River in order to improve its water quality, especially of BOD reduction (see previous (b)). Besides, the discharged water will contribute to increase electric-power production of the power plant located at the lowest course of Bogota River stream. Hence, incremental GDP resulted from increased electric power will be counted as the benefit.

Electric power supply and demand of Colombia is currently as follows; supply capacity – 13,100MWh, and demand – 8,000MWh (source: EMGESA). The supply exceeds demand at present. However, electric power shortage is foreseen from 2014 assuming annual 4% growth of demand (3.2% of increase in 2002 forecasted by EMGESA). Accordingly the benefit can be counted from 2014. The base consumptions are presented in Table-9.5.

Table-9.5 Assumptions for Benefit

Benefit	Assumptions
1. Emergency Water Supply	1) Supply Volume: 4.6 m^3/s - 63 production wells: 3.3 m^3/s (=2.23 m^3/s x 150%) - 13 recharging wells: 1.3 m^3/s (=0.87 m^3/s x 150%)
	2) Water Price: 1,500 Col\$/m^3 (EAAB average price of Jan-April 2002)
	3) Magnitude of Emergency (Accident) - Frequency: every 15 year since 1997 - Water Supply Stop: 6 months considering 3-month water stock of San Rafael Reservoir
2. Regular Water Supply	1) Supply Volume: 2.0 m^3/s (=2.23 m^3/s x 90%) from Year 2018 when EAAB water production shortage against demand can be foreseen.
	2) Water Price: 1,500 Col\$/ m^3 (Average price of Jan-April 2002)
3. Dissolved Oxygen Increase effect in Bogota River	1) Present BOD concentration:15,13,50,250,90,49mg BOD/l at 6 locations
	2) Increased Dissolved Oxygen: Proportional to the increased water volume of by the ratio of 1.6 O2 : 2mg^3/second water (web site of CTI Science System Co. Ltd)
	3) Unit Cost: 0.005 Col\$/mg BOD (Salitre Waste Water Treatment Plant: 648 Col\$ /125,000 mg BOD)
4.GDP increase by contribution of incremental electric power at Bogota River Baisn	1) GDP contribution of electricity: 1% (=70% of 1.5% in Japan)
	2) Year 2002 GDP estimation: 190 Col\$ trillion
	3) Contribution from year 2014 when electric power shortage is assumed against demand.

(2) Bogota Western Plain Project

3% of total annual recharged water is assumed to be available for floriculture irrigation use. This available water amount is converted to cultivated area (ha) expansion taking into account floriculture water consumption (0.3l/second/ha). According to 'Anuario 1999, Governacion de Cundinamarca', floriculture industries contribution to agriculture GRDP of Cundinamarca reaches 50%. Thus the benefit of this project is set. Assumptions are shown in Table-9.6.

Table-9.6 Assumptions for Benefit

Benefit	Assumptions
Floriculture Contribution to GRDP Increase	1) 3% of Annual Recharged Water for Floriculture Irrigation Use
	2) Conversion to cultivated area (ha) taking into account floriculture use (0.3l/s/ha)
	3) Agriculture GRDP of Cundinamarca: 2.7 Col\$ trillion - Floriculture contribution : 50% to GRDP

9.1.4 Result of Economic Evaluation

Economic evaluation of 2 projects is conducted applying all criteria mentioned above. The results of economic evaluation are summarized in Table-9.7.

Table-9.7 Result of Economic Evaluation of 2 Projects

Project	EIRR	Net Present Value	B/C
Bogota Eastern Hill Project	23%	Col\$ 85.8 billion	1.9
Bogota Western Plain Project	21%	Col\$ 12.0 billion	1.3

(1) Analysis of Bogota Eastern Hill Project

EIRR of Bogota Eastern Hills Project results in 23% that obviously exceeds 13% of opportunity cost of capital. Consequently it must be noted that this project is feasible from economic point of view and worth promoting. The precise economic evaluation sheet is shown in Appendix-9.1.

(2) Analysis of Bogota Western Plain Project

EIRR of Bogota Western Plain Project comes out 21% that also evidently exceeds 13% of opportunity cost of capital. In case of 2% use of yearly recharged water, EIRR would be 17%, also exceeds opportunity cost. As a result, this project must be noted to be in economic efficiency and worth promoting. The precise economic evaluation sheet is shown in Appendix-9.2.

9.2 Financial Analysis

9.2.1 Bogota Eastern Hill Project

(1) Financial Evaluation

(a) Financial Cost

Financial cost consists of financial project cost and O&M cost (operation and maintenance cost).

(b) Revenue

Developed groundwater can be used for emergency supply. Moreover, groundwater will be supplied routinely for the purpose of substituting a part of production of Tibitoc Plant where the production cost is deemed too high. Accordingly the production cost of Tibitoc Plant (only variable cost such as electricity, chemical, water charges and concession fees as shown in Table-9.8) corresponding to groundwater supply amount is obviously recognized as financial revenue over the period of substituting purpose (until before 2018 when EAAB water supply shortage is foreseen). Financial revenue will be fully derived from groundwater supply amount from 2018 afterward.

Table-9.8 Estimated Variable Cost of Tibitoc Plant

Items	Cost (Col$/$m^3$)	Remarks
Electricity	45	Actual cost of year 2000
Chemical	21	Twice as large as Viterma of year 200
Water Charges	120	Assumed from actual case
Depreciation	50	Concession fee minus chemical cost (year 2000)

(c) Result of Financial Evaluation

Financial evaluation of Bogota Eastern Hill Project is conducted applying all criteria mentioned above. 14% of opportunity cost of capital is applied in this study based on the EAAB standards. Result of Evaluation is summarized in Table-9.9.

FIRR (Financial Internal Rate of Return) of Bogota Eastern Hill Project results in 23% that obviously exceeds 14% of opportunity cost of capital. Consequently this project is feasible from financial point of view and worth promoting.

The precise financial evaluation sheet is shown in Appendix-9.3.

Table-9.9 Result of Financial Evaluation of Bogota Eastern Hill Project

Project	FIRR	Net Present Value	B/C
Bogota Eastern Hill Project	23%	Col$ 62.9 billion	1.7

(2) Funds Scheme for Project Cost

Total project cost will amount to Col$ 75.4 billion (US$ 27.9 million).

Bogota Eastern Hill Project is groundwater development and conservation projects. However, it must be noted that the Project is obviously environmental project as well. Taking it into account, funds for project cost could be raised from foreign soft loan.

Accordingly, the funds composition is preliminarily proposed as follows;

- Own Funds of Implementation Organization (EAAB)	: 20%	Col$17.1 billion (US$ 6.3million)
- Foreign Soft Loan	: 80%	Col$58.3 billion (US$21.6million)

Note: Land acquisition cost and administration cost are excluded from Foreign Soft Loan.

Assuming that the domestic interest rate would be 13% per annum and foreign soft loan would be lent by 2.2% per annum, the weighted average interest rate of this project would be 4.6%. This considerably low interest rate could lift more the FIRR.

The funds scheme by year in line with construction progress is summarized in Table-9.10.

