CHAPTER 2 NATURAL CONDITION

(1) Topography

Study area is located on a basin which lies on the west slope of Cordillera Oriental running from the south to the north direction in the east part of Colombia. The basin is called as Bogotá Plain with the altitude of 2500m – 2600m. The basin is surrounded with mountains and hills. The basin is bordered with steep slope of Cordillera Oriental in the east and the north. On the other hand, the basin is bordered with low mountains and hills with gentle slope in the south and the west. Toward the further west of the Study Area, the slope again becomes steep descending down to the Magdalena River. Topographical future of the Study area can be classified into five categories shown as below;

- Low land around rivers.
- Flat plains of Quaternary, which occupy most of the Bogotá Plain.
- Gentle slopes of colluvial deposits distributing at the foot of the mountains.
- Hills with gentle slopes consisting of mainly Tertiary around Bogotá Plain, some exists isolated within Bogotá Plain.
- Mountains with steep slopes consisting of Cretaceous around Bogotá Plain, some exists within Bogotá Plain.

(2) Geology of the Study Area

The Study Team carried out geological analysis of Cundinamarca Department and made regional geological section of the Cundinamarca Department. This geological section is based on the existing geological maps (1/500,000, Atlas Geologic Digital Colombia, 1997, INGEOMINAS, see Figure-2.1). The examples of the geological sections are shown in Figure-2.2. In addition to this, the Study Team made more detailed geological sections of the Study Area (see Figure-2.3) These geological sections are based on the existing geological map of 1/100,000 by INGEOMINAS, The examples of the geological sections are shown in Figure-2.4.

As Table-2.1 shows, the Cundinamarca Department is stratigraphically underlain by sedimentary rocks from Cambrian to Tertiary time and Quaternary sediments. No igneous rocks are found in this area. The Study area exposes the Chipague Formation of Cretaceous age and the newer formations than Chipaque.

(a) Pre-Cretaceous Strata

Pre-Cretaceous strata consist of the Quetame Group, the Gutierrez Sandstone Formation and the Guatiquia Red Bed Formation of Palaeozoic age and the Bata Formation of Jurassic age. These formations are not distributed in the Study area, but are known to be present in the eastern part of the Cundinamarca Department. Especially, the Jurassic Formation is restricted in distribution.

(b) Cretaceous Strata

Cretaceous strata are lithostratigraphically divided into the Caqueza Groupe, the Villeta Groupe, and the Guadalupe Group in ascending order. The Study area exposes the Chipaque Formation of Cretaceous age and the newer formations than Chipaque. All of Cretaceous formations are of marine origin. Salt domes distributed in the northern part of the Study area were formed in the sea of Cretaceous age.

