CHAPTER 6 GROUNDWATER DEVELOPMENT PLAN

6.1 Basic Policy of the Plan

6.1.1 Importance of Plan

Proposed plan for groundwater development, conservation and management was formulated by objective and scientific approach, based on i) data of natural condition (meteorology, hydrology and hydrogeology) that were accumulated by reliable observation and measurement, ii) well inventory and iii) prediction of future water demand.

According to the result of survey and analysis that were carried out in this Study before formulation of this plan, 20m^3/s of groundwater in annual average is occurring in the Study Area. This amount corresponds to 18% of annual precipitation (800mm). Currently 3.7m^3/s of groundwater, which is 20% of groundwater occurrence, is used. This groundwater is used for important social and economic activities such as irrigation for flower production, industrial use and water supply. In this plan, strategic method is proposed which ensure sustainable groundwater use and safety groundwater development depending on future water demand. This plan can be guideline of sustainable groundwater use for wealthy social and economic activities of people living in Bogotá Plain. This plan was formulated with target year of 2015, and should be successively revised according to change of water demand corresponding to social and economic situation and newly obtained data by hydrogeological survey that will be implemented .

6.1.2 Basic Policy of Groundwater Development

(1) Optimum Groundwater Development Corresponding to Safe Yield

In new groundwater development plan, production well should be designed considering safe yield (60% of groundwater recharge) by basin, of which groundwater level will be affected by this groundwater development. Amount of groundwater by new development should be less than remaining safe yield (= safe yield – current pumping rate) by basin. Groundwater development of small/medium-scale, which will cause only small influence, should be planed considering remaining safe yield by basin. Groundwater development of large-scale, which will cause large influence to several basins, should be planed considering total of remaining safe yield of these basins. However, before the implementation of the project, change of groundwater flow and groundwater level by this project must be studied by groundwater simulation etc in order to confirm that this plan is safety.

Table-6.1 Remaining Safe Yield by Basin

Basin	Current Yield (mm/year)	Safe Yield (mm/year)	Safe Yield of basin		Possible No of standard wells to be drilled
			(mm/year)	(m3/day)	
Bogotá 1-3	42	63	21	39	390
Bogotá 4-6	72	90	18	11	114
Bogotá 7-9	18	37	19	28	290
Bojaca	36	77	41	24	246
Chicu	122	112	(-10)	(-3)	(-37)
Frio	23	60	37	19	197
Neusa	7	112	105	124	1,243
Sisga	0	86	86	35	358
Muna	4	35	31	10	109
Subachoque 1	3	43	40	3	35
Subachoque 2	52	90	38	40	402
Teusaca	15	100	85	82	822
Tomine	1	66	65	65	655
Tunjuelito	10	198	188	208	2,081
All Study Area	27	86	59	689	6,899

Note-1) Safe yield = groundwater recharge x 60%
Note-2) Yield of standard well is 10m^3/day

(2) Basic Policy of Groundwater Development by Aquifer

There are three aquifers (Quaternary, Tertiary and Cretaceous) in each basin of the Study Area. Groundwater is continuous in these aquifers. Safe yield was calculated as total amount of groundwater that can be pumped up from three aquifers. Therefore, total pumping amount should be less than safe yield by each basin in new groundwater development. Basic policy of groundwater development for each aquifer is as follows.

<Quaternary>

Quaternary aquifer is classified into two areas, i) area where groundwater has been already developed fully and ii) area with little current development. In the area of fully developed, new groundwater development should be subject to restriction, and groundwater conservation is necessary to continue the current groundwater use. On the other hand, in area with little current groundwater development, groundwater development should be promoted from now on depending on its water demand.

<Tertiary>

Only little water can be pumped up from wells of Tertiary. Small-scale groundwater development is possible in the future in Tertiary aquifer as well as now.

<Cretaceous>

Cretaceous System of the Study Area distributes in mountains/hills and deep part of ground in entire Bogotá Plain. This Cretaceous system has high capacity of groundwater production. However, only little groundwater of Cretaceous has been developed in every basin of the Study Area so far. It is concluded that Cretaceous aquifer is most promising in new groundwater development. However, groundwater development of deep Cretaceous aquifer will cost high and has considerable risks. On the other hand, groundwater development of Cretaceous aquifer that distributes in mountains/hills has little risks and has high possibility. Consequently, new groundwater development of Cretaceous aquifer should be implemented in mountains/hills of Bogotá Plain depending on water demand. As Cretaceous aquifer distributes entire Study Area and has high production capacity, this aquifer is suitable for large-scale groundwater development. Moreover, Cretaceous aquifer extends beyond river basins, and there is possibility that groundwater can be developed more than safe yield of basin where groundwater development sites locate.