Table-9.10 Funds Scheme by Year

Year	Project Cost by Year		EAAB own		Foreign Soft Loan	
	Col$ billion	US$ million	Col$ billion	US$ million	Col$ billion	US$ million
2006	23.4	8.7	4.9	1.8	18.5	6.9
2007	17.2	6.3	3.6	1.3	13.6	5.0
2008	18.4	6.8	4.5	1.7	13.9	5.1
2009	16.4	6.1	4.1	1.5	12.3	4.6
Total	75.4	27.9	17.1	6.3	58.3	21.6

(3) Financial Conditions of EAAB

Water consumption has not grown as expected due to long lasting economic stagnancy; however profit of EAAB improved with tariff increase and cost cut. These activities generated Col$290billion of operational cash flow in 2001.

EAAB has aggressively invested to water and sewerage operation. The investment amounted to Col$390billion in 2001 that was procured from operational cash flow and loan. As a result, accumulated indebtedness of EAAB expanded to Col$630billion (as of July 2002), same as 2001 annual sales of Col$645billion. However, borrowing conditions of the loans are generally of long-term and low-interest rate. According to the repayment schedule, the repayment will peak in 2006 (Col$140billion) when EAAB will redeem corporate bond issued in 1999 for the first time. These amounts could be procured from operational cash flow and new loan. Financial Statements (Balance Sheet, Profit and Loss, Cash Flow, Indebtedness and Debt Repayment) of EAAB from 1996 to 2001 are presented in Appendix-9.4.

<Repayment of Loans for the Projects>

According to the loan repayment schedule estimated by the Study team, the sum of repayment and interest will peak in 2016 (Col$6.8 billion) as shown in Table-9.11. As it is commonly recognized in the capital and financial market that EAAB is financially sound, the repayment of loan and interest payment is judged to be executed as scheduled. Incidentally EAAB acquired the high credit rate of AA^+ from credit rating company (Duffs & Phelps de Colombia) for Col$ 270billion corporate bond issue programmed in 2002–2004.

Table-9.11 Loan Repayment Schedule

Items	2011	2016	2021
Repayment (Col$ billion)	1.4	5.1	3.2
Interest (Col$ billion)	3.1	1.7	0.7
Total	4.5	6.8	3.9

9.2.2 Bogota Western Plain Project

(1) Implementation Organization and Funds Composition

Joint implementation between Government and groundwater users (principally flower cultivators associated with ASOCOLFLORES) is proposed in execution of the Project. However, Government should play a majority role because principal objective of the Project is environmental conservation.

Total project cost amounts to Col$62.6 billion. The Project does not aim to recover its cost, so that the funds for the Project consist of investment or subsidies. Accordingly, the funds composition is preliminarily proposed as shown in Table-9.12.

Table-9.12 Implementation Scheme

Joint Partners	Funds Shares	Fund Resources	Remarks
Government	70%	Groundwater Charges	For the most part, charges collected from flower cultivator
		Investment or Subsidies	Possible to be raised from foreign soft loan by reason of environmental project
Users (Principally ASOCOLFLORES)	30%	Investment or cost sharing	Spontaneous contribution by ASOCOLFLORES members

The respective burdens by year are estimated as presented in Table-9.13.

Table-9.13 Respective Burdens by Year (Col$ million)

Year	Project Cost	Government			ASOCOLFLORES	
		Groundwater charges	Investment or Subsidies	Total	Total	Per Member (assumed to be 400)
2006	5,497	738	3,110	3,848	1,649	4.1
2007	5,497	753	3,095	3,848	1,649	4.1
2008	5,497	768	3,080	3,848	1,649	4.1
2009	5,497	783	3,065	3,848	1,649	4.1
2010	5,497	799	3,049	3,848	1,649	4.1
2011	5,497	815	3,033	3,848	1,649	4.1
2012	5,497	831	3,017	3,848	1,649	4.1
2013	1,000	800	-	700	300	0.8
2014	1,000	800	-	700	300	0.8

(2) Incentive Measures to Investors

In order to forward the Project, the following incentive measures are recommended to promote users spontaneous investment and uplift environmental conservation awareness among them.

<Income Tax Reduction >

- Investment amount by users is preferentially deducted from income tax to avoid users' double payment because groundwater charges seem to be already collected from users.
- Moreover, income tax reduction over fixed years is granted to investors corresponding to the investment amount.

< Increment Volume of Groundwater Concession >

- Increment of Concession volume is granted corresponding to the investment amount.

9.3 Social Evaluation

The objective of social evaluation is to assess the projects from the viewpoint of the social benefits such as positive effects on regional economy and society and to mitigate the negative impacts to the social environment.

The proposed 2 projects will induce several positive and negative effects to the project area. The projects will increase a supply of safe and sufficient municipal and irrigation water to users. At the same time, the projects will induce other social and economic benefits and social environmental impacts to the affected area.

9.3.1 Social Benefits

(1) Bogota Eastern Hill Project

<To Secure Water in case of Emergency >

Groundwater development enables EAAB to secure and supply water in case of emergency such as large accident/disaster of Chingaza and droughts. Especially inhabitants at Eastern Hills and Suba receive a great benefit from groundwater development because current system is unable to distribute water to such higher places from main aqueducts of Tibitoc line.

<Construction of Water Supply Facilities at Soacha>

Development plan area is located at hills of Soacha where inhabitants live in poverty and population has been growing rapidly. Groundwater development corresponds with strong request of inhabitants to construct water supply facilities.

<To Secure Forests Fire Fighting Water>

Forest fires occur at Eastern Hills every year especially during dry season from January to February. Firehouse of Bogota City fights a forest fire. Water for fire fighting is taken normally from tanks; however taken from reservoir by helicopter in case of big fire. The Project plans to construct many tanks and distribution pipes, which could offer a significant increase of intake places for fire fighting.

(2) Bogota Western Plain Project

Artificial recharge would prevent from lowering of groundwater level and generate incremental availability of groundwater use. Moreover, it would contribute to secure irrigation water to some extent in case of drought. These all might bring a great benefit to flower cultivator and agriculture farmers who mostly depend on groundwater.

(3) Integrated Effects

<Increase of Employment Opportunity and Activation of Regional Economy>

Facility construction and related equipment installation works for projects such as wells, weirs, pipelines, tanks and access roads would offer a new labor opportunity to the people unemployed and under-employed of the region in construction sector itself and the related sectors. The employment effect in monetary basis by the Projects is estimated as shown in Table-9.14.

Table-9.14 Employment Effect by the Projects

Project	Required Manpower (hours)	Estimated Wages
Bogota Eastern Hill Project	680,000	Col$ 1.3 billion
Bogota Western Plain Project	1,304,000	Col$ 2.5 billion

Note: assumptions - 8 work-hours/ day, 20 work-days/ month and minimum salary Col$309,000/month

In general, the workers spend their earnings for living such as food, clothes and miscellaneous goods there. Their consumption behavior will stimulate the business activities of the related manufacturers and retail shops of the region. Thus, this increased consumption by new workers will induce a multiplied economic effect to the region, which activates the regional economy as a whole.

9.3.2 Social Environment Impacts

On the other hand, the proposed projects could induce several social problems among societies and residents in the affected area during construction and operation period. The negative social impacts derived from the problems must be mitigated in implementation of the projects. So the social environmental problems that might break out and the mitigating measures should be carefully studied.