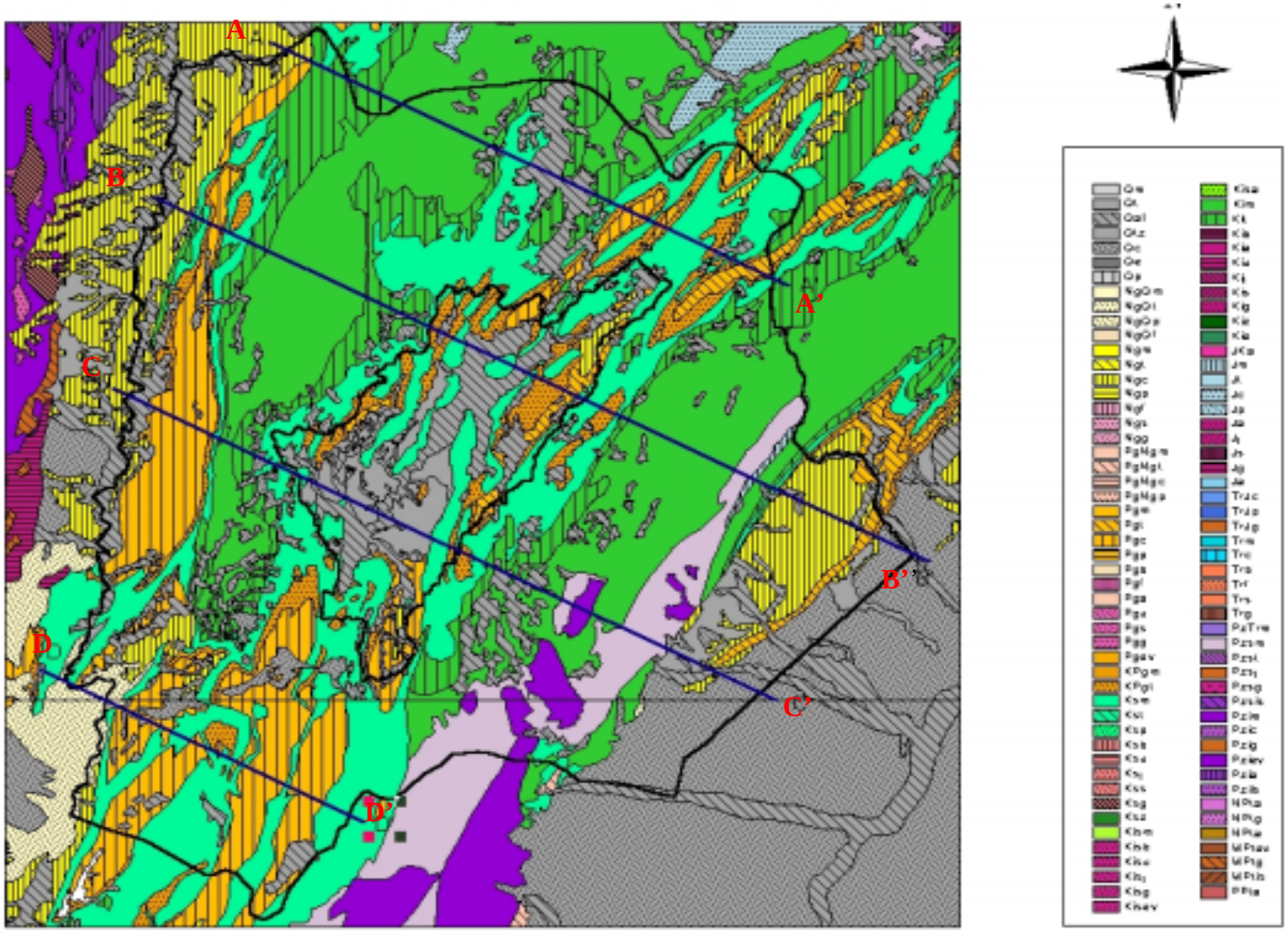


Figure-2.1 Regional Geological Map

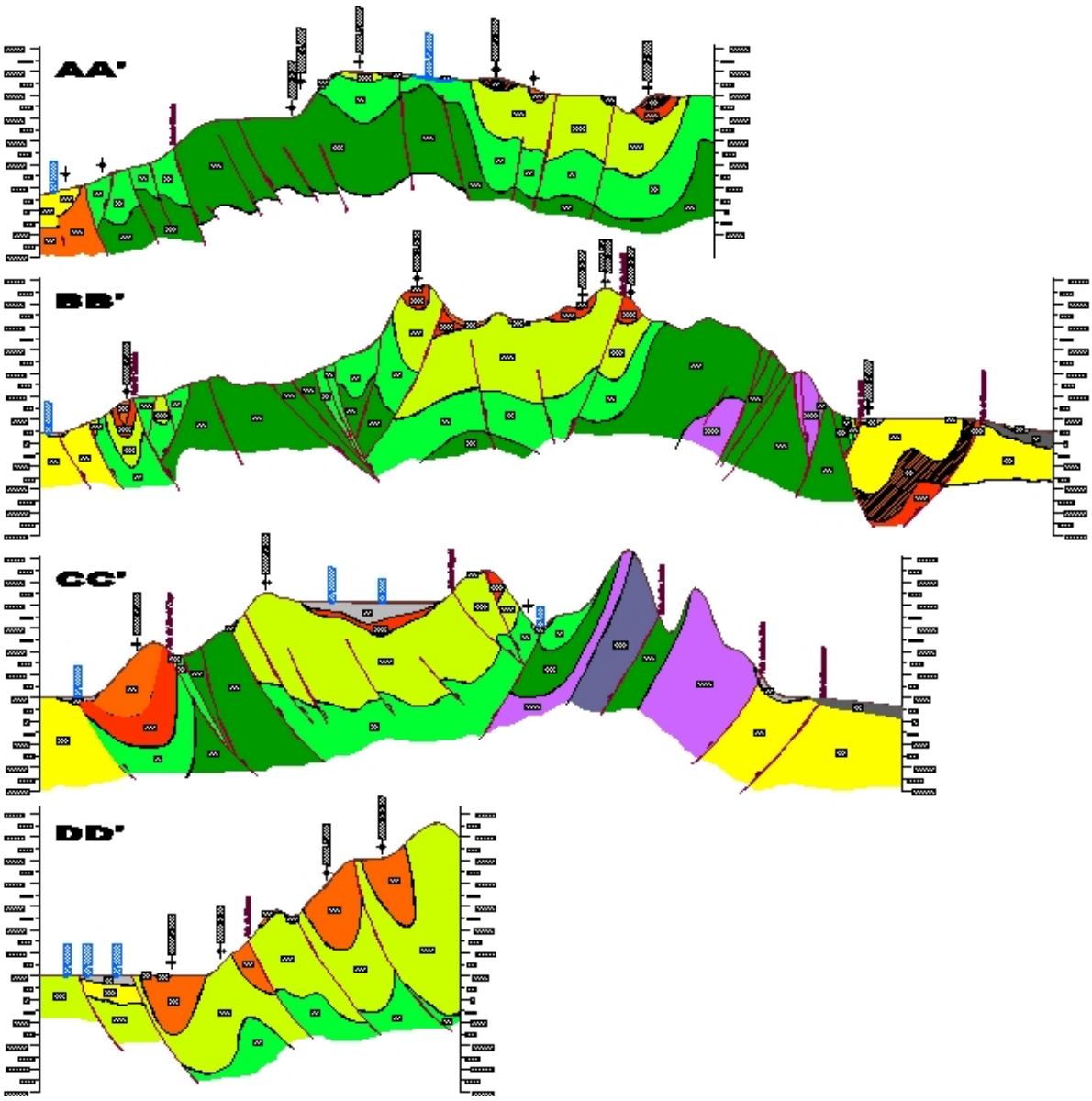


Figure-2.2 Geological Section of the Regional Geology

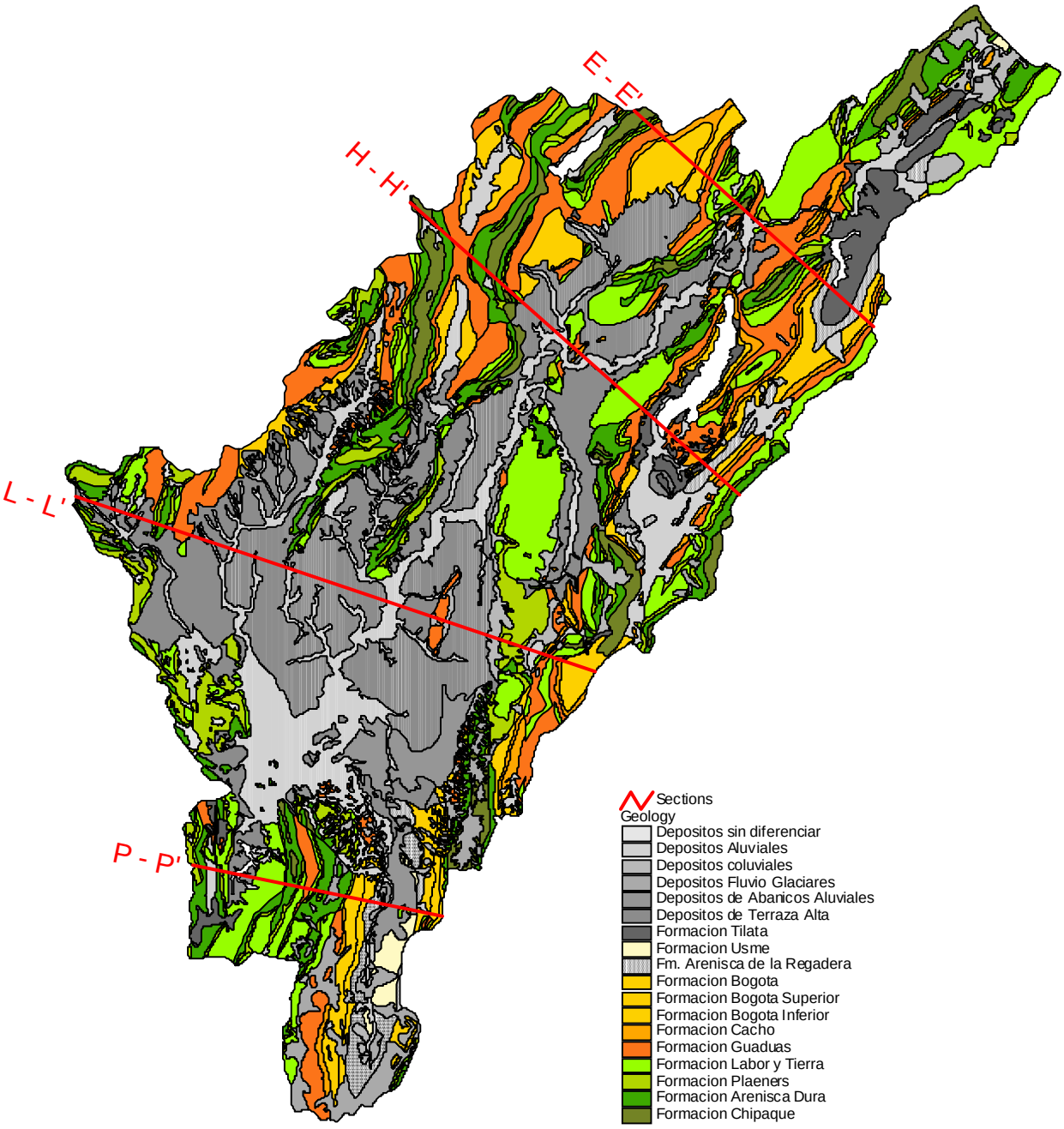


Figure-2.3 Geological Map of the Study Area

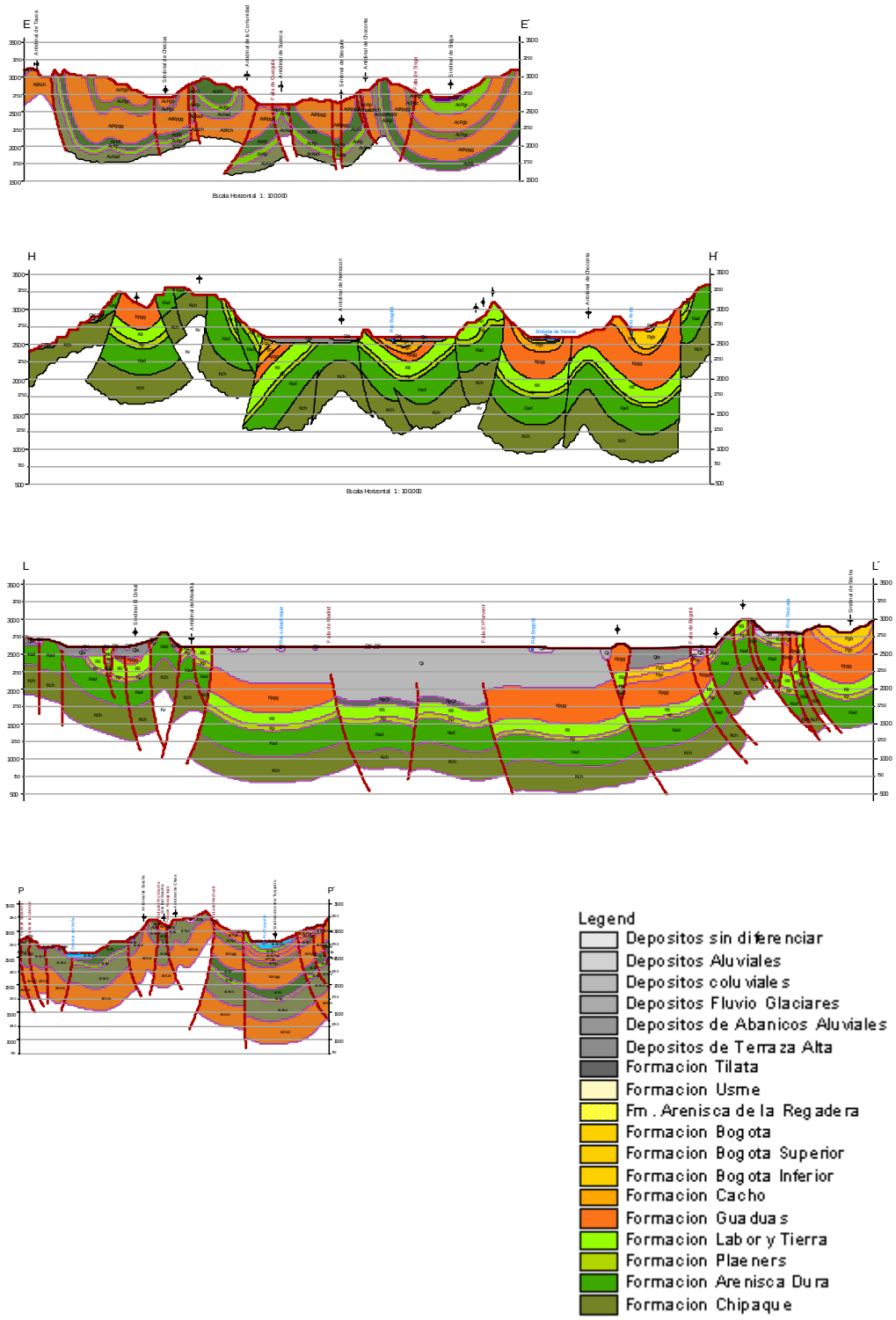


Figure-2.4 Geological Section of the Study Area

Table-2.1 Lithostratigraphy in the Area of the Cundinamarca Department

Geological Time			Lithostratigraphic Classification		Rock Facies
Cenozoic	Quaternary	Holocene	Alluvium		Clay, silt, sand, gravel
		Pleistocene	Terraza Formation		Clay, silt, fine-grained sand
			Sabana Formation		Clay, clayey sand, volcanic ash
			Tilata Formation		clay, silt, sand, gravel rich, volcanic ash, consolidated in the inferior Tilata
	Tertiary	Oligocene	Usme Formation		Claystone, iron-containing sandstone,
		Eocene	Regadera Formation		med.-coa. grained clayey sandstone
			Bogotá Formation		Claystone, intercalating thin layers of sandstone
		Palaeocene	Cacho Formation		Sandstone, intercalation of mudstone
			Guaduas Formation		Claystone, locally fine-grained sandstone, coal vains, iron-containing
Mesozoic	Cretaceous	Superior	Guadalupe Group	Labor & Tierna Fm.	fine – coarse grained sandstone
				Plaeners Fm.	fine grained sandstone, siltstone
				Dura Santstone Fm.	Silicified sandstone
			Villeta Group	Chipaque Fm.	clay stone, siltstone, iron-containing mudy fine sandstone
		Inferior		Une Fm.	fine – coarse grained silicified sandstone
				Fomeque Fm.	Claystone, siltstone, calcareous mudstone, fine grained silicified sandstone
			Caqueza Group	Juntas Sandstone Fm.	Sandstone
				Macanal Shale Fm.	Shale
				Guavio Limestone Fm.	Limestone
	Jurassic		Bata Formation		Mudstone, sandstone
Palaeozoic	Devonian – Carboniferous		Guatiquia Red Bed Fm.		red sandstone, mudstone
			Gutierrez Sandstone Fm.		Sandstone, slate
	Cambrian — Ordovician		Quetame Group		Limestone, sandy claystone, silicified sandstone

Note: 1) Cretaceous Formations of the western part of Cundinamarca are named the different ones.
2) Stratigraphy of the Study Area is marked with bold lines.

