CHAPTER 2　Landslides in Soacha Municipality

2.1 Outline of Landslides

2.1.1 Outline

The study areas are parts of COMUNA 4 named Altos de Cazuca and El Divino Nino in COMUNA 6. Altos de Cazuca located near at the boundary of he southern urban area of Bogota city is divided into 32 districts named Barrios. El Divino Nino is one of the barrio in COMUNA 6.

Landslides, mostly classified into rock fall and surface collapses, in the study areas are found at abandoned quarries in Altos de Cazuca where houses gathered in the upper and lower area close to steep slopes and landslide hazard areas, Also, houses gathered in landslide hazard area formed by a quarry in El Divino Nino.

Term "Landslide" : the perceptible downward sliding or falling of a mass of earth, rock, or mixture of the two. The term landslide includes a wide range of ground movement, such as rock falls, deep failure of slopes, and shouldow debris flows.

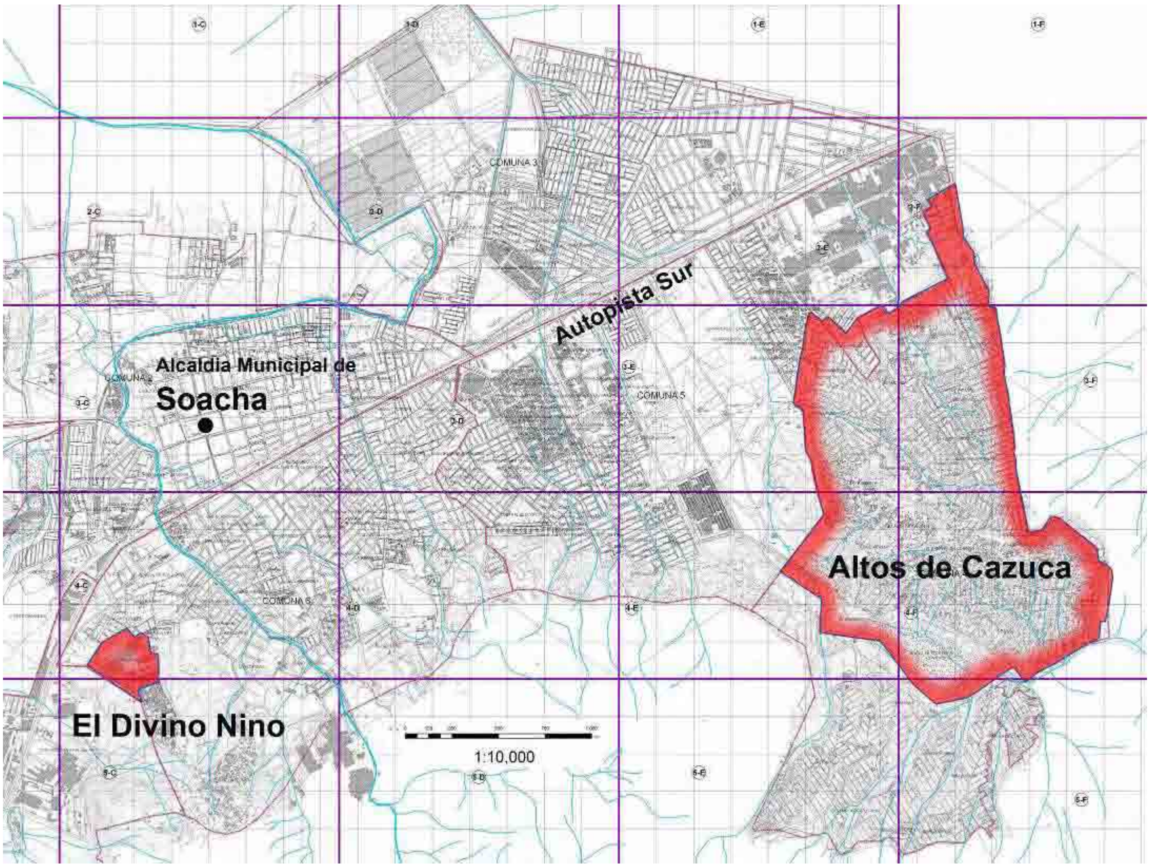


Figure S5-2-1 Guide Map of the Landslide Study Areas in Soacha Municipality

Figure S5-2-2 is geological map showing the study area. Both Guaduas Formation (KTg) and Guadalupe Group (Ksglt) consists of sandstone layers with mudstone layers and some coal layers. These layers are classified into soft rocks. Ktg and Ksglt are partially covered with high terrace deposit (Qta).