(3) Basic Policy of Groundwater Development by Basin

Groundwater development by basin should be planed based on comparison between amount of the current pumping and safe yield by basin. Table-6.2 shows the current rate of groundwater utilization.

Table-6.2 Current Rate of Groundwater Utilization

Current groundwater utilization	Rate of utilization	Basin
Area of high groundwater use	More than 40%	Bogotá 1-3、Bogotá 4-6、Chicu
Area of medium groundwater use	20%-40%	Bogotá 7-9、Bojaca、Frio、Subachoque
Area of low groundwater use	Less than 20%	Neusa、Sisga、Teusaca、Tomine、Tunjelito

Note) Rate of groundwater utilization = Amount of groundwater use÷Safe Yield

<Area of high groundwater use>

In this area, new groundwater development should be subject to restriction. Moreover, groundwater conservation is necessary to continue current groundwater use.

<Area of medium groundwater use>

There is groundwater development potential still remaining in this area. However, careful planning for new groundwater development is necessary based on safe yield. At the same time, groundwater conservation plan should be formulated.

<Area of low groundwater use >

In this area, the amount of current pumping is much less than safe yield. Groundwater development should be strongly promoted depending on water demand of this area.

6.1.3 Basic Policy of Groundwater Conservation

Areas where groundwater conservation is necessary are classified as shown below.

①Area where rate of groundwater utilization is middle to high.

②Area where large-scale groundwater development is planed

Groundwater conservation plan is proposed for each area as shown below.

(1) Area where Rate of Groundwater Utilization is Middle to High

Central and western part of Bogotá Plain is classified into this area. Agricultural production is high and rate of groundwater utilization is also high in this area. Groundwater conservation is necessary to continue the current groundwater use. Method of conservation is proposed as follows.

<Groundwater artificial recharge>

Groundwater artificial recharge is proposed to compensate groundwater storage of Quaternary aquifer that was consumed by pumping. Excess river water of tributaries of up-stream in the central and western Bogotá Plain will be stored in settling ponds. This water will be injected into Quaternary aquifer though recharge wells. This artificial recharge will contribute to stabilization of water supply for agriculture use in Bogotá Plain, taking in account the water quality.

<Lightening of burden from groundwater in water use>

In order to lighten the burden from groundwater in water use, it should be promoted: Use of alternative water resource for flower culture production (reuse of drained water, use of rainfall and river water of Bogotá main River), change of sites for new flower production, promotion of study on improvement of irrigation efficiency.

(2) Area where Large-scale Groundwater Development is planed

Groundwater recharge to Cretaceous aquifer by rainfall is limited, though Cretaceous aquifer has high productivity. Consequently, in large-scale groundwater development, artificial recharge using surplus river water should be implemented in order to minimize influence by development.