Initial environment examination (IEE) on the project is conducted in Chapter 8 and the mitigating measures for these negative social impacts are presented. The careful planning of these measures is effective to mitigate the social negative impacts, but should be disclosed and explained publicly, and discussed with the society and the residents. All of theses entire implementations could minimize effectively the social environment impacts.

Appendix-2.1 Current Water Sources by Sector and by Municipality

Municipalities			Domestic			Industrial/Commercial/public		Flower		Agriculture	
			S-W		G-W	S-W	G-W	S-W	G-W	S-W	G-W
			EAAB	Others							
A.	Bogotá D.C.		○	X	X	○	○	-	-	-	-
B.	Municipalities (13) close to Bogotá D.C.										
	B-1	Municipalities (10): Water Supplied by EAAB									
	1)	Cajicá	○	X	X	○	○	○	○	△	○
	2)	Chía	○	X	X	○	○	○	○	△	○
	3)	Funza	○	X	○	○	○	○	○	△	○
	4)	Gachancipá	○	X	X	○	○	○	○	△	○
	5)	La Calera	○	X	X	○	X	○	○	△	○
	6)	Madrid	○	○	○	○	○	○	○	△	○
	7)	Mosquera	○	X	○	○	○	○	○	△	○
	8)	Soacha	○	X	X	○	○	○	○	△	○
	9)	Sopó	○	X	X	○	○	○	○	△	○
	10)	Tocancipá	○	X	X	○	○	○	○	△	○
		Subtotal	10	1	3	10	9	10	10	-	10
	B-2	Municipalities (3): Water Self-supplied									
	1)	Cota	X	X	○	○	○	○	○	△	○
	2)	Facatativá	X	○	○	○	○	○	○	△	○
	3)	Zipaquirá	X	○	○	○	○	○	○	△	△
		Subtotal	0	2	3	3	3	3	3	-	2
	Subtotal		10	3	6	13	12	13	13	-	12
C.	Other Municipalities (17)										
	1)	Bojacá	X	○	○	○	○	○	○	△	○
	2)	Chocontá	X	○	X	○	X	○	○	△	○
	3)	Cogua	X	○	X	○	X	○	○	△	○
	4)	Cucunubá	X	○	○	○	X	-	-	△	△
	5)	El Rosal	X	X	○	○	X	-	-	△	△
	6)	Guasca	X	○	X	○	X	○	○	△	△
	7)	Guatavita	X	○	X	○	X	-	-	△	△
	8)	Nemocón	X	○	X	○	X	○	○	△	○
	9)	Pasca	X	○	X	○	X	-	-	△	△
	10)	Sesquilé	X	○	X	○	○	○	○	△	○
	11)	Sibaté	X	○	X	○	○	○	○	△	△
	12)	Subachoque	X	○	X	○	○	○	○	△	○
	13)	Suesca	X	○	○	○	X	○	○	△	△
	14)	Tabio	X	○	X	○	○	○	○	△	○
	15)	Tausa	X	○	○	○	X	-	-	△	△
	16)	Tenjo	X	○	○	○	○	○	○	△	○
	17)	Villapinzón	X	○	X	○	X	-	-	△	△
	Subtotal		0	16	6	17	6	11	11	-	8
Total of Municipalities			10	19	12	30	18	24	24	-	20
Bogotá & All Municipality			11	19	12	31	18	24	24	-	20

Note: 1) S-W; Surface Water, G-W; Groundwater

2) ○; actually used, X; actually not used, and △; provably used

Appendix-2.2 Population Projection of the Study Area

Unit: persons

Municipalities	All Municipality related to Study Area					Study Area				
	DANE	Projection by EAAB and CAR				DANE	Projection by EAAB and CAR			
	2000	2000	2005	2010	2015	2000	2000	2005	2010	2015
A. Bogotá D.C.	6,437,842	6,484,968	7,282,781	8,086,532	8,878,537	6,437,842	6,484,968	7,282,781	8,086,532	8,878,537
B. Municipalities (13) close to Bogotá D.C										
B-1 Municipalities (10): Water Supplied by EAAB, in Total or Part										
1) Cajicá	40,154	40,457	46,916	53,533	60,175	40,154	40,457	46,916	53,533	60,175
2) Chía	61,743	56,865	63,487	71,158	79,943	61,743	56,865	63,487	71,158	79,943
3) Funza	51,508	50,806	58,017	65,165	72,084	51,508	50,806	58,017	65,165	72,084
4) Gachancipá	6,707	7,681	9,246	10,960	12,809	6,707	7,681	9,246	10,960	12,809
5) La Calera	24,188	21,056	22,911	25,139	27,751	17,051	16,016	18,572	21,515	24,791
6) Madrid	52,110	53,276	62,488	72,425	83,025	52,110	53,276	62,488	72,425	83,025
7) Mosquera	27,753	31,837	38,822	46,316	54,371	27,753	31,837	38,822	46,316	54,371
8) Soacha	283,889	378,015	494,250	623,704	765,112	283,889	378,015	494,250	623,704	765,112
9) Sopó	14,586	13,949	15,485	16,958	18,341	14,586	13,949	15,485	16,958	18,341
10) Tocancipá	14,602	16,719	20,306	24,159	28,303	14,602	16,719	20,306	24,159	28,303
Subtotal	577,240	670,661	831,928	1,009,517	1,201,914	570,103	665,621	827,589	1,005,893	1,198,954
B-2 Municipalities (3): Water Self-supplied										
1) Cota	14,784	15,012	17,157	19,307	21,417	14,784	15,012	17,157	19,307	21,417
2) Facatativá	90,266	82,342	91,212	100,878	111,458	90,266	82,342	91,212	100,878	111,458
3) Zipaquirá	91,113	79,238	86,387	95,440	106,649	91,113	79,238	86,387	95,440	106,649
Subtotal	196,163	176,592	194,756	215,625	239,524	196,163	176,592	194,756	215,625	239,524
Subtotal	773,403	847,253	1,026,684	1,225,142	1,441,438	766,266	842,213	1,022,345	1,221,518	1,438,478
C. Other Municipalities (17)										
1) Bojacá	6,010	5,642	5,936	6,274	6,659	5,538	5,241	5,557	5,915	6,319
2) Chocontá	17,974	15,447	14,610	13,901	13,305	16,183	13,980	13,312	12,752	12,288
3) Cogua	15,202	13,821	13,735	13,715	13,765	15,202	13,821	13,735	13,715	13,765
4) Cucunubá	9,581	9,189	9,766	10,407	11,126	1,069	1,032	1,074	1,117	1,162
5) El Rosal	7,828	7,828	8,482	9,464	10,845	7,828	7,828	8,482	9,464	10,845
6) Guasca	11,208	8,690	7,555	6,604	5,807	8,129	6,364	5,631	5,014	4,492
7) Guatavita	6,953	6,517	6,511	6,535	6,592	5,034	4,748	4,815	4,909	5,033
8) Nemocón	10,778	9,987	10,569	11,248	12,036	10,778	9,987	10,569	11,248	12,036
9) Pasca	11,383	9,917	9,442	9,033	8,684	891	763	697	636	581
10) Sesquilé	6,779	6,245	6,080	5,946	5,844	6,779	6,245	6,080	5,946	5,844
11) Sibaté	29,808	24,823	24,966	25,228	25,602	28,004	23,468	23,746	24,129	24,612
12) Subachoque	13,751	18,774	19,018	19,339	19,747	13,285	18,080	18,336	18,670	19,089
13) Suesca	13,680	11,784	12,014	12,312	12,684	10,787	9,361	9,664	10,033	10,474
14) Tabio	11,962	11,148	11,468	11,859	12,329	11,962	11,148	11,468	11,859	12,329
15) Tausa	7,214	6,552	6,274	6,019	5,788	4,787	3,810	3,600	3,401	3,213
16) Tenjo	19,357	21,060	25,355	30,611	37,070	19,357	21,060	25,355	30,611	37,070
17) Villapinzón	16,312	14,210	13,375	12,659	12,052	11,818	10,433	10,017	9,674	9,399
Subtotal	215,780	201,635	205,157	211,155	219,934	177,430	167,369	172,139	179,093	188,550
Total of Municipalities	989,183	1,048,888	1,231,841	1,436,297	1,661,372	943,696	1,009,582	1,194,484	1,400,611	1,627,028
Bogotá and All Municipality	7,427,025	7,533,856	8,514,622	9,522,829	10,539,909	7,381,538	7,494,550	8,477,265	9,487,143	10,505,565

