6.4 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-6.22. Monitoring wells should be selected following items below.

Table-6.22 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 (within 1km) in order to confirm effect of artificial recharge.

(2) Water quality

It is necessary to analyze groundwater quality of wells near artificial recharge wells to identify influence by artificial recharge in Eastern Hills and western part of Bogotá plain.

(3) Land subsidence

It is pointed 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.

6.5 Institution and Operation/Maintenance

(1) Water Resources and Groundwater Management

(a) Establishment of Joint Commission for Water Basin Management and Technical Commission for Groundwater 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 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 water 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.

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. 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.

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

(b) 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 should carry out analysis and evaluation of the data obtained from the monitoring. 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.

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

Currently CAR 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.

(d) 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.

(e) 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. 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 intake but at times of groundwater 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 in this option.

B) The application is to be done at times of surface water intake and not application at times of groundwater abstraction. Recharged water 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.

(1) Research and Development for Technology on Efficient Groundwater Use

(a) Establishment of Project Implementation Unit

Since the nature of project of technical research and development (R&D) includes two major elements, i.e., water use for irrigation and the groundwater resource conservation, the project should be implemented by CAR and ASOCOLFLORES. The two organizations should establish immediately 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.

(b) 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. Additional funds should be complementally raised by the two organizations.

(2) Human Resource Development

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

(a) 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.

(b) 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.

(c) 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 master courses or Ph. D. courses in Colombian or foreign universities. 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 for those who want to study 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.

6.6 Design and Cost Estimate

6.6.1 Design

(1) 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

(2) Capacity of well

Arrangement of production and recharge wells is designed based on size and capacity of standard well as shown in Table-6.23.

Table-6.23 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	3000m^3/day

(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-6.24 and Table-6.25.

Table-6.24 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-6.24 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
Yenobabuena	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-6.25 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

6.6.2 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-6.26.

- 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-6.26 Rough Cost Estimate—Groundwater development and Conservation in Plain

unit：Billion Col$

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.

6.7 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 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-6.27. Before implementation of two environmental projects: ①groundwater 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-6.27 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

6.8 Initial Environment Examination

The examination has been undertaken to determine the environmental impacts that may be created by the groundwater development plan proposed in this CHAPTER. The examination has started from a screening process and proceeded to a scoping process based on existing information and data, and the results of this study. Finally, an overall evaluation has been conducted for 4 environmental items as below:

- Groundwater
- Artificial Recharge and its Impacts on Groundwater
- Protection of Wetland
- Subsidence

All 4 items are classified to "C" category, means "Extent of impact is unknown(Examination is needed. Impacts may become clear as study progresses)".

Check lists of screening and scoping are attached in Supporting Report.

Table-6.28 Project Description

Item	Description	description
Project Name	Groundwater Development plan	Groundwater Conservation plan
Background	Development Potential still remain while, water demand is require development	- Abolishing of existing 2 purification plants take place - Spare river water - Remarkable lowering of water table require artificial recharge
Objective	Groundwater development	Groundwater conservation
Location	Eastern mountainous region other potential area	Eastern mountainous region Central Bogotá Plain
Executing Agency	EAAB	Eastern mountainous region: EAAB Central Bogotá Plain: CAR
Beneficiaries		
Project Components		
Type of Project	Groundwater development	Artificial recharge
Character of Project	Drinking water	Sustainable use for drinking and agricultural purpose
Water Depth/Quality	200~300m	200~300m
Main plan/Structure	Deep well, settling basin	Deep well, settling basin, reservoir
Storage tank		
Purification Unit		
Appurtenant Facilities		
Others		

Table-6.29 Site Description

Item		Description
Project Name		Groundwater Development Plan Groundwater conservation plan
Social environment	Inhabitants: (residents/indigenous people/their views on the project, etc.	Residents request stable water supply worry lowered water table
	Facilities related living (wells. Reservoir. waterworks /electricity)	House connection in urban Private deep well in rural Perfect electrification
	Hygiene(infectious. sickness /hospital/habit	good
Natural Environment	Topography and geology: (steep slopes, soft ground, wetlands/dislocations etc.)	Lift basin soft ground in plain
	Groundwater. Lakes & marshes Rivers. Me theology (water quality, quantity, rein fall)	Plenty of reservoirs, rivers and groundwater
	Valuable fauna and flora And their habitats: (national parks/habitats of rare species, etc.)	Rare species in wetlands
Pollution	Complaints: (pollution at most concerned)	Contamination of river Lowered water table, subsidence
	Measures taken: (institutional measures/ compensation, etc.)	
Others		

Table-6.30 Overall Environmental Evaluation

Environmental Item	Evaluation	Study Plan	Remarks
Groundwater	C	To examine BOD & COD	
Artificial recharge and its impact to groundwater	C	Monitoring of water quality	
Protection of wetland	C	Study of water balance	
Subsidence	C	Observation of subsidence Classification of subsidence on shallow soft land	

Note: Evaluation categories
A: Serious impact is expected
B: Some impact expected
C: Extent of impact is unknown (Examination is needed. Impact may become clear as study progresses)
D: No impact is expected. IEE/EIA is not necessary.

6.9 Project Evaluation

6.9.1 Economic Evaluation

Economic evaluation of Bogotá Eastern Hill Project and Bogotá Western Plain Project is carried out in this Chapter based on Economic Internal Rate of Return (EIRR), Net Present Value (NPV) and Benefit-Cost Ratio (B/C).