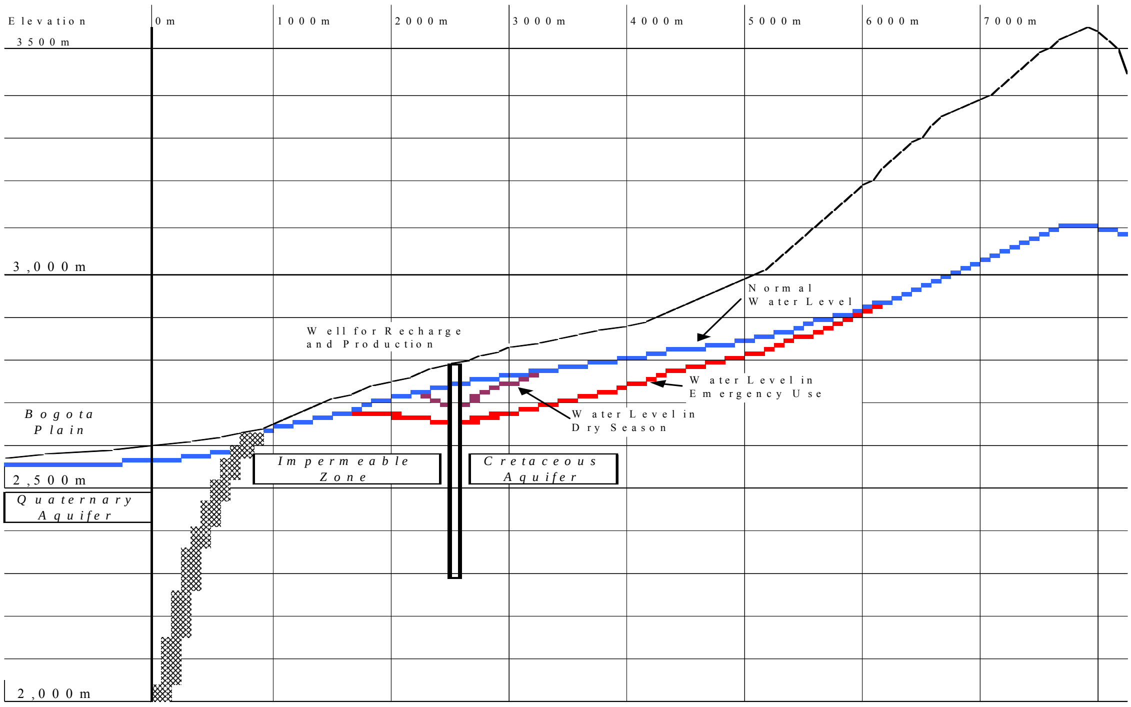


Figure-6.1 Concept of Artificial Recharge

6.3 Demand Projection of Groundwater

6.3.1 Current Conditions of the Study Area

(1) Water Sources

Water sources in the Study Area are summarized in Figure-6.2. The tables shows that the groundwater is used; for domestic use in 12 municipalities (39% of all municipalities), for non-domestic use in 18 municipalities (58%), for flower irrigation in 24 municipalities (77%) and for agriculture irrigation in 20 municipalities (71%). It is assumed that irrigation use would be the most predominant in the Study Area.

Table-6.3 Water Sources by Type and by Sector of the Study Area

Resources	Supplier	Domestic Use	Non-domestic Use	Irrigation Use	
				Flower	Agriculture
Surface Water	EAAB	11 municipalities	11 municipalities	-	-
	Others	19 municipalities	19 municipalities	24 municipalities	30 municipalities
Groundwater		12 municipalities	18 municipalities	24 municipalities	20 municipalities

Note: 1) Surface water for flower represents mostly an intake from rain water.
2) Figures of surface water for agriculture use are presumed.

(2) Water Supply System of EAAB

Current water supply system of EAAB is illustrated in Table-6.3. Actual water supply and production capacity of EAAB is described in Table-6.4. The production capacity was 24.7m^3/second until 2000, but has enlarged to 26.3m^3/second in 2001 due to newly established El Dorado Plant that has entered into operation since 2001 year end and will shortly take the place of these 3 plants ; Vitelma, La Laguna and San Diego.

Table-6.4 Production Capacity and Actual Supply by Treatment Plant (m³/second)

Plant		Items	1996	1997	1998	1999	2000	2001
EAAB Total		Production Capacity	24.7					(26.3)
		Actual Supply	17.6	15.5	15.7	14.8	14.7	14.6
		Operation Rate (%)	71	63	64	60	60	60
Treatment Plant	Wiesner	Production Capacity	12.0					
		Actual Supply	11.0	5.2	9.3	8.5	9.4	8.3
		Operation Rate (%)	92	43	78	71	78	69
	Tibitoc	Production Capacity	11.0					
		Actual Supply	5.3	9.0	5.4	4.9	4.0	5.2
		Operation Rate (%)	48	82	49	45	37	47
	Vitelma	Production Capacity	1.2					
		Actual Supply	0.9	0.9	0.7	1.0	0.9	0.7
		Operation Rate (%)	76	75	61	83	78	58
	La Laguna	Production Capacity	0.3					
		Actual Supply	0.28	0.27	0.22	0.25	0.29	0.3
		Operation Rate (%)	93	90	73	83	97	100
	San Diego	Production Capacity	0.17					
		Actual Supply	0.13	0.11	0.10	0.12	0.12	0.10
		Operation Rate (%)	76	65	59	71	71	59
	El Dorado	Production Capacity	(1.6)					
		Actual Supply	-	-	-	-	-	(0.0024)
		Operation Rate (%)	-	-	-	-	-	-