1) Caqueza Group

The Caqueza Group of lower Cretaceous age consists of 7 formations. This group is largely distributed in the western part of the Cundinamarca Department. In the eastern part of the Department, the Guavio Limestone Formation, the Macanal Shale Formatio and the Juntas Sandstone Formation are correlative with the Caqueza Group. Only upper Caqueza can be aquifer science the Caqueza Group is mostly silty, at upper part sandy.

2) Villeta Group

The Villeta Group consists of Fómeque Formation and the Une Formation of lower Cretaceous age and Chipaque Formation of upper Cretaceous age in ascending order.

<u>Fomaque Formation</u>

The Fomaque Formation is composed of claystone, siltstone and calcareous mudstone

which were deposited under tranquil marine conditions. The Formation contains thin beds of fine-grained silicified sandstone. The Fomeque Formation is mostly muddy and should be an aquiclude.

Une Formation

The Une Formation consists of fine-to-coarse-grained silicified sandstones grading upward into mudstones. The sandstones show low porosity due to cementation by silicification. The Une Formation is a aquiclude.

Chipaque Formation

The Chpaque Formation consists mostly of claystone and siltstone containing a greater amount of marine organic sediments with intercalations of iron-containing muddy fine-grained sandstones. The Formation becomes calcareous in the lower portion and sandy in the upper portion. This Formation is commonly distributed along the Guadalupe Group. The Chipaque Formation is an aquiclude.

3) Guadalupe Group

The Guadalupe Group consists of the Dura Sandstone Formation, the Plaeners Formation, and Labor & Tierna Formations, all of which are marine origin. This Group is widely exposed in the mountainous districts of the Study area.

Dura Sandstone Formation

The Dura Sandstone Formation is made up largely of fine-grained sandstones, but contains some thin beds of mudstones. This Formation has low permeability due to silisification, but can be easily fractured, and fracture type aquifers are partly formed.

Plaeners Formation

The Plaeners Formation consists of silisified fine-grained sandstone and siltstone. The permeability of this Formation is not so high because of fine grain size.

Labor＆Tierna Formation

The Labor & Tierna Formations consist mostly of thick layers of fine to coarse-grained sandstone alternating with thin layers, about 2-3m thick, of mudstone. This Formation is a good aquifer owing to weak cementation.

(c) Tertiary

The Tertiary strata, from the base upward, consist of the Guaduas Formation, the Cacho Formation, the Bogotá Formation, the Regadera Formation and the Usme Formation. Tertiary strata form gentle foothill slopes in front of steep Cretaceous mountains and crop out in each basin. The Regadera Formation and the Usme Formation of upper Tertiary age were worn away by glacial erosion of Pleistocene age in the eastern part of the Study area. The Usme Formation is distributed in a limited area of the Tunjuelito River Basin which located in the southern part of the Study area. Tertiary strata of post-Guaduas are continental in origin because the orogeny occurred after entering the middle Palaeocene of Tertialy. The Guaduas Formation of marine origin widely covered the Cretaceous strata from the beginning, but now, the Cretaceous strata are exposed along the crest of the mountains by glacial erosion.

Guaduas Formation

The Guaduas Formation consists mostly of claystone and partly of fine-grained sandstone. This Formation is marine in origin. This Formation can be identified by presence of coal veins. The Guaduas Formation is an aquiclude because it is riche in claystone.

Cacho Formation

The Cacho Formation consists largely of sandstones, but contains mudstones. This Formation is composed of fluvial deposits. The permeability of the Cacho is comparatively high among the Tertiary strata because this Formation is rich in sandstone.

Bogotá Formation

The Bogotá Formation consists mostly of claystones, but contains some thin beds of sandstones. This Formation is composed of lake deposits. The Bogotá Formation is an aquiclude.

Regadera Formation

Te Regadera Formation consists of medium to cores-grained clayey sandstone. This Formation is composed of fluvial deposits. The Sandstone of the Regadera Formation has low permeability owing to containing clayey matrix.

Usme Formation

The Usme Formation consists of claystone containing thin beds of sandstone in the lower Usme and of sandstone containing irons in the upper Usme. This Formation is composed of fluvial deltaic deposits and lake deposits.

(d) Quaternary

Quaternary strata which form the Bogotá Plain, consist of the Tilata Formation, the Sabana Formation and the Terraza Formation of Pleistocene age and Alluvium of Holocene age. The Cretaceous strata and Tertiary strata were eroded on a large scale by Pleistocene glaciers and a thick sequence of glacial sediments accumulated in the Bogotá Plain.

Tilata Formation

The Tilata Formation consists of sand and gravel containing volcanic ash and organic matter-contained clay in the lower Tilata and of sandy clay, organic matter-contained clay, silt and sand containing volcanic ash in the upper Tilata. The lower Tilata is consolidated. The Tilata Formation is an aquifer because this Formation is comparatively rich in gravel.

Sabana Formation

The Sabana Formation consists of clay, clayey sand and volcanic ash. This Formation is composed of lake deposits. Aquifer names of most of wells located in the Bogata plane are registered in the name of Sabana.

Terraza Formation

The Terraza Formation consists of alternating beds of clay, silt and fine-grained sandstone.

Alluvium

Alluvium consists of clay, silt, sand and gravel. This Formation is composed of fluvial bed deposits, flood plain deposits, talus deposits, alluvial fan deposits etc. Alluvial fan deposits are restricted in distribution, but present near Usme and Soacha in the southern part of the Study area.

(3) Meteorology

(a) Meteorology Network

Meteorological observation is carried out by CAR, IDEAM in the Study Area. Locations of the existing meteorological station in the Study Area is shown in Figure-2.5. Most of these stations belong to CAR, and some to EAAB. Items of the meteorological observation are

listed below.

1) Precipitation 2) Temperature 3) Humidity 4) Solar radiation
5) Evaporation 6) Sunshine hour 7) Wind direction and speed.

(b) Meteorological Characteristics of the Study Area

As an example of the meteorological characteristics of the Study Area, observed date of Guaymaral station is shown in

Figure-2.5, which is located in the center of the Study Area. Characteristics of meteorological characteristics of the Study Area are outlined below.

Precipitation

Annual average precipitation is shown in Figure-2.6. As shown in Figure-2.6, average annual precipitation of the Study Area is 600mm-1,300mm. Generally in the Study Area, annual precipitation is higher in hills and mountains bordering the Study Area, and becomes lower toward the center of the Study Area. This is effect of topography of the Study Area.

Seasonal precipitation variation has two maximums of seasonal precipitation in around May and November. This type is seen in the majority of the Study Area. Seasonal precipitation variation causes seasonal river discharge variation.

Temperature

Average temperature of the Study Area is 10℃～14℃. Eastern area has a little higher temperature than western area in the Study Area. As shown in Figure-2.7, seasonal temperature variation shows the maximum in March – April and in November. The pattern of seasonal variation is the same over all the Study Area.

Humidity

Average humidity is 74%～80% in the Study Area. Average humidity is higher in the western part and lower in the eastern part of the Study Area, however this difference is small. Seasonal humidity variation has the two maximums in May – July and in November in majority of the Study Area. Seasonal humidity variation seems to have relation with seasonal precipitation.

Pan-evaporation

The average of annual pan-evaporation is 800mm ～ 1,200mm in the Study Area. Pan-evaporation seems higher in the northern part and lower in southern part of the Study Area. As shown in Figure-2.7, seasonal pan-evaporation variation has maximum in January and minimum in May-July. Seasonal pan-evaporation variation is similar to seasonal variation of solar radiation and sunshine hours. This means that pan-evaporation is more influenced by solar-radiation and sunshine hours than temperature in the Study Area. Pan-evaporation is measured by CLASS-A Pan (120cm diameter, 20 cm depth) in the Study Area.

Solar radiation and sunshine hours

The annual average solar radiation is 115 cal/cm^2/day to140 cal/cm^2/day. The average sunshine hour is 3.5 hours/day. Variation of solar radiation and sunshine hours has the maximum in January and minimum in May – October.

Wind Speed

Average wend speed of the Study Area is 1.8m/s～4.2m/s. Wind speed is higher in the south-east of the Study Area and becomes lower toward the north-west of the Study Area. The seasonal variation of wind speed has the maximum in June and August.