Note:

Municipalities	Unit Consumption Rate (liter/person)				Service Coverage Ratio (%)				Basic Water Demand				Water Loss Rate (%)			
	2000	2005	2010	2015	2000	2005	2010	2015	2000	2005	2010	2015	2000	2005	2010	2015
A. Bogotá D.C.	115,6	112,5	109,3	109,3	88,1	90,7	90,7	90,7	749,9	819,1	884,2	970,4	31,2	31,0	31,2	31,3
B. Municipalities (13) close to Bogotá D.C																
B-1 Municipalities (10): Water Supplied by EAAB, in Total or Part																
1) Cajicá	137,3	137,3	137,3	137,3	91,1	91,5	92,0	92,4	5,6	6,4	7,4	8,3	34,2	34,2	34,2	34,2
2) Chía	182,2	182,2	182,2	182,2	97,9	98,0	98,1	98,2	10,4	11,6	13,0	14,6	39,1	32,0	32,0	32,0
3) Funza	103,0	103,0	103,0	103,0	82,4	84,2	85,7	87,2	5,2	6,0	6,7	7,4	34,2	34,2	34,2	34,2
4) Gachancipá	103,0	103,0	103,0	103,0	76,1	78,5	80,6	82,6	0,8	1,0	1,1	1,3	34,2	34,2	34,2	34,2
5) La Calera	103,0	103,0	103,0	103,0	80,7	82,6	84,4	85,9	1,6	1,9	2,2	2,5	34,2	34,2	34,2	34,2
6) Madrid	103,0	103,0	103,0	103,0	83,0	84,7	86,2	87,6	5,5	6,4	7,5	8,6	34,2	34,2	34,2	34,2
7) Mosquera	103,0	103,0	103,0	103,0	54,0	58,6	62,7	66,5	3,3	4,0	4,8	5,6	34,2	34,2	34,2	34,2
8) Soacha	112,1	112,1	112,1	112,1	87,5	88,8	89,9	90,9	42,4	55,4	69,9	85,7	18,2	18,1	18,2	18,3
9) Sopó	106,2	106,2	106,2	\	91,8	92,2	92,6	93,0	1,5	1,6	1,8	1,9	34,2	34,2	34,2	34,2
10) Tocancipá	103,0	103,0	103,0	103,0	88,6	89,7	90,8	91,2	1,7	2,1	2,5	2,9	34,2	34,2	34,2	34,2
Subtotal	117,1	116,5	116,1	115,8	86,1	87,4	88,6	89,7	77,9	96,4	116,8	138,9				
B-2 Municipalities (3): Water Self-supplied **(EAAB projects to supply Cota and Zipaquira from 2005.)**																
1) Cota	103,0	103,0	103,0	103,0	70,9	73,8	76,4	78,8	1,5	1,8	2,0	2,2	34,2	34,2	34,2	34,2
2) Facatativá	137,3	137,3	137,3	137,3	93,0	93,4	93,7	94,0	11,3	12,5	13,9	15,3	31,2	31,0	31,1	31,3
3) Zipaquirá	137,3	137,3	137,3	137,3	95,3	95,5	95,8	96,0	10,9	11,9	13,1	14,6	34,2	34,2	34,2	34,2
Subtotal	134,4	134,3	134,2	134,2	92,2	92,6	93,1	93,5	23,7	26,2	28,9	32,2				
Subtotal	118,8	118,0	117,5	117,1	87,4	88,4	89,4	90,4	101,6	122,5	145,7	171,0				
C. Other Municipalities (17)																
1) Bojacá	185,8	179,7	173,0	165,8	80,0	82,0	83,8	85,4	0,9	1,0	1,0	1,0	35,0	35,0	35,0	35,0
2) Chocontá	93,9	107,0	120,5	134,4	80,0	82,0	83,8	85,4	1,3	1,4	1,5	1,6	35,0	35,0	35,0	35,0
3) Cogua	160,1	157,0	153,1	148,5	80,0	82,0	83,8	85,4	2,2	2,2	2,1	2,0	35,0	35,0	35,0	35,0
4) Cucunubá	152,9	147,7	142,2	136,4	80,0	82,0	83,8	85,4	0,2	0,2	0,2	0,2	35,0	35,0	35,0	35,0
5) El Rosal	157,6	155,2	151,7	147,0	80,0	82,0	83,8	85,4	1,2	1,3	1,4	1,6	35,0	35,0	35,0	35,0
6) Guasca	148,7	151,2	150,2	144,9	80,0	82,0	83,8	85,4	0,9	0,8	0,7	0,6	35,0	35,0	35,0	35,0
7) Guatavita	157,4	154,6	151,2	147,0	80,0	82,0	83,8	85,4	0,7	0,7	0,7	0,7	35,0	35,0	35,0	35,0
8) Nemocón	167,8	163,8	159,0	153,2	80,0	82,0	83,8	85,4	1,7	1,7	1,8	1,8	35,0	35,0	35,0	35,0
9) Pasca	159,8	157,9	154,7	150,1	80,0	82,0	83,8	85,4	0,1	0,1	0,1	0,1	35,0	35,0	35,0	35,0
10) Sesquilé	160,6	155,7	149,7	142,7	80,0	82,0	83,8	85,4	1,0	0,9	0,9	0,8	35,0	35,0	35,0	35,0
11) Sibaté	181,8	176,2	169,9	163,0	80,0	82,0	83,8	85,4	4,2	4,1	4,1	4,0	35,0	35,0	35,0	35,0
12) Subachoque	155,3	151,3	146,8	141,9	80,0	82,0	83,8	85,4	2,6	2,5	2,5	2,5	35,0	35,0	35,0	35,0
13) Suesca	161,3	158,2	154,4	149,9	80,0	82,0	83,8	85,4	1,5	1,5	1,5	1,6	35,0	35,0	35,0	35,0
14) Tabio	162,8	158,2	153,0	147,2	80,0	82,0	83,8	85,4	1,8	1,8	1,8	1,8	35,0	35,0	35,0	35,0
15) Tausa	151,4	146,1	139,8	132,4	80,0	82,0	83,8	85,4	0,6	0,5	0,5	0,4	35,0	35,0	35,0	35,0
16) Tenjo	158,8	158,5	153,4	144,9	80,0	82,0	83,8	85,4	3,3	4,0	4,7	5,4	35,0	35,0	35,0	35,0
17) Villapinzón	163,1	160,7	156,4	150,2	80,0	82,0	83,8	85,4	1,7	1,6	1,5	1,4	35,0	35,0	35,0	35,0
Subtotal	132,2	131,9	130,1	127,0	80,0	82,0	83,8	85,4	26,0	26,5	27,1	27,7				
Total of Municipalities	121,0	120,0	119,1	118,3	86,1	87,5	88,7	89,8	127,7	149,1	172,8	198,7				
Bogotá and All Municipality	116,3	113,5	110,7	110,7	87,8	90,2	90,4	90,6	877,6	968,2	1.057,0	1.169,1				
												Reference: EAAB Projection (Residencial + Mixto				