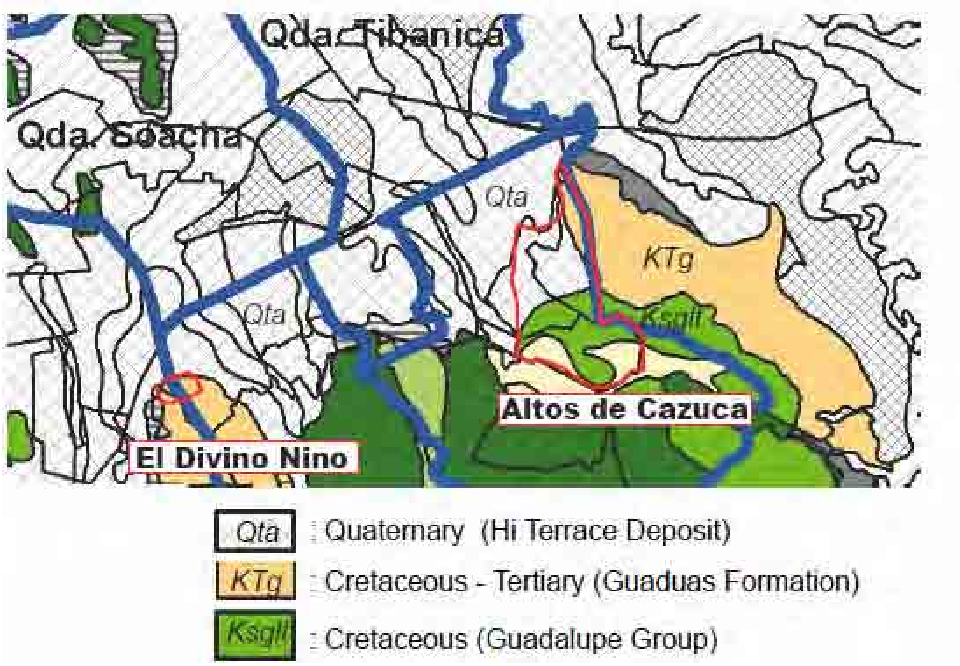


Figure S5-2-2 Geological map of Soacha Municipality

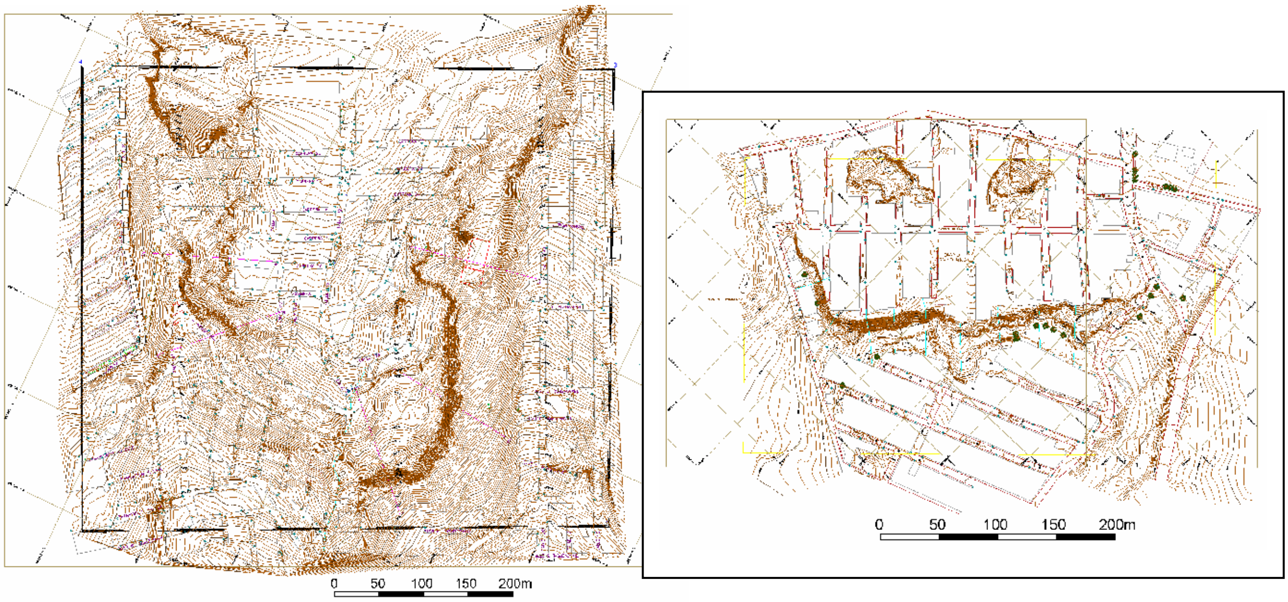


Figure S5-2-3 Topographic Map of La Capilla (left) and El Divino Nino
(The places where contour lines are dense are steep slope.)

La Capilla in Altos de Cazuca

El Divino Nino

Photo S5-2-1 Photo on West Part of La Capilla and El Divino Nino

2.2 Existing Studies

2.2.1 Existing Studies

Though the number of studies in Soacha is limited, a few studies exist to serve as a reference listed in Table S5-2-1.

Table S5-2-1 Existing Studies on Landslide in Soacha Municipality

Year	Contents	Organization
1992	High Risk Zones Study	Municipio de Soacha, Oficina de Planeacion Municipal
1996	Geotechnical Study Cazuca Sector La Capilla Agreement No. 034 of 1995	INGEOMINAS
2000	Technical report about the view of emergency to the neighborhood Villa Esperanza from the Soacha Municipality – Cundinamarca	INGEOMINAS
2004	Pre-diagnosis for the formulation of the partial plan for Cazuca and Altos de Cazuca, Soacha Municipality	Universidad Nacional
2004	Zoning and analyze for the hazard due to mass removal phenomena in the sector of Cazuca (Soacha, Cundinamarca)	Universidad Nacional
2006	Zoning of the high risk area in Soacha (Finished)	INGEOMINAS
2006	Houses Survey (in Altos de Cazuca and El Divino Niño after May 2006 disasters)	Soacha Municipality

A study by Soacha Municipality planning office (1992) includes general description of the study area, and mentions high risk area then, including barrios Esperanza and Altos de Cazuca.