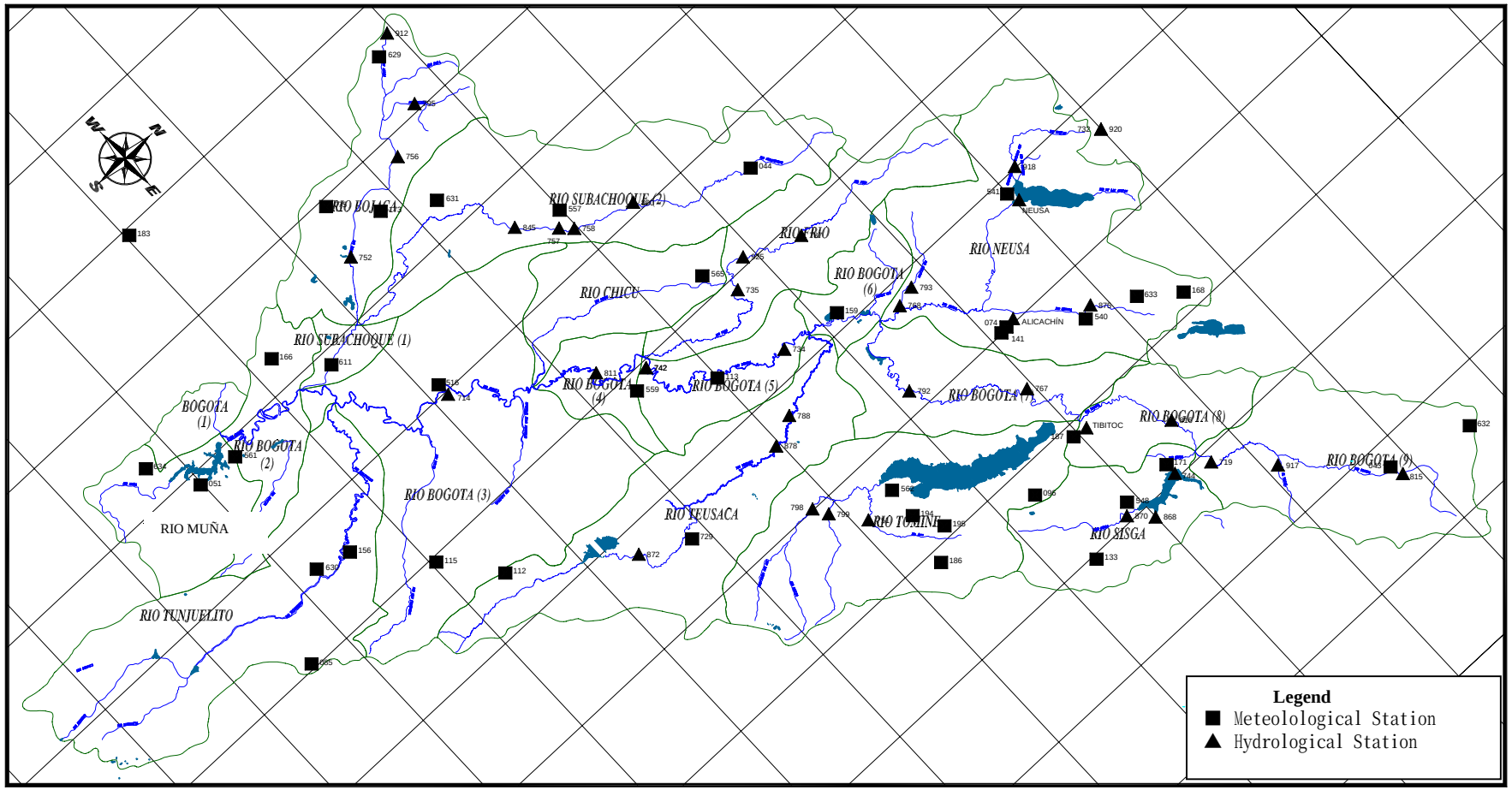


Figure-2.5 Meteorological and Hydrological Stations in the Study Area

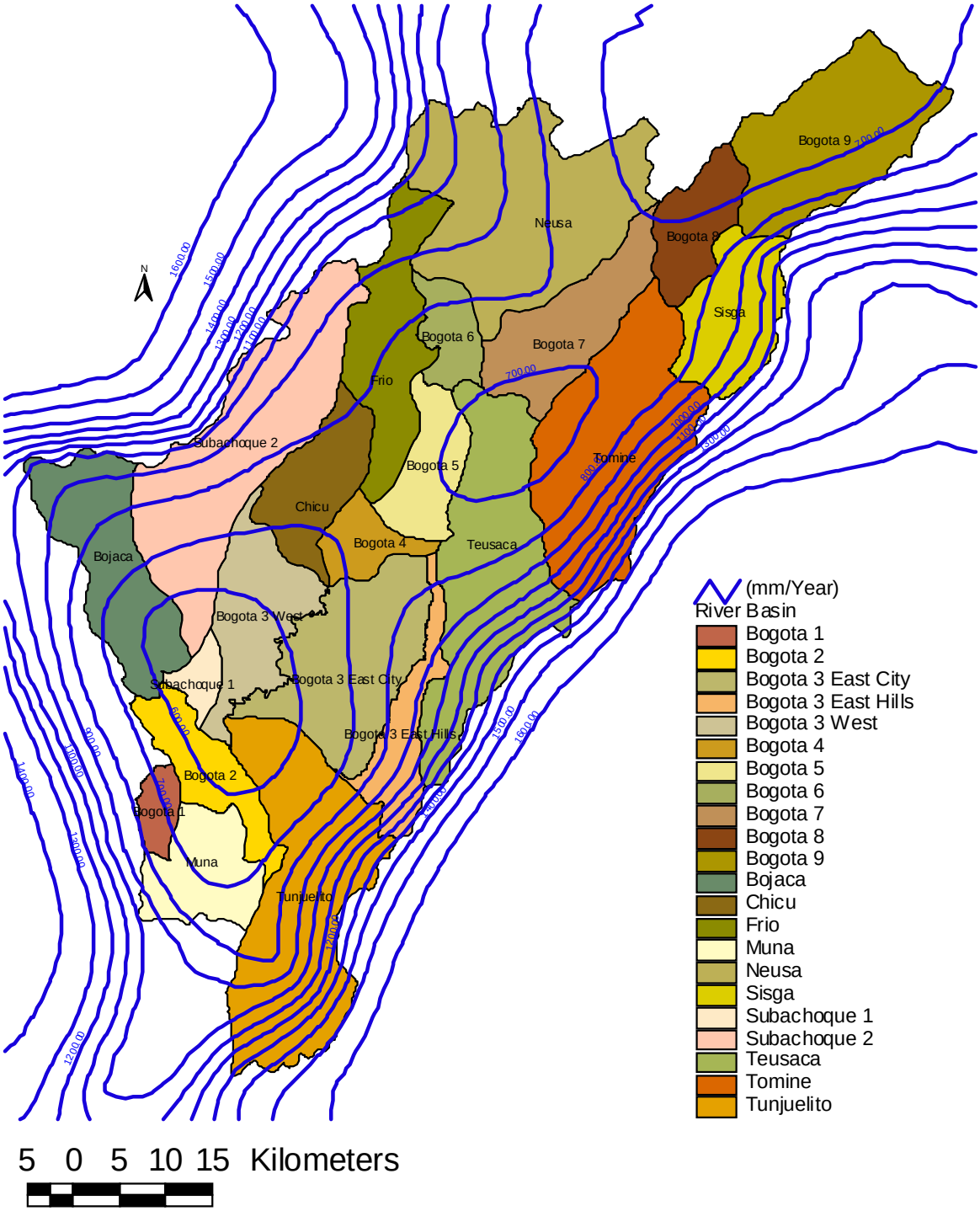
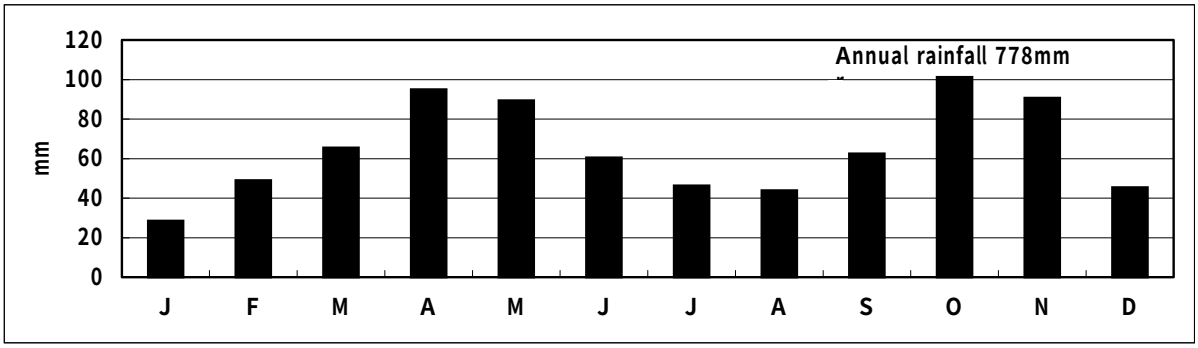
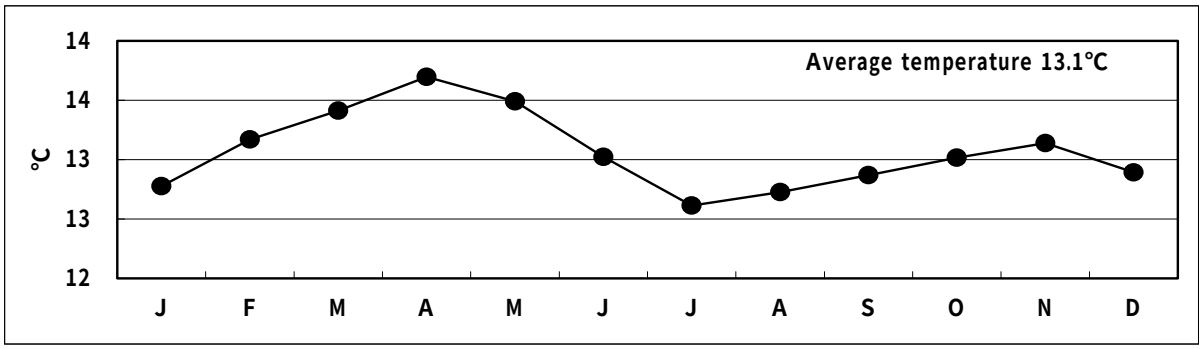