Source: 1) Bogotá D.C. and 13 Municipalities; "Actualizacion de la Proyeccion de la Demanda de Agua, Informe Final 1999", EAAB
2) Other 17 Municipalities; "Inventario y Diagnpstico de los Recursos Naturales Renovables del Area Jurisdiccional de la CAR 1999", CAR

Note: 1) Service Coverage Ratio: ①Bogotá D.C.; bill (demanda facturada)/basic demand, ②13 Municipalities; "Monografias Territoriales (POT), ③Other 17 municipalities; estimation by the Study T
④Coverage ratio increase; by 5% during 5 years if the ratio being attained more than 90% and by 10% if less than 90%
2) Water Loss Rate of other 17 Municipalities; estimation by the Study Team

Appendix-2.4 Projection of Non-domestic Water Demand

Unit: 1

Municipalities	Baisic Water Demand								Surface Water Demand				Groundwater Demand		
	Industrial				Commercial, Public and Others				Total of Non-domestic Use				Total of Non-domestic U		
	2000	2005	2010	2015	2000	2005	2010	2015	2000	2005	2010	2015	2000	2005	2010
A. Bogotá D.C.	58,2	75,3	90,0	108,6	137,5	179,4	215,1	259,6	284,3	369,1	443,1	535,6	15,2	18,5	22,5
B. Municipalities (13) close to Bogotá D.C															
B-1 Municipalities (10): Water Supplied by EAAB, in Total or Part															
1) Cajicá	0,3	0,4	0,5	0,6	0,2	0,2	0,2	0,3	0,7	0,9	1,1	1,3	0,2	0,3	0,3
2) Chía	0,8	0,9	0,9	1,0	0,3	0,4	0,4	0,5	2,0	1,9	2,0	2,2	0,0	0,0	0,0
3) Funza	0,7	0,8	1,0	1,2	0,1	0,2	0,2	0,2	1,3	1,5	1,8	2,1	0,2	0,3	0,3
4) Gachancipá	0,0	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,1	0,1	0,2	0,2	0,4	0,5	0,6
5) La Calera	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,2	0,3	0,3	0,3	-	-	-
6) Madrid	0,7	0,9	1,0	1,2	0,2	0,2	0,2	0,3	1,3	1,6	1,9	2,2	0,8	1,0	1,2
7) Mosquera	0,4	0,6	0,8	1,0	0,1	0,1	0,1	0,1	0,7	1,0	1,4	1,7	1,9	2,3	2,8
8) Soacha	7,1	10,8	14,5	18,2	1,3	1,7	2,2	2,7	10,3	15,3	20,4	25,6	1,4	1,7	2,1
9) Sopó	0,1	0,1	0,1	0,1	0,0	0,1	0,1	0,1	0,2	0,2	0,3	0,3	0,4	0,5	0,6
10) Tocancipá	0,1	0,1	0,2	0,2	0,1	0,1	0,1	0,1	0,2	0,3	0,4	0,5	0,2	0,3	0,4
Subtotal	10,3	14,8	19,3	23,8	2,4	2,9	3,6	4,3	17,0	23,2	29,8	36,5	5,7	6,9	8,4
B-2 Municipalities (3): Water Self-supplied															
1) Cota	0,1	0,1	0,1	0,2	0,0	0,0	0,1	0,1	0,2	0,2	0,3	0,3	0,2	0,2	0,2
2) Facatativá	1,3	1,4	1,5	1,7	0,4	0,4	0,5	0,5	2,4	2,6	2,9	3,2	0,9	1,1	1,3
3) Zipaquirá	1,2	1,4	1,5	1,6	0,4	0,4	0,4	0,5	2,4	2,7	2,9	3,2	0,0	0,0	0,0
Subtotal	2,6	2,9	3,2	3,5	0,8	0,8	0,9	1,0	5,0	5,5	6,1	6,7	1,1	1,3	1,6
Subtotal	12,9	17,7	22,5	27,2	3,1	3,8	4,5	5,4	21,9	28,7	35,9	43,2	6,8	8,2	10,0
C. Other Municipalities (17)															
1) Bojacá	0,0	0,0	0,1	0,1	0,0	0,0	0,0	0,0	0,1	0,1	0,1	0,1	0,5	0,6	0,8
2) Chocontá	0,1	0,1	0,1	0,1	0,0	0,0	0,0	0,1	0,2	0,2	0,2	0,2	-	-	-
3) Cogua	0,0	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,2	0,2	0,2	0,2	-	-	-
4) Cucunubá	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,1	0,1	0,1	-	-	-
5) El Rosal	0,6	0,6	0,6	0,6	0,0	0,0	0,0	0,0	0,9	1,0	1,0	1,0	-	-	-
6) Guasca	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,1	0,1	0,1	-	-	-
7) Guatavita	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,1	0,1	0,1	-	-	-
8) Nemocón	0,1	0,1	0,1	0,1	0,0	0,0	0,1	0,1	0,2	0,2	0,2	0,2	-	-	-
9) Pasca	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,1	0,1	0,1	-	-	-
10) Sesquilé	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,1	0,1	0,1	0,0	0,0	0,0
11) Sibaté	0,2	0,2	0,2	0,2	0,1	0,1	0,1	0,1	0,5	0,5	0,5	0,5	2,3	2,8	3,4
12) Subachoque	0,0	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,2	0,2	0,2	0,2	0,0	0,0	0,0
13) Suesca	0,0	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,2	0,2	0,2	-	-	-
14) Tabio	0,0	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,2	0,2	0,2	0,0	0,0	0,0
15) Tausa	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,1	0,0	0,0	-	-	-
16) Tenjo	0,0	0,1	0,1	0,1	0,1	0,1	0,1	0,2	0,2	0,3	0,4	0,4	0,3	0,3	0,4
17) Villapinzón	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,2	0,2	0,2	0,2	-	-	-
Subtotal	1,4	1,5	1,6	1,7	0,9	0,9	0,9	0,9	3,5	3,7	3,8	4,0	3,1	3,8	4,6
Total of Municipalities	14,3	19,2	24,0	28,9	4,0	4,7	5,5	6,3	25,4	32,4	39,7	47,2	9,9	12,0	14,7
Bogotá and All Municipality	72,5	94,4	114,1	137,5	141,5	184,1	220,5	265,9	309,7	401,5	482,8	582,8	25,1	30,6	37,2
						Reference: EAAB Projection			284,3	369,1	443,1	535,6			