(1) Assumptions for Economic Evaluation

(a) Principal Assumptions

On estimating the economic cost and benefit, the principal assumptions as presented in Table-6.31 are applied.

Table-6.31 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)

(b) Project Cost

Total project costs are summarized in Table-6.32.

Table-6.32 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$ 40.1 billion	(Col$ 40.5 billion)

(c) Additional Construction Costs

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-6.33.

Table-6.33 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

(d) O&M Cost

O&M (Operation and Maintenance Cost) of 2 projects is estimated based on the assumptions in Table-6.34.

Table-6.34 O&M Cost

Project	Assumptions
1) Bogotá Eastern Hill Project	1) Electricity
	- Consumption: 74 kwh/day/well
	- Price: Col$87kwh (same as price of Vitelma 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) Bogotá Western Plain Project	2% of project cost

(e) Benefit

Bogotá Eastern Hill Project

The benefit is estimated based on the assumptions in Table-6.35.

< Emergency Water Supply>

Groundwater supply amount in emergency is counted as benefit.

<Regular Water Supply>

Groundwater supply amount developed by the Project is counted as benefit. However, benefit can be counted only from 2018 when groundwater shortage against demand is foreseen.

<Dissolved Oxygen Increase in Bogotá River>

Groundwater development will decrease Tibitoc Plant intake from Bogotá River. The decreased amount could be discharged into Bogotá River in order to improve its water quality and irrigate. The reduction of Biological Oxygen Demand (BOD) in the Bogotá River Basin after the location of Tibitoc Plant can be counted as the benefit.

<Incremental Electric Generation at Bogotá River>

Besides, the discharged water will contribute to increase electric-power production of the power plant located at the lowest course of Bogotá River stream. Hence, incremental GDP resulted from increased electric power will be counted as the benefit, from 2014 when electric power shortage is foreseen.

Table-6.35 Assumptions for Benefit

Benefit	Assumptions
1. Emergency Water Supply	1) Supply Volume: 4.0 m^3/s
	-63 production wells: 3.3 m^3/s (=2.19 m^3/s x 150%)
	- 13 recharging wells: 0.7 m^3/s (=0.45 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 (=2.19 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 Bogotá 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 Bogotá 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.

Bogotá 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. Floriculture industries contribution to agriculture GRDP of Cundinamarca is counted as the benefit of this project. Assumptions are shown in Table-6.36.

Table-6.36 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

(2) 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-6.37. EIRR of Bogotá Eastern Hill Project and Bogotá Western Plain Project results respectively in 22% and 21% cut, that exceed 14% of opportunity cost of capital. Consequently it is noted that the Projects are feasible from economic point of view.

Table-6.37 Result of Economic Evaluation of 2 Projects

Project	EIRR	Net Present Value	B/C
Bogotá Eastern Hill Project	22%	Col\$ 79.2 billion	1.9
Bogotá Western Plain Project	21%	Col\$ 12.0 billion	1.3

6.9.2 Financial Analysis

(1) Bogotá Eastern Hill Project

(a) Revenue

Developed groundwater can be used for emergency supply. Moreover, groundwater could 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 (as presented in Table-6.38) corresponding to groundwater supply amount is obviously recognized as financial revenue over the period of substituting purpose. Financial revenue will be fully derived from groundwater supply amount from 2018 afterward when EAAB water supply shortage is foreseen.

Table-6.38 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 Vitelma of year 200
Water Charges	120	Assumed from actual case
Depreciation	50	Concession fee minus chemical cost (year 2000)

(b) Result of Financial Evaluation

14% of opportunity cost of capital is applied in this study based on the EAAB standards. Result of Evaluation is summarized in Table-6.39. FIRR (Financial Internal Rate of Return) of Bogotá 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.

Table-6.39 Result of Financial Evaluation of Bogotá Eastern Hill Project

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

(c) Funds Scheme for Project Cost

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

(d) Financial Conditions of EAAB

Assuming that total of project costs are borrowed, the sum of repayment and interest will peak in 2016 (Col$6.8 billion). However, as it is commonly recognized in the capital and financial market that EAAB is financially sound, the repayment of loan and interest payment is judged to be executed as scheduled. Incidentally EAAB acquired the high credit rate of AA^+ from credit rating company (Duffs & Phelps de Colombia) for Col$ 270billion corporate bond issue programmed in 2002–2004.

(2) Bogotá Western Plain Project

(a) 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.
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 proposed as shown in Table-6.40.

Table-6.40 Implementation and Funds 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

(b) 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.

6.9.3 Social Evaluation

The following social benefits are expected from the Projects.

(1) Bogotá 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 of Bogotá City and Suba receive a great benefit from groundwater development because current system has to invest a lot 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 Bogotá City fights a forest fire. The Project plans to construct many tanks and distribution pipes, which could offer a significant increase of intake places for fire fighting activities.

(2) Western Plain Project

The following effects are estimated, which bring a great benefit to flower cultivators and agriculture farmers who mostly depend on groundwater.

- To prevent from lowering of groundwater level
- To generate incremental availability of groundwater use.
- To secure irrigation water to some extent in case of drought.

(3) Integrated Effects

An increase of employment opportunity and activation of Regional Economy are expected. The employment effect in monetary basis by the Projects is estimated at Col$1.3billion from Bogotá Eastern Hill Project and at Col$2.6billion from Bogotá Western Plain Project.