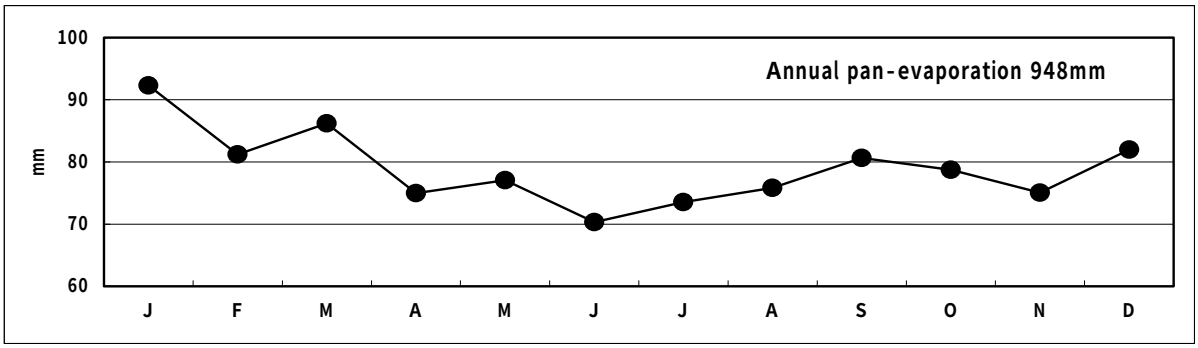
Figure-2.6 Distribution of Annual Precipitation of the Study Area



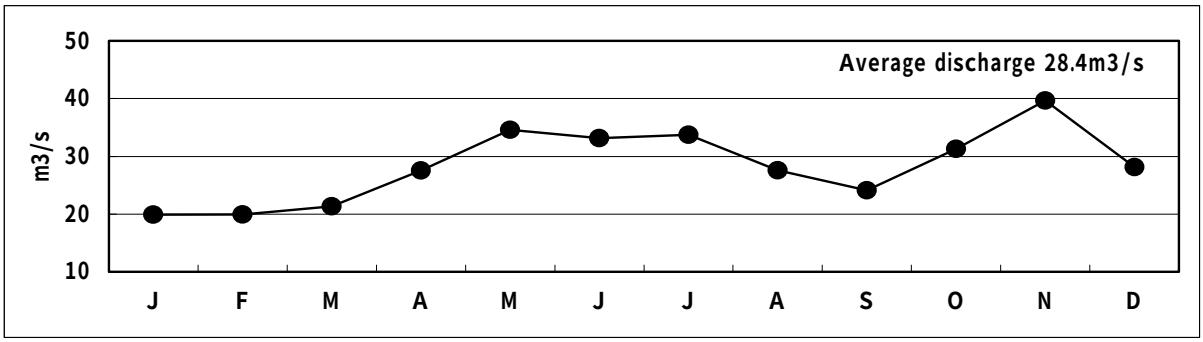
(a) Monthly Precipitation at Guaymaral



(b) Monthly Temperature at Guaymaral



(c) Monthly Pan-evaporation at Guaymaral



(d) Monthly Discharge at Aricachin

Figure-2.7 Meteorological and Hydrogeological Characteristics of the Study Area

Table-2.2 Meteorological Stations of the Study Area

Station No.	Name of Station	Coordinate		Precipitation	Temperature	Humidity	Evaporation	Sunshine hours	Wind speed
		X=E	Y=N	Observation Period	Observation Period	Observation Period	Observation Period	Observation Period	Observation Period
2120019	Bocagrande Salitre	994181	970617	-	-	-	-	-	-
2120020	El Hato	988632	976147	-	-	-	-	-	-
2120044	LA PRADERA	993954	1044880	1951-1999	-	-	-	-	-
2120051	APOSTOLICA	981174	989870	1956-1999	-	-	-	-	-
2120054	IBERIA	1038800	1048900	-	-	1966-1999			
2120060	Guaraní - El Peñón	975683	981679	-	-	-	-	-	-
2120074	ZIPAQUIRA	1007620	1047850	1932-1999	-	-	-	-	-
2120075	BOJACA	970678	1014937	1960-1999	-	-	-	-	-
2120085	EL BOSQUE	999560	986200	1963-1999	-	-	-	-	-
2120096	EL CONSUELO	1032500	1043500	1967-1999	-	-	-	-	-
2120103	Santa Teresa	1016376	1007479	-	-	-	-	-	-
2120112	LA CASITA	1005400	1004320	1972-1999	-	-	-	-	-
2120113	ALMAVIVA	1005600	1029965	1973-1999	-	-	-	-	-
2120115	EDIFICIO MANUEL MEJIA	1000500	1000500	1981-1999	-	-	-	-	-
2120141	ACANDY	1019820	1051680	1977-1999	-	-	-	-	-
2120156	PICOTA	994600	995500	1980-1999	-	-	-	-	-
2120159	ALCO	1008600	1041700	1980-1999	-	-	-	-	-
2120166	EL FUTE	977280	1002150	1959-1999	-	-	-	-	-
2120168	ALTO DE AIRE	1028300	1065500	1986-1999	-	-	-	-	-
2120171	REPRESA SISGA	1038500	1053900	1939-1999	-		1962-1997		
2120173	CAMPOBELLO	974300	1018200	1986-1999	-	-	-	-	-
2120183	DARIO VALENCIA	960600	1000400	1988-1999	-	-	-	-	-
2120186	LA MARIA	1031172	1033300	1993-1999	-	-	-	-	-
2120187	BOMBAS SESQUILE	1031100	1049890	1984-1999	-	-	-	-	-
2120194	EL CHOCHE	1026400	1034300	1996-1998	-	-	-	-	-
2120195	MONTECILLOS	1029000	1035750	1996-1999	-	-	-	-	-
2120210	Los Tunjos	986780	966932	-	-	-	-	-	-
2120509		992332	977989	-	-	-	-	-	-
2120516	LA RAMADA	989110	1011430	1989-1999	1992-1999	1938-1991	1941-1998		
2120540	CHECUA	1024110	1057500	1953-1999	1961-1999	1962-1999	1961-1999	1984-1998	1982-1997
2120541	REPRESA DEL NEUSA	1011400	1060090	1954-1999	1955-1999	1954-1999	1962-1998	1958-1998	1956-2001
2120548	LA IBERIA	1038800	1048900	1953-1999	1966-1999		1966-1998	1966-1998	1968-1997
2120557	LA PRIMAVERA	984942	1027753		1966-1999	1967-1999	1966-1997	1966-1998	1968-1997
2120559	APTO GUAYMARAL	1001550	1023950	1965-1999	1966-1999	1968-1999	1966-1998	1966-1998	1967-1998
2120561	MUÑA	981444	993817	1966-1999	1966-1999	1966-1999	1966-1998	1966-1998	1968-1999
2120562	GUATAVITA	1023500	1034500	-	1968-1999	1968-1999	1956-1998	1984-1998	1968-1998
2120565	Tabio	1016373	1018538	-	1970-1997	1970-1997	1970-1998	1970-1997	1970-1999
2120611	ENTRERIOS	981300	1005680	-		-	1975-1985	-	-
2120629	VENECIA	964155	1027480	-	1985-1999	1985-1999	1984-1998	1985-1998	1985-1997
2120630	DOÑA JUANA	993700	992300	-	1989-1998	1989-1999	1989-1998	1989-2000	1989-1998
2120631	TISQUESUSA	977080	1021250	-	1982-1998	1982-1998	1981-1998	1985-1998	-
2120632	LA FORTUNA	1054376	1075976	1963-1999	-	-	-	-	-
2120633	BARRANCAS	1025740	1062200	1966-1999	1982-1999	1982-1999	1981-1999	-	-
2120634	PARAISO PERDIDO	976800	987300	-	-	-	1988-1997	-	-
2120729	LA CABAÑA	1014520	1018540	1955-1999	-	-	-	-	-
2401110	ISLA DEL SANTUARIO	1038000	1096400	1957-1999	-	-	-	-	-

(4) Hydrology

(a) River System

The Study Area was divided into 20 river basins as shown in Figure-2.8 and Figure-2.9. Catchment area of each basin is shown in Table-2.3.