Source: 1) Bogotá D.C.; "Actualizacion de la Proyeccion de la Demanda de Agua, Informe Final 1999", EAAB
2) 30 Municipalities; "Inventario y Diagnpstico de los Recursos Naturales Renovables del Area Jurisdiccional de la CAR 1999", CAR
Note: Water Loss Rate is the same as applied to Domestic Water in Appendix-6.3

Appendix-2.5 Projection of Floricultuere Water Demand

Municipalities		Areas (ha)			Consumption	Total Water Demand				Groundwat	
		Registered	Unregistered	Total	(liter/sec./ha)	2000	2005	2010	2015	2000	2005
A. Bogotá D.C.		-	-	-	-	-	-	-	-	-	-
B. Municipalities (13) close to Bogotá D.C											
B-1 Municipalities (10): Water Supplied by EAAB, in Total or Part											
1)	Cajicá	126,8	55,1	181,9	0,30	54,6	60,2	66,5	73,4	43,7	48,2
2)	Chía	188,9	82,1	270,9	0,30	81,3	89,7	99,1	109,4	65,0	71,8
3)	Funza	362,9	157,7	520,6	0,30	156,2	172,4	190,4	210,2	124,9	137,9
4)	Gachancipá	85,6	37,2	122,8	0,30	36,8	40,7	44,9	49,6	29,5	32,5
5)	La Calera	7,0	3,0	10,0	0,30	3,0	3,3	3,7	4,1	2,4	2,7
6)	Madrid	827,6	359,5	1187,1	0,30	356,1	393,2	434,1	479,3	284,9	314,6
7)	Mosquera	67,6	29,3	96,9	0,30	29,1	32,1	35,4	39,1	23,3	25,7
8)	Soacha	60,0	26,1	86,1	0,30	25,8	28,5	31,5	34,8	20,7	22,8
9)	Sopó	169,5	73,6	243,1	0,30	72,9	80,5	88,9	98,2	58,4	64,4
10)	Tocancipá	263,3	114,4	377,7	0,30	113,3	125,1	138,1	152,5	90,6	100,1
Subtotal		2.159,2	938,0	3.097,2		929,2	1.025,9	1.132,6	1.250,5	743,3	820,7
B-2 Municipalities (3): Water Self-supplied											
1)	Cota	138,5	60,2	198,7	0,30	59,6	65,8	72,7	80,2	47,7	52,6
2)	Facatativá	290,4	126,1	416,5	0,30	124,9	138,0	152,3	168,2	100,0	110,4
3)	Zipaquirá	59,6	25,9	85,5	0,30	25,6	28,3	31,3	34,5	20,5	22,7
Subtotal		488,5	212,2	700,7		210,2	232,1	256,2	282,9	168,2	185,7
Subtotal		2.647,6	1.150,2	3.797,8		1.139,4	1.257,9	1.388,9	1.533,4	911,5	1.006,3
C. Other Municipalities (17)											
1)	Bojacá	96,9	42,1	138,9	0,30	41,7	46,0	50,8	56,1	33,3	36,8
2)	Chocontá	1,5	0,7	2,2	0,30	0,6	0,7	0,8	0,9	0,5	0,6
3)	Cogua	18,5	8,0	26,5	0,30	8,0	8,8	9,7	10,7	6,4	7,0
4)	Cucunubá	-	-	-	-	-	-	-	-	-	-
5)	El Rosal	-	-	-	-	-	-	-	-	-	-
6)	Guasca	68,3	29,7	98,0	0,30	29,4	32,5	35,8	39,6	23,5	26,0
7)	Guatavita	-	-	-	-	-	-	-	-	-	-
8)	Nemocón	90,9	39,5	130,3	0,30	39,1	43,2	47,7	52,6	31,3	34,5
9)	Pasca	-	-	-	-	-	-	-	-	-	-
10)	Sesquilé	126,5	55,0	181,5	0,30	54,4	60,1	66,4	73,3	43,5	48,1
11)	Sibaté	88,5	38,4	126,9	0,30	38,1	42,0	46,4	51,3	30,5	33,6
12)	Subachoque	445,5	193,5	639,0	0,30	191,7	211,6	233,7	258,0	153,4	169,3
13)	Suesca	171,7	74,6	246,3	0,30	73,9	81,6	90,1	99,4	59,1	65,3
14)	Tabio	32,7	14,2	46,8	0,30	14,1	15,5	17,1	18,9	11,2	12,4
15)	Tausa	-	-	-	-	-	-	-	-	-	-
16)	Tenjo	255,0	110,8	365,7	0,30	109,7	121,1	133,7	147,7	87,8	96,9
17)	Villapinzón	-	-	-	-	-	-	-	-	-	-
Subtotal		1.395,8	606,4	2.002,2		600,6	663,2	732,2	808,4	480,5	530,5
Total of Municipalities		4.043,4	1.756,6	5.800,0		1.740,0	1.921,1	2.121,1	2.341,8	1.392,0	1.536,9
						150,3 1000m3/day	166,0 1000m3/day	183,3 1000m3/day	202,3 1000m3/day	120,3 1000m3/day	132,8 1000m3/day

Appendix-9.1

Economic Evaluation of Bogota Eastern Hill Project
(Groundwater Development and Conservation Project in the Bogota Eastern Hills)

Project Cost (Col$ million)	72,889
EIRR	22%
NPV (Col$ million)	79,171
B/C	1.9

(Col$ million)

Year		Cost			Benefit					Net
		Invest. & Replace	O&M	Total	Groundwater Supply		Dissolved Oxygen	Electric Generation	Total	
					Emergency	Regular				
1	2006	23,106	497	23,604	0	0	0	7	7	-23,597
2	2007	16,975	1,833	18,808	0	0	0	534	534	-18,274
3	2008	17,400	4,168	21,568	0	0	0	825	825	-20,743
4	2009	15,408	6,287	21,695	0	0	0	1,030	1,030	-20,665
5	2010	0	6,287	6,287	0	0	0	1,030	1,030	-5,258
6	2011	0	6,287	6,287		0	0	1,030	1,030	-5,258
7	2012	0	6,287	6,287	94,867	0	0	1,030	95,897	89,610
8	2013	0	6,287	6,287	0	0	0	1,030	1,030	-5,258
9	2014	2,860	6,287	9,147	0	0	8,361	1,030	9,391	244
10	2015	2,200	6,287	8,487	0	0	8,361	1,030	9,391	903
11	2016	1,650	6,287	7,937	0	0	8,361	1,030	9,391	1,453
12	2017	1,650	6,287	7,937	0	0	8,361	1,030	9,391	1,453
13	2018	0	6,287	6,287	0	94,755	8,361	1,030	104,145	97,858
14	2019	0	6,287	6,287	0	94,755	8,361	1,030	104,145	97,858
15	2020	0	6,287	6,287	0	94,755	8,361	1,030	104,145	97,858
16	2021	0	6,287	6,287	0	94,755	8,361	1,030	104,145	97,858
17	2022	2,860	6,287	9,147	0	94,755	8,361	1,030	104,145	94,998
18	2023	2,200	6,287	8,487	0	94,755	8,361	1,030	104,145	95,658
19	2024	1,650	6,287	7,937	0	94,755	8,361	1,030	104,145	96,208
20	2025	-23,570	6,287	-17,283	0	94,755	8,361	1,030	104,145	121,428