In the study by INGEOMINAS (1996 study in Capilla), topography survey was made and topography map of 1/500 scale with 1-meter interval contour was made. By interpretation of aerial photos with 1/5,000 scale and field works to identification and mapping of geological and geomorphologic unit, a geological map of 1/500 scale was made. For subsoil exploration studies, five lines of geophysical exploration, two trenches, and three borings with depth between from 8 m to 22 m and laboratory tests were made. The study made four assumed models of rotational landslide hazard areas and made stability analysis using modified Bishop's limit equilibrium method. Based on the results of analysis, it proposed mitigation works for different part of the slope.

INGEOMINAS (2000) study in Villa Esperanza was made on an emergency visit. The study made a preliminary zoning map of 1/10,000 scale for the short term purpose. The zoning map was made using hazard zoning map of 1/25,000 by INGEOMINAS in 1988 and a topographic map of 1/10,000 scale in 1989, in which Villa Esperanza is not yet figured.

A study by Universidad Nacional (2004) is basically from viewpoint of urban planning, includes location of infrastructures such as water pipelines

Ongoing study by INGEOMINAS covers entire municipality urban area, and is based on geology and geomorphology to identify high risk areas.

There are a few more potentially useful but unconfirmed information at the time of writing. Hearing from a resident in Villa Esperanza in Altos de Cazuca mentions a study as mitigation works by corps of military engineer was made in seven years ago, but the document was not found. Another one is a study by Medicos Sin Frontera that was mentioned elsewhere, but is not yet found so far.

Any study regarding El Divino Nino was not found elsewhere. Any significant landslide monitoring has not been implemented by Soacha Municipality.