Table-2.3 River Basin Division of the Study Area

River Basin and Reference Point	Catchment Area (km^2)	Note	River Basin and Reference Point	Catchment Area (km^2)	Note
Q01	4,268	Tequendama Fall	Q16	194	
Bogotá River Basin (1)	35		Frio River Basin	194	
Q02	4,233	= Q03 + Q04	Q17	2,032	
Q03	129		Bogotá River Basin (5)	104	
Soacha River Basin	129		Q18	1,927	= Q19 + Q20
Q04	4,105		Q19	352	
Bogotá River Basin (2)	111		Teusaca River Basin	352	
Q05	3,993	= Q06 + Q10 + Q11	Q20	1,575	
Q06	635		Bogotá River Basin (6)	66	
Subachoque River Basin (1)	31		Q21	1,509	= Q22 + Q23
Q07	604	= Q08 + Q09	Q22	432	
Q08	219		Neusa River Basin	432	
Bojaca River Basin	219		Q23	1,077	
Q09	386		Bogotá River Basin (7)	174	
Subachoque River Basin (2)	386		Q24	903	= Q25 + Q26
Q10	405		Q25	368	
Tunjuelito River Basin	405		Tomine River Basin	368	
Q11	2,953		Q26	535	
Bogotá River Basin (3)	531		Bogotá River Basin (8)	103	
Q12	2,421	= Q13 + Q14	Q27	432	= Q28 + Q29
Q13	133		Q28	153	
Chicu River Basin	133		Sisga River Basin	153	
Q14	2,288		Q29	280	
Bogotá River Basin (4)	62		Bogotá River Basin (9)	280	
Q15	2,226				

In Table-2.3, river basins of Bogotá- 1 to Boogta-9 are divided along Bogotá River. The others are tributaries of Bogotá River (see Figure-2.8 and Figure-2.9).

(b) Hydrological Observation Network

Location of the existing hydrological observation stations in the Study Area is shown in

Figure-2.5. Outline of the stations is summarized in

Table-2.4. CAR is responsible for hydrological observation in the Study Area. IDEAM and EAAB also carry out hydrological observation in the some parts of the Study Area.

(c) Water Flow Condition

Bogotá Rive is the main river in the Study Area. Many tributaries join Bogotá River in the Study Area, and Bogotá River finally goes out from the Study Area around the Tequendama Fall. Average annual discharge of this point is estimated 37/ls. Water from Chingaza Dam that is located in out of the Study Area is conveyed to the Study area. The amount of the conveyed water is estimated $12m^3$/day, which is used for water supply to Bogotá City by EAAB. Sewerage water that occurs from this water supply along Bogotá River. On the other hand, huge amount of river water is pumped up for irrigation and water supply. Analyzed long-term average river discharge of basins is shown in Figure-2.9.

Seasonal variation of the discharge of Bogotá River has two maximums in between May and November. This variation is similar to seasonal variation of precipitation. Seasonal variation patter of the tributaries is also similar to seasonal variation of precipitation in each tributary.

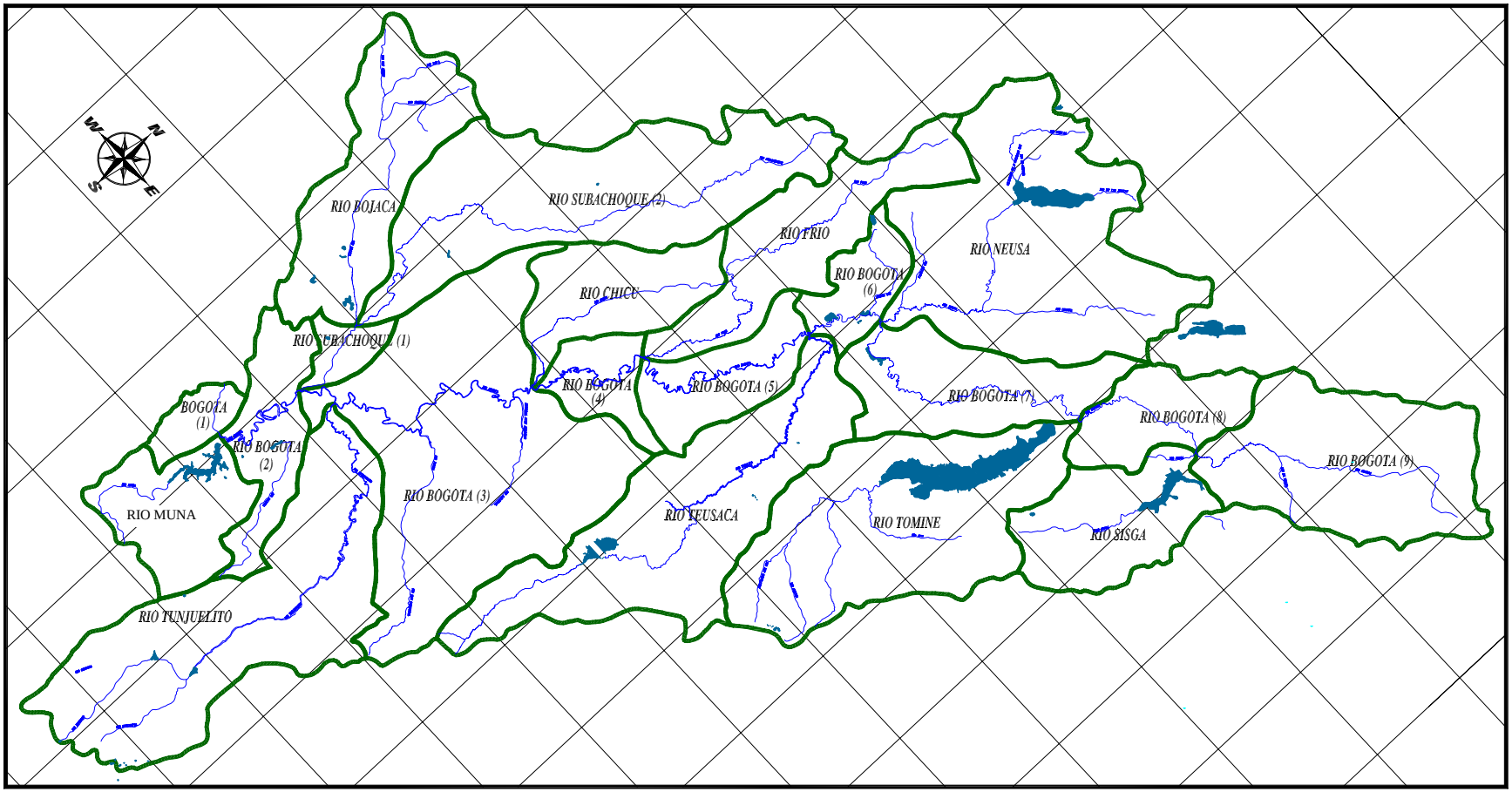


Figure-2.8 River Basin Division of the Study Area

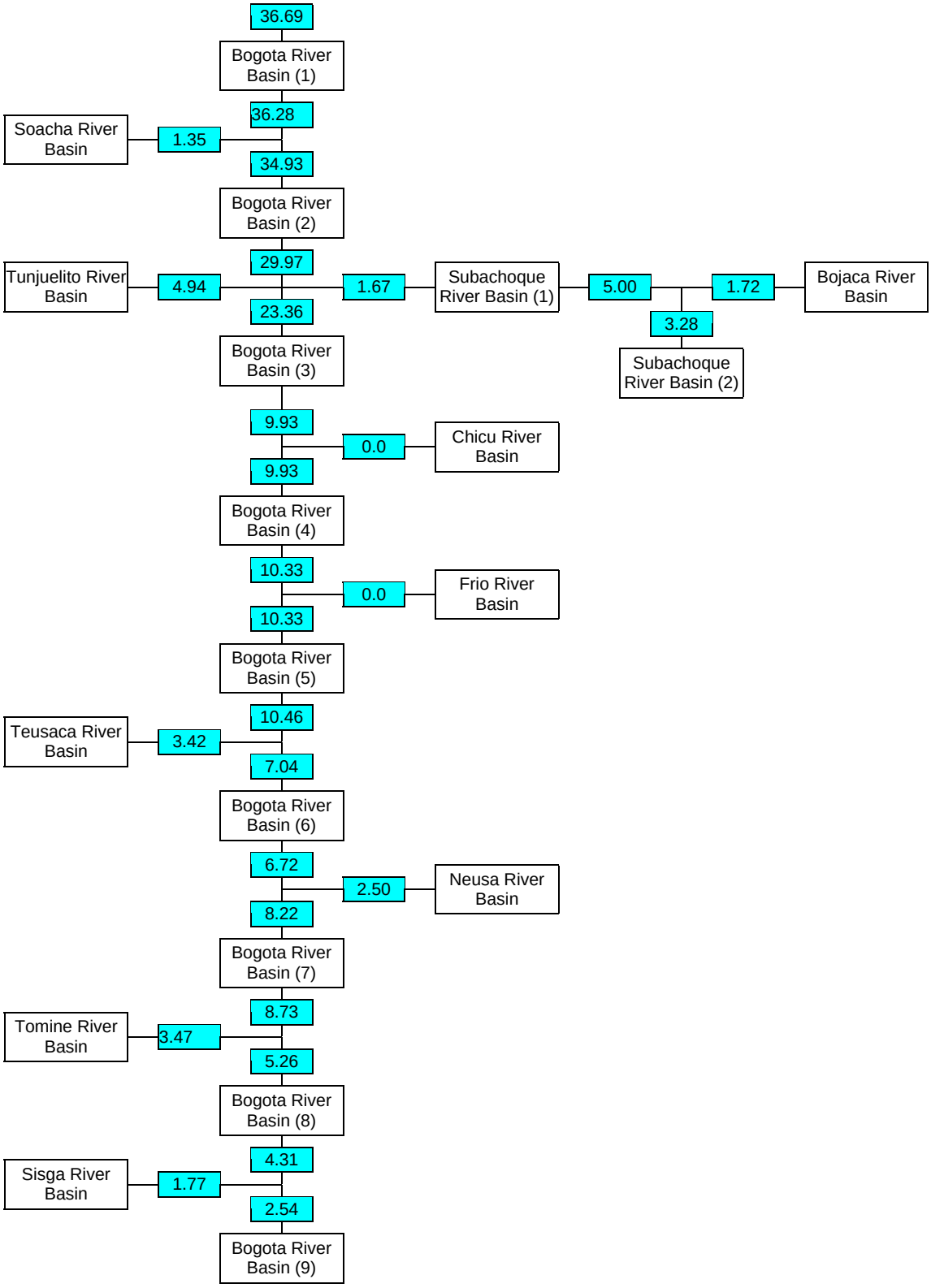


Figure-2.9 System of River Basin Division of the Study Area (m^3/seg)