Note: Opportunity cost of capital = 13%

Appendix-9.2

Economic Evaluation of Bogota Western Plain Project
(Groundwater Development and Conservation Project in the Bogota Western Plain)

Project Cost (Col$ million)	40,099
EIRR	21%
NPV (Col$ million)	12,049
B/C	1.3

(Col$ million)

Year		Cost									Benefit	Net
		Project				Greenhouse				Total		
		Invest. & Replace	Research & Develop.	O&M	Total	Invest.	Replace	Running Cost	Total			
1	2006	4,443	1,000	87	5,529	1,216	0	334	1,550	7,079	1,638	-5,442
2	2007	4,443	1,000	173	5,616	1,216	0	668	1,884	7,500	3,275	-4,225
3	2008	4,443	1,000	260	5,702	1,216	143	1,002	2,218	7,921	4,913	-3,007
4	2009	4,443	1,000	346	5,789	1,216	143	1,336	2,552	8,341	6,551	-1,790
5	2010	4,443	1,000	433	5,875	1,216	285	1,670	2,886	8,762	8,189	-573
6	2011	4,443	1,000	519	5,962	1,216	285	2,004	3,220	9,182	9,826	644
7	2012	4,443	1,000	606	6,049	1,216	428	2,338	3,554	9,603	11,464	1,861
8	2013	0	1,000	606	1,606	0	428	2,338	2,338	3,944	11,464	7,520
9	2014	73	1,000	606	1,679	0	570	2,338	2,338	4,017	11,464	7,447
10	2015	73	0	606	679	0	428	2,338	2,338	3,017	11,464	8,447
11	2016	73	0	606	679	0	570	2,338	2,338	3,017	11,464	8,447
12	2017	73	0	606	679	0	428	2,338	2,338	3,017	11,464	8,447
13	2018	73	0	606	679	0	570	2,338	2,338	3,017	11,464	8,447
14	2019	73	0	606	679	0	428	2,338	2,338	3,017	11,464	8,447
15	2020	73	0	606	679	0	570	2,338	2,338	3,017	11,464	8,447
16	2021	0	0	606	606	0	428	2,338	2,338	2,944	11,464	8,520
17	2022	0	0	606	606	0	570	2,338	2,338	2,944	11,464	8,520
18	2023	0	0	606	606	0	428	2,338	2,338	2,944	11,464	8,520
19	2024	0	0	606	606	0	570	2,338	2,338	2,944	11,464	8,520
20	2025	-12,904	0	606	-12,298	-1,234	428	2,338	1,104	-11,194	11,464	22,658

Note: Opportunity cost of Capital = 13%

Appendix-9.3

Financial Evaluation of Bogota Eastern Hills Project
(Groundwater Development and Conservation Project in the Bogota Eastern Hills)

Project Cost (Col$ million)	75,415
FIRR	23%
NPV (Col$ million)	62,989
B/C	1.7

(Col$ million)

Year		Cost			Benefit			Net Cash Flow
		Invest. & Replace	O&M	Total	Decrease of O&M (Tibitoc)	Water Supply	Total	
1	2006	23,397	517	23,914	1,161	0	1,161	-22,753
2	2007	17,163	1,905	19,067	4,181	0	4,181	-14,886
3	2008	18,418	4,331	22,750	11,429	0	11,429	-11,321
4	2009	16,437	6,534	22,971	14,914	0	14,914	-8,058
5	2010	0	6,534	6,534	14,914	0	14,914	8,380
6	2011	0	6,534	6,534	14,914	0	14,914	8,380
7	2012	0	6,534	6,534	14,914	0	14,914	8,380
8	2013	0	6,534	6,534	14,914	0	14,914	8,380
9	2014	2,860	6,534	9,394	14,914	0	14,914	5,520
10	2015	2,200	6,534	8,734	14,914	0	14,914	6,180
11	2016	1,650	6,534	8,184	14,914	0	14,914	6,730
12	2017	1,650	6,534	8,184	14,914	0	14,914	6,730
13	2018	0	6,534	6,534	0	94,755	94,755	88,221
14	2019	0	6,534	6,534	0	94,755	94,755	88,221
15	2020	0	6,534	6,534	0	94,755	94,755	88,221
16	2021	0	6,534	6,534	0	94,755	94,755	88,221
17	2022	2,860	6,534	9,394	0	94,755	94,755	85,361
18	2023	2,200	6,534	8,734	0	94,755	94,755	86,021
19	2024	1,650	6,534	8,184	0	94,755	94,755	86,571
20	2025	-23,570	6,534	-17,036	0	94,755	94,755	111,791

Note: Opportunity cost of capital = 14%

Appendix-9.4 Financial Statement of EAAB (1/3)

1) Profit and Loss Statement of EAAB

(Col$ million)

Items			1996	1997	Increase%	1998	Increase%	1999	Increase%	2000	Increase%	2001	Increase%
Operational Revenue	Water		179,708	186,031	3.5	233,291	25.4	253,451	8.6	341,581	34.8	435,981	27.6
	Sewerage		73,533	80,812	9.9	106,412	31.7	123,745	16.3	162,308	31.2	210,861	29.9
	Others		-	-		-8		-114		4,194		-1,887	
	Total		253,241	266,843	5.4	339,695	27.3	377,082	11.0	508,083	34.7	644,955	26.9
Expenses	Operation	Water	45,672	87,935	92.5	130,462	48.4	140,450	7.7	230,323	64.0	184,558	-19.9
		Sewerage	11,145	18,961	70.1	31,470	66.0	33,914	7.8	40,457	19.3	71,231	76.1
		Total	56,817	106,896	88.1	161,932	51.5	174,364	7.7	270,780	55.3	255,789	-5.5
	Administrative		118,467	141,666	19.6	167,973	18.6	255,638	52.2	279,998	9.5	304,923	8.9
	Total		175,284	248,562	41.8	329,905	32.7	430,002	30.3	550,778	28.1	560,712	1.8
Operational Profit			77,957	18,281		9,790		-52,920		-42,695		84,243	
Non-operational	Income		56,203	81,085	44.3	116,013	43.1	166,192	43.3	117,990	-29.0	137,170	16.3
	Expenses		15,466	58,698	279.5	107,212	82.7	282,259	163.3	76,102	-73.0	168,605	121.6
Non-operational Profit			40,737	22,387	-45.0	8,801	-60.6	-116,067	-	41,888	-	-31,435	-
Net Profit before Extraordinary Items			**118,694**	**40,668**	**-65.7**	**18,591**	**-54.2**	**-168,987**	-	**-807**	-	**52,808**	-
Extraordinary Profit	Surplus from Adjustment for Inflation		54,681	51,924	-5.0	31,118	-40.0	13,491	-56.6	22,678	-	69,508	-
Net Profit after Extraordinary Items			173,375	92,592	-46.6	49,709	-46.3	-155,496	-	21,871	-	122,316	559.3

2) Cash Flow of EAAB

(Col$ million)