2.2.2 Past Disasters

Some statistical data have been prepared even though records of individual disasters have not been prepared properly. There are some descriptions about landslides in the area as follows;

According to the study by chamber of commerce cited in the report by Soacha Municipality in 1992, 16,500 people lived in Altos de Cazuca and 228 people in Esperanza at that time. It was also reported that 163 people or 37 families needed urgent evacuation.

In Villa Esperanza, the study by INGEOMINAS in 1988 already mentioned the area as high risk area. Due to the rainy season at the end of 1999, landslide occurred in January 6, 2000. Emergency visit and study was made in February 29, 2000 by INGEOMINAS.

In 2001, historical landslide records in recent years in Soacha were compiled by Ingeniería y Geotecnia Ltda. (IGL) in JICA study. The purpose was to develop a slope disaster database in Bogotá and eight municipalities in Cundinamarca department using uniform format. The result was summarized in Table S5-2-2.

In El Divino Nino, there was a large rock fall of larger than one meter in size in 2004, though fortunately there was no human damage.

According to the record of fire fighter response to landslide disasters in the municipality in last 5 years, nine times of dispatches to La Capilla in Altos de Cazuca were most, and five times of dispatches to El Divino Nino were second.

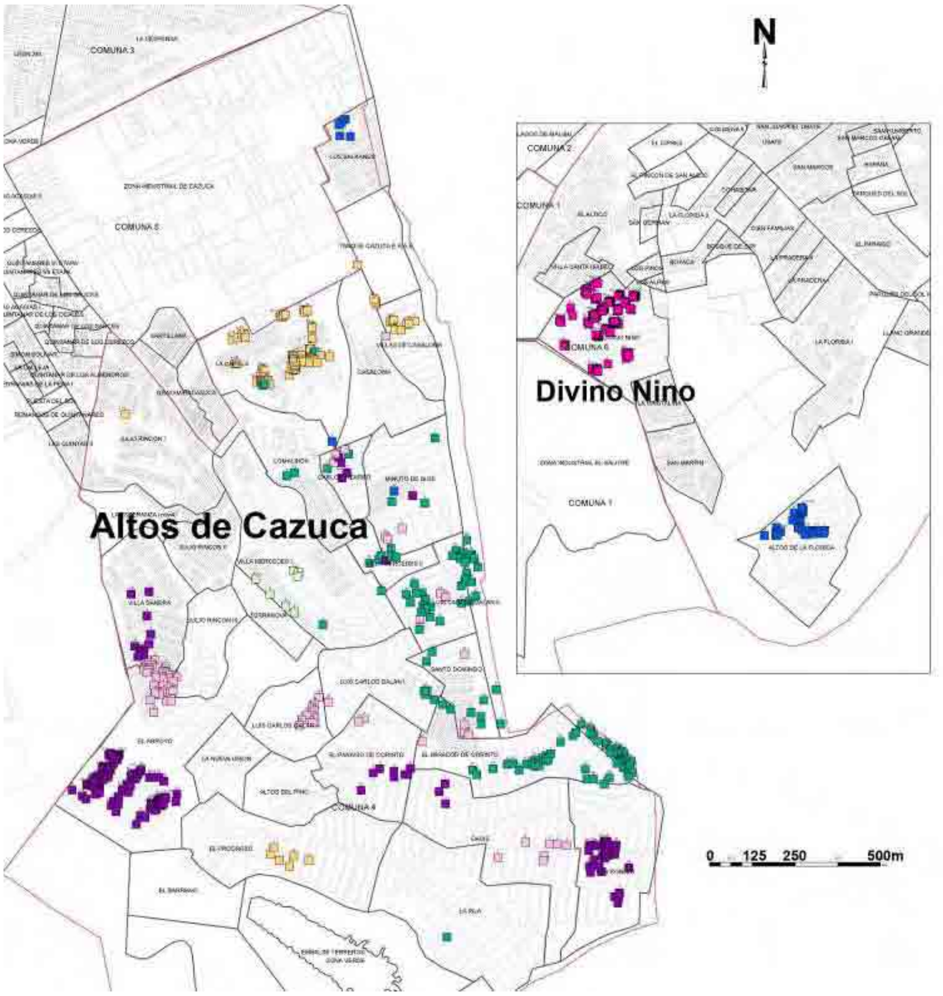
All of descriptions above about the landslide in Soacha musicality do not show the spots of affaires.