Table-2.4 Hydrological Observation Stations in the Study Area

	Station No	Name of station	Coordinate		Period of Observation	Annual Discharge (m^3/s)
			x=N	Y=E		
Bogotá	-	ALICACHÍN	1051860	1019820	1956-1999	28.421
	2120806	-	-	-	-	31.152
	2120802	CANALETA PARSHALL	984600	1004350	1970-2001	23.066
	2120714	PTE CUNDINAMARCA	1010950	989670	1957-1999	9.487
	2120742	LA BALSA	1025800	1000700	1940-1999	6.812
	2120734	PTE VARGAS	1035920	1007895	1946-1999	2.478
	2120793	EL ESPINO	1047940	1011570	1953-1999	2.612
	2120792	TOCANCIPÁ	1041500	1018200	1928-1999	4.833
	2120767	PTE FLORENCIA	1049290	1025200	1962-1999	5.986
	2120755	SAN JORGE	989110	987600	1961-1999	0.027
	2120816	STA ROSITA	1056782	1036018	1973-1999	5.036
Tunjuelito	2120701	PUENTE BOSA	980200	1002255	1970-2001	4.649
	2120836	AVENIDA BOYACA	992991	997146	1989-2001	4.836
	2120750	CANTARRANA	995200	987150	1958-1998	2.908
	2120759	CANALETA PARSHALL	990000	977000	1960-2001	0.374
Bojaca	2120752	PTE GALINDO	1013340	975580	1956-1999	0.519
	2120756	EL RECREO	1022485	971885	1960-1999	0.637
	2120795	ALTAMIRA	1026800	969460	1968-1998	0.227
	2120912	LA TRIBUNA	1029300	963200	1993-1999	0.104
Choconta	2120719	SAUCIO	11056820	1041145	1945-1999	2.546
	2120815	VILLAPINZON	1068510	1053100	1973-1999	0.854
	2120917	PTE CHOCONTA	1060970	1045390	1992-1999	0.573
Chicu	2120879	LAS MERCEDES	-	-	1993-1999	0.063
Frio	2120735	PTE LA VIRGINIA	1036500	1001200	1947-1999	1.765
	2120925	PTE CALAMAR	1038840b	999380	1996-1999	1.198
	2120787	-	1043930	1001520	1964-1999	1.091
	2120768	LAS LAJAS	1046060	1012085	1955-1999	2.508
Neusa	2120875	PTE CHECUA	1058500	1023600	1990-1999	0.204
	2120918	EL VOLADOR	1062000	1010000	1993-1999	0.565
	-	Neusa	1060090	1011800	1954-2000	1.716
	2120793	EL ESPINO	1047940	1011570	1953-1999	6.633
	Reservoir	Sisga	-	-	1995-2000	1.641
Sisga	2120870	LA IBERIA	1048320	1039460	1994-1999	1.258
	2120868	STA MARTA	1049850	1041350	1991-1999	0.324
	2120845	EL BOSQUE	1025800	983600	1992-1999	0.582
Subachoque	2120758	LA MURALLA	1029600	987280	1960-1999	0.072
	2120800	PTE MANRIQUE	1035011	989155	1950-1999	0.516
	2120766	LA PRADERA	1044880	993954	1962-1999	0.272
	2120788	PTE ADOBES	1032210	1012505	1968-1999	3.151
Teusaca	2120878	EL VERGEL	1029500	1013700	1981-1999	2.869
	2120872	PTE LA CALERA	1014000	1012400	1991-1999	0.230
	Reservoir	Tomine	-	-	1995-2000	3.1416
Tomine	2120751	LA VEGA	1031010	1024110	1957-1999	1.477
	2120798	SAN ISIDRO	1028040	1020000	1959-1999	1.165
	2120799	STO DOMINGO	1028800	1021300	1959-1999	1.006

Appendix-1.1 Areas (km2) of the STUDY AREA by Municipality

Municipality		Municipality Areas (km^2)	Study Area	
			Areas (km^2)	% to Municipality Areas
1	Bogotá	1.605	769,0	48
2	Bojacá	106	81,6	77
3	Cajicá	53	53,0	100
4	Chía	76	76,0	100
5	Chocontá	302	253,2	84
6	Cogua	132	131,9	100
7	Cota	52	52,0	100
8	Cucunubá	110	14,3	13
9	El Rosal	88	73,0	83
10	Facatativá	160	156,1	98
11	Funza	71	71,0	100
12	Gachancipá	44	44,0	100
13	Guasca	346	213,9	62
14	Guatavita	249	157,9	63
15	La Calera	340	184,8	54
16	Madrid	120	120,0	100
17	Mosquera	107	107,0	100
18	Nemocón	99	99,0	100
19	Pasca	277	28,7	10
20	Sesquilé	143	142,7	100
21	Sibaté	120	98,0	82
22	Soacha	187	185,9	99
23	Sopó	103	103,0	100
24	Subachoque	207	197,5	95
25	Suesca	176	123,0	70
26	Tabio	74	74,0	100
27	Tausa	194	142,8	74
28	Tenjo	117	117,0	100
29	Tocancipá	72	72,0	100
30	Villapinzón	235	138,6	59
31	Zipaquirá	194	188,0	97
Total of Areas		6.159	4.268,7	69

Source: Mucipality Areas; from IGAC

Note:

(1) The Study Team overlaid the study area map on the IGAC municipality topographic map of 1:100,000 scales in 1993 and then calculated the areas of the Study Area by municipality.

(2) Areas of Soacha, Subachoque and El Rosal that were divided or newly created after 1995 were adjusted.

Appendix-1.2 Census Population of the Study Area

Unit: persons

Municipalities		All Municipality related to Study Area				Study Area			
		Census			Estimation	Census			Estimation
		1973	1985	1993	2000	1973	1985	1993	2000
A. Bogotá D.C.		2.571.548	3.982.941	4.945.448	6.437.842	2.571.548	3.982.941	4.945.448	6.437.842
B. Municipalities (13) close to Bogotá D.C									
B-1	Municipalities (10): Water Supplied by EAAB, in Total or Part								
1)	Cajicá	12.439	20.749	29.504	40.154	12.439	20.749	29.504	40.154
2)	Chía	20.602	36.956	45.696	61.743	20.602	36.956	45.696	61.743
3)	Funza	17.660	27.229	37.774	51.508	17.660	27.229	37.774	51.508
4)	Gachancipá	2.625	3.356	5.506	6.707	2.625	3.356	5.506	6.707
5)	La Calera	11.807	15.332	17.852	24.188	7.665	10.190	12.482	17.051
6)	Madrid	18.099	27.047	39.212	52.110	18.099	27.047	39.212	52.110
7)	Mosquera	7.660	12.344	20.440	27.753	7.660	12.344	20.440	27.753
8)	Soacha	37.753	109.051	230.335	283.889	37.753	109.051	230.335	283.889
9)	Sopó	5.852	8.256	11.416	14.586	5.852	8.256	11.416	14.586
10)	Tocancipá	4.465	6.674	11.155	14.602	4.465	6.674	11.155	14.602
	Subtotal	138.962	266.994	448.890	577.240	134.820	261.852	443.520	570.103
B-2	Municipalities (3): Water Self-supplied								
1)	Cota	4.827	8.080	11.471	14.784	4.827	8.080	11.471	14.784
2)	Facatativá	34.348	51.639	69.552	90.266	34.348	51.639	69.552	90.266
3)	Zipaquirá	41.506	55.370	69.695	91.113	41.506	55.370	69.695	91.113
	Subtotal	80.681	115.089	150.718	196.163	80.681	115.089	150.718	196.163
	Subtotal	219.643	382.083	599.608	773.403	215.501	376.941	594.238	766.266
C. Other Municipalities (17)									
1)	Bojacá	2.982	3.744	4.846	6.010	2.551	3.311	4.461	5.538
2)	Chocontá	13.232	14.954	14.074	17.974	11.731	13.280	12.646	16.183
3)	Cogua	8.630	11.503	12.485	15.202	8.630	11.503	12.485	15.202
4)	Cucunubá	5.157	5.975	7.719	9.581	577	624	885	1.069
5)	El Rosal	-	-	-	7.828	-	-	-	7.828
6)	Guasca	6.996	11.679	9.150	11.208	4.905	7.865	6.581	8.129
7)	Guatavita	4.781	5.116	5.752	6.953	3.392	3.649	4.126	5.034
8)	Nemocón	6.208	6.804	8.385	10.778	6.208	6.804	8.385	10.778
9)	Pasca	10.557	9.446	9.117	11.383	889	787	730	891
10)	Sesquilé	4.490	5.601	6.381	6.779	4.490	5.601	6.381	6.779
11)	Sibaté	14.037	20.049	21.266	29.808	12.952	19.057	19.964	28.004
12)	Subachoque	9.614	14.180	16.704	13.751	9.261	13.641	16.068	13.285
13)	Suesca	7.643	9.002	10.410	13.680	5.663	6.805	8.161	10.787
14)	Tabio	7.094	8.310	10.063	11.962	7.094	8.310	10.063	11.962
15)	Tausa	4.484	6.062	6.118	7.214	3.086	4.010	4.182	4.787
16)	Tenjo	6.733	8.920	15.493	19.357	6.733	8.920	15.493	19.357
17)	Villapinzón	11.890	14.324	13.130	16.312	8.187	9.870	9.439	11.818
	Subtotal	124.528	155.669	171.093	215.780	96.349	124.037	140.049	177.430
Total of Study Area		344.171	537.752	770.701	989.183	311.850	500.977	734.288	943.696
Bogotá and All Municipality		2.915.719	4.520.693	5.716.149	7.427.025	2.883.398	4.483.918	5.679.736	7.381.538