Items		1996	1997	1998	1999	2000	2001
Operating CF	Income	77,957	18,281	9,790	-52,920	-42,695	84,243
	Depreciation & Provision	58,292	54,072	63,197	337,787	103,382	73,135
	Working Capital	-127,722	-18,293	65,119	123,707	145,366	195,137
	Subtotal	8,527	54,060	138,106	408,574	206,053	352,515
	Extraordinary Income	30,606	41,101	127,679	111,091	16,129	34,016
	Extraordinary Expenses	-13,062	-12,993	-23,038	-160,521	-833	-93,874
	Subtotal	17,544	28,108	104,641	-49,430	15,296	-59,858
	Total	26,071	82,168	242,747	359,144	221,349	292,657
Investment CF		-104,531	-158,393	-179,909	-411,097	-320,445	-390,619
Financial CF	Foreign & Domestic Loans	45,852	134,437	102,455	272,295	92,805	81,688
	Repayment of Loans	-44,880	-49,055	-116,261	-153,433	-20,207	-28,016
	Net	972	85,382	-13,806	118,862	72,598	53,672
	Financial Income	51,631	74,900	44,675	87,406	99,207	103,154
	Financial Expenses	-2,403	-45,704	-84,171	-121,737	-75,269	-74,731
	Net Profit	49,228	29,196	-39,496	-34,331	23,938	28,423
	Total	50,200	114,578	-53,302	84,531	96,536	82,095
Cash Increase		-28,260	38,353	9,536	32,578	-2,560	-15,867
Cash & the Likes at End of Year		105,945	144,298	153,933	187,182	143,585	128,951

Appendix-9.4 Financial Statement of EAAB (2/3)

3) Balance Sheet of EAAB

(Col$ million)

Assets		1996	1997	1998	1999	2000	2001
Current Assets	Cash and Bank	11,119	11,633	24,015	27,936	72,254	63,041
	Short-term Account Receivable	159,045	191025	198,830	195,818	214,755	227,935
	Inventory	10,290	8,542	11,611	13,917	16,469	10,380
	Short-term Investment	94,825	133,021	130,589	118,209	71,332	65,910
	Others	4,810	4,136	8,842	1,039	3,558	546
	Subtotal	280,089	348,357	373,887	356,919	378,368	367,812
Fixed Assets	Facilities, Machinery & Equipment	1,527,132	1,236,658	1,552,202	1,876,978	2,276,566	2,753,587
	Long-term Investment	120,011	159,104	104,474	171,970	131,659	103,552
	Long-term Account Receivable	29,518	32,695	29,597	30,006	51,031	46,356
	Others	4,793	3,609	9,488	13,068	45,620	69,962
	Subtotal	1,681,454	1,432,066	1,695,761	2,092,022	2,504,876	2,973,457
Total of Assets		1,961,543	1,780,423	2,069,648	2,448,941	2,883,244	3,341,269
Liabilities & Equities		1996	1997	1998	1999	2000	2001
Current Liabilities	Short-term Account Payable	70,642	63,972	95,714	141,450	185,289	64,105
	Interest and Loan Payable	18,792	22,062	34789	22236	35,092	58,167
	Bond & Note Payable			25,811	7,636	2,553	1,341
	Others	17,558	52,002	69,979	32,366	118,266	117,134
	Subtotal	106,992	138,036	226,293	203,688	341,200	240,747
Fixed Liabilities	Loan Payable	259,006	341,118	314,585	454,567	519,820	583,767
	Other Financial Debt	18,405	18,405	-	32,564	32,138	-
	Others	369,667	437,769	462,050	711,814	785,344	1,066,663
	Subtotal	647,078	797,292	776,635	1,198,945	1,337,302	1,650,430
Total of Liabilities		754,070	935,328	1,002,928	1,402,633	1,678,502	1,891,177
Equities	Paid-in Capital	920	335	335	335	335	335
	Fiscal Capital	-	-	-	-	47,409	75,715
	Donation	116,766	153231	209636	241,940	239,285	239,285
	Reserve	311,339	118,695	347,967	397,676	397,676	419,548
	Evaluation	603,316	332,803	458,316	561,095	652,904	747,631
	Retained Earnings	175132	240,031	50,466	-154,738	-132,867	-32,422
	Subtotal	1,207,473	845,095	1,066,720	1,046,308	1,204,742	1,450,092
Total of Liabilities and Equities		1,961,543	1,780,423	2,069,648	2,448,941	2,883,244	3,341,269

Appendix-9.4 Financial Statement of EAAB (3/3)

4) Current Indebtedness (Bonds and Loans) of EAAB

(Col$ million)

	Lender	Contract Year	Objectives	Amount			Terms and Conditions		
							Period		
				Initial	2001 Dec	Currency	Debt	Grace	Interest Rate (%)
1	Bond	1999 Dec	to replace IBRD loan	50,000	50,000	Col$ M	7	(7)	DTF+3.25
2		1999 Dec	to replace IBRD loan	30,000	35,354	Col$ M	7	(7)	11.15
3		1999 Dec	Investment to Sewerage	20,000	20,000	Col$ M	10	(10)	DTF+3.4
4		2002 p	Investment to Water and Sewerage	70,000	-	Col$ M	10	(10)	
5		2003 p	Investment to Water and Sewerage	100,000	-	Col$ M	10	(10)	
6		2004 p	Investment to Water and Sewerage	100,000	-	Col$ M	10	(10)	
7	Banco Popular	1999 Feb	to replace	30,000	30,000	Col$ M	10	(3)	DTF+4.5
8	FINDETER (Sustitution)	1999 Jun	to replace IDB loan	28,000	28,000	Col$ M	12	(3)	DTF+4.0
9	FINDETER (Dorado)	1999 Oct	El Dorado Plant	26,000	26,000	Col$ M	12	(3)	DTF+4.0 or +3.0
10		2000 Dec	Distribution System of El Dorado	3,000	3,000	Col$ M	12	(3)	DTF+3.0
11		2001 Jun	Distribution System of El Dorado	7,000	7,000	Col$ M	12	(3)	DTF+3.0
12		2002 Jan	Distribution System of El Dorado	7,800	-	Col$ M	12	(3)	DTF+4.5
13	FINDETER (Fontibon)	2001 Dec	Sewerage Plant	15,300	-	Col$ M	12	(3)	DTF+4.0
14	Distrito capital - PIDUZOB	1972 Dec	Dev of Oriental Zone of Bogota	3.5	0.16	US$ M	30	(7.5)	2.0
15	IDB	1986 Jan	Ciudad Bolivar	3.4	2.06	US$ M	28	(5)	2.0
16	National Government	1993 Aug	Refinance for External Debt 93-97	147.8	55.8	US$ M	17	(4.5)	10-years US Bond + 300 basis
17	IBRD	1995 Dec	Santa Fe Project	58.0	38.5	US$ M	17	(5)	Libor
18		1995 Dec	Santa Fe Project	87.0	58.9	US$ M	15	(3.5)	Libor
19	JBIC	1991 Dec	San Rafael Reservoir, Control Center and Park	8,375.0	4,387	JPY M	25	(7)	4.75
Total of Actual Indebtedness					631,508	Col$ M			DTF:8.54% (June 17, 2002)
(as of December 2001)					275.6	US$ M			IPC: 7.7 % (2001)

Note: P=Programmed