Source: Informe Anual Dirección de Producción, Año 1996-2001, EAAB

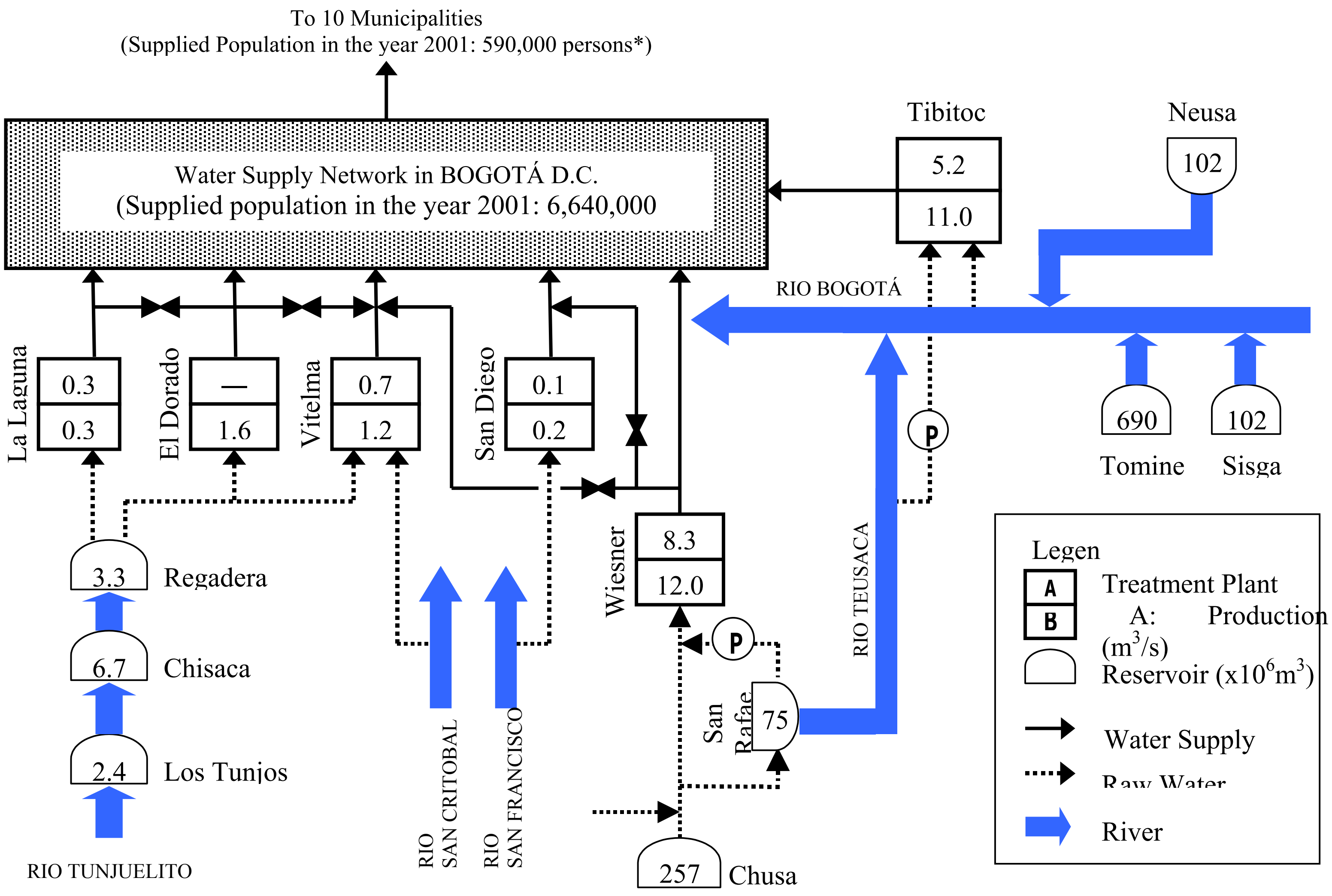
The actual water supply produced in six (6) treatment plants of EAAB in 2001 was 14.6m³/second that equaled to 56 % of year 2001 production capacity of 26.3m³/second. Incidentally, the water supply volume has been declining due to consumption decrease caused by such as 1) a sharp rise of tariff, 2) a reduction of water transfer pressure, 3) a campaign of saving water and 4) a nationwide economic slowdown.

EAAB currently supplies 10 municipalities of Cundinamarca Department as well as Bogotá D.C, mostly with block supply except Bogotá D.C., Soacha and Gachancipá. According to the report "Actualización de la Proyección de la Demanda de Agua", EAAB has a plan to extend its water supply to another 2 municipalities such as Cota and Zipaquirá from 2005.

The production capacity was judged enough until year 2015 for the highest demand of the projection "Actualización de la Proyección de la Demanda de Agua 1999" of EAAB that was projected based on 1998 supply level (15.7m³/second). Demand Projection of EAAB is presented in Table-6.5. EAAB currently may hold sufficient supply capacity against actual and future demand until 2015. Nevertheless, EAAB relies almost half of the production capacity on Wiesner Plant, water resources of which are located at a distant place. Consequently, the Plant is regarded vulnerable against disasters. So, it is widely concerned to develop and keep safe and reliable water against them as well as emergencies such as droughts that may occur to the Bogotá River and other rivers, also valuable water resources for EAAB.

Table-6.5 EAAB Demand Projection（medium demand level）

Year	2000	2005	2010	2015	2020
M³/second	15.3	18.1	20.3	23.0	25.9



Source (*): Actualizacion de la Proyeccion de la Demanda de Agua, EAAB

Note: Production is the amount of the year 2001