Source: Colombia Estadistica 1993-1997,DANE, 1999 / Anuario Estadistico 1997-1998, Cundinamarca

Note: Study Area Population was calculated;

① (Urban population)+ (Rural population; each area (km^2) proportion of the Study Area was applied to calculate each rural populatic

② Urban population of Cucunabá, Tausa and Pasca were eliminated due to nonexistence within the Study Area.

Appendix-1.3 Cropping Areas of the Study Area in 1999

Unit: ha

Cropping Classification		Transitory			Permanent	Annual	Total
Municipalities		Potato	Others	Total			
1	Bojacá	55	698	753	0	0	753
2	Cajicá	0	437	437	8	0	445
3	Chía	100	160	260	0	28	288
4	Chocontá	828	95	923	132	0	1.056
5	Cogua	2.897	100	2.997	5	0	3.002
6	Cota	170	585	755	0	0	755
7	Cucunubá	19	16	35	0	0	35
8	El Rosal	600	440	1.040	48	0	1.088
9	Facatativá	190	165	355	47	0	402
10	Funza	500	658	1.158	0	0	1.158
11	Gachancipá	48	20	68	0	28	96
12	Guasca	1.003	79	1.082	23	0	1.105
13	Guatavita	2.004	125	2.129	0	0	2.129
14	La Calera	456	72	529	11	0	540
15	Madrid	790	2.925	3.715	80	0	3.795
16	Mosquera	40	330	370	0	0	370
17	Nemocón	0	80	80	0	0	80
18	Pasca	128	116	244	30	0	273
19	Sesquilé	2.396	20	2.416	4	0	2.420
20	Sibaté	1.407	219	1.626	117	78	1.822
21	Soacha	220	53	273	3	0	276
22	Sopó	40	100	140	18	0	158
23	Subachoque	1.788	277	2.065	0	0	2.065
24	Suesca	1.381	245	1.626	4	28	1.658
25	Tabio	150	150	300	0	0	300
26	Tausa	3.608	72	3.680	0	0	3.680
27	Tenjo	150	12	162	0	100	262
28	Tocancipá	44	80	124	23	29	176
29	Villapinzón	2.775	52	2.828	5	24	2.856
30	Zipaquirá	6.500	740	7.240	0	0	7.240
Total of Study Area		30.288	9.122	39.409	558	315	40.282
Cundinamarca		61.505	59.631	121.136	91.051	8.840	221.027

Source: Estadisticas Agropecarias Vol. 16 - 2000, URPA, Governacion de Cundinamarca

Note: Original data was adjusted by the proportion of areas of the Study Area in Appendix-7.1.

Appendix-1.4 Livestock of the Study Area in 1999

Item		Cattle	Production of Milk	Pastureland (ha)		Poultry
Municipalities		(head)	(liter/day)	Total Area	Irrigated Area	(head)
1	Bojacá	2.360	9.154	1.946	35	19.025
2	Cajicá	4.282	17.321	2.500	1.600	600.000
3	Chía	7.800	30.800	4.000	120	220.000
4	Chocontá	10.764	11.178	3.974	422	92.488
5	Cogua	14.489	52.444	6.493	1.786	179.810
6	Cota	11.113	44.800	4.800	2.800	40.000
7	Cucunubá	475	1.155	219	1	1.411
8	El Rosal	5.667	37.011	5.300	0	320.000
9	Facatativá	15.270	60.800	7.500	530	80.000
10	Funza	17.016	80.115	4.690	250	34.000
11	Gachancipá	8.175	16.700	6.500	1.275	430.000
12	Guasca	7.365	27.474	3.478	0	4.083
13	Guatavita	3.717	6.262	7.514	0	3.131
14	La Calera	7.888	10.589	7.966	215	9.127
15	Madrid	14.322	85.492	5.100	4.900	64.960
16	Mosquera	12.010	56.784	6.300	4.650	53.350
17	Nemocón	13.500	109.200	6.800	4.500	100.000
18	Pasca	916	1.331	1.228	717	10.769
19	Sesquilé	8.236	20.165	7.587	799	91.838
20	Sibaté	6.685	22.028	5.027	547	12.509
21	Soacha	8.314	44.265	6.700	1.600	1.534
22	Sopó	10.812	82.164	7.400	2.400	83.000
23	Subachoque	9.946	35.827	10.372	2.401	4.258
24	Suesca	5.730	15.465	5.523	1.105	135.318
25	Tabio	6.350	33.275	3.825	2.820	43.000
26	Tausa	5.643	9.564	6.102	0	1.443
27	Tenjo	14.070	68.900	8.237	880	10.000
28	Tocancipá	6.532	59.355	15.402	880	170.000
29	Villapinzón	6.823	8.673	3.244	220	150.339
30	Zipaquirá	13.419	58.122	10.700	2.000	3.550
Total of Study Area		259.688	1.116.413	176.429	39.453	2.968.944
Cundinamarca		1.177.644	2.191.705	1.174.014	76.500	33.676.748

Source: Estadisticas Agropecarias Vol. 16 - 2000, URPA, Governacion de Cundinamarca

Note: Original data was adjusted by the proportion of areas of the Study Area in Appendix-7.1.

Appendix-1.5 Cultivate Areas of Flower for Export Ornament in CUNDINAMARCA (Registered Areas in ICA 1998)

Unit: ha

Municipalities		Total Areas	Carnation	Mini-carnation	Rose	Spray-rose	Pompon	Alstro-emeria	Gypso-phila	Statice	Others
1	Bojacá	96.9	37.9	10.0	32.0	0.2	-	7.5	-	-	9.3
2	Cajicá	126.8	22.0	0.5	88.1	-	3.6	0.2	4.8	0.3	7.3
3	Chía	188.9	11.3	10.4	103.7	0.5	21.7	5.1	20.2	1.1	14.9
4	Chocontá	1.5	-	-	1.5	-	-	-	-	-	-
5	Cogua	18.5	-	-	18.4	-	-	-	-	-	0.1
6	Cota	138.5	3.8	37.1	71.9	13.8	-	1.1	3.7	-	7.1
7	Facatativá	290.4	120.8	30.0	101.3	1.4	-	12.5	9.0	1.0	14.4
8	Funza	362.9	78.1	74.8	105.0	0.5	46.3	29.1	7.7	1.4	20.0
9	Gachancipá	85.6	25.9	10.9	35.8	-	-	1.5	-	5.3	6.2
10	Guasca	68.3	33.9	8.9	14.8	-	-	-	6.8	-	3.9
11	La Calera	7.0	-	-	6.8	-	-	-	-	-	0.3
12	Madrid	827.6	228.5	99.3	308.6	3.7	66.5	57.0	23.1	12.3	28.6
13	Mosquera	67.6	3.0	8.4	32.0	1.0	1.0	11.4	-	2.0	8.7
14	Nemocón	90.9	38.2	17.7	28.7	-	-	-	3.2	1.0	2.0
15	Sesquilé	126.5	7.3	9.1	78.1	0.5	-	-	18.2	2.9	10.5
16	Sibate	88.5	79.7	1.8	7.0	-	-	-	-	-	-
19	Soacha	60.0	37.0	2.5	19.5	-	-	-	-	1.0	0.0
20	Sopó	169.5	89.7	29.2	26.6	-	-	3.8	6.5	2.9	10.8
21	Subachoque	445.5	131.0	36.1	243.3	6.3	1.7	4.0	5.7	3.2	14.2
22	Suesca	171.7	40.7	9.2	105.2	4.6	-	1.5	4.4	3.3	2.9
23	Tabio	32.7	-	-	29.4	-	1.3	-	1.0	0.9	0.1
24	Tenjo	255.0	44.4	16.9	153.5	-	1.5	5.8	7.2	7.1	18.5
25	Tocancipá	263.3	61.3	26.9	148.2	1.2	3.0	6.1	7.9	2.5	6.2
26	Zipaquirá	59.6	12.9	4.4	19.6	-	6.5	0.5	0.8	2.4	12.5
Total of Study Area		4,043.4	1107.4	444.1	1778.9	33.6	153.1	147.2	130.0	50.7	198.6
Cundinamarca		4,160.8	1125.7	447.1	1785.3	33.6	155.1	149.9	130.0	53.4	280.7

Source: Instituto Colombiano Agropecuario -ICA-