Table S5-2-2 Causes of Past Slope Disasters

Barrios	Type of Slope Disasters	Intrinsic Factor				Rain		Human Factor			
		lithology	weathering	joints	underground	erosion	saturation	discharges	excavation	overloads	scour
Casaloma	Earth flow	x	x	x		x	x	x	x	x	
Casaloma – Flanco derecho	Debris flow	x	x	x		x	x	x	x	x	
Cazuca	Debris flow	x				x	x			x	
Divino Nino	Rock fall	x	x	x		x			x	x	
Julio Lincon – Tercera etapa	Earth flow	x			x		x	x	x	x	
Julio Rinco – Tercera etapa	Earth flow	x					x	x		x	x
La Capilla	Rotational landslide	x			x		x	x	x	x	
La Capilla	Translational landslide	x		x		x	x		x	x	
Lomalinda	Earth flow	x			x		x	x	x	x	
Rincon de San Meteo	Rock fall	x		x		x			x		
Villa Esperanza	Rotational landslide	x			x		x	x			
Villa Esperanza – El Barreno	Debris flow	x	x			x	x	x	x		
Villa Mercedes	Earth flow	x					x	x		x	
Villa Mercedes	Rotational landslide	x			x		x	x		x	
Villa Sandra	Debris flow	x	x		x	x	x		x	x	

(Source: Ingeniería y Geotecnia Ltda., compiled for JICA study, 2001)

The Soacha Municipality activates a special survey program after the landslide event on May 11, 2006, in order to establish the number of inhabitants (families) and houses affected. Social Development Secretariat was designed as leader for all municipality staffs in order to compile the social information to provide, initially basic household as sprung mattress, blankets, etc and then, a monetary subsidy to the families who accepted to be evacuated. At first moment, the municipality surveyed 1200 families for basic household help and then, almost 700 families were surveyed again for monetary subsidy. This second survey was directed in Altos de Cazuca and El Divino Niño. The Survey Data Base was done applying a special format, which includes property of land, inhabitants of houses, structural features, observation results, and priority to intervene. The actual spots of houses surveyed were specified on the map as shown in Figure S5-2-4, based on names of house owners and address on the format of survey. Most of houses are not only affected by landslides but also water and mud flows. Generally, lack of slope protection after exploitation and improper treatment of sewage water due to shortage of sewer system can be major inducing factors. The average annual rainfall for several years at nearby Casablanca station in Altos de Cazuca by EAAB is 575 mm (INGEOMINAS, 1996). The rainfall has not been a major inducing factor in general. However, the rainfall in May 2006 was so heavy that this could be main inducing factor.



(square mark : point of house, color indicates barrios) in Altos de Cazuca and El Divino Nino)

Figure S5-2-4 Location Map of Houses Registered as in Danger in the Emergency Survey after May 2006

2.2.3 Critical Areas in the Study Area

According to the statistic record mentioned above, the number of residential houses suffered from landslides in El Divino Nino and La Capilla of Altos de Cazuca is highest in Soacha Municipality. Prompt measures should be taken to save people in these areas.

Table S5-2-3 Number of Houses Registered as in Danger in the Emergency Survey after May 2006 (A)and Times of Fire Fighter Activated in Last 5years (B).

	Number of houses in danger	Times of fire fighter activated in last 5 years
El Divino Nino	140	5
La Capilla	54	9
Villa Esperanza	107	3
Mirador de Corintos III	29	0

Table S5-2-4 Number of Houses Registered as in Danger in the Emergency Survey after May 2006

BARRIO	COUNT	BARRIO	COUNT
ALTOS DE LA FLORIDA	28	LOS PINOS	9
CARLOS PIZARRO	10	LOS ROBLES	33
CASALOMA	4	LUIS CARLOS GALAN I	5
EL ARROYO (Villa Esperanza)	107	LUIS CARLOS GALAN II	23
EL DIVINO NINO	140	LUIS CARLOS GALAN III	9
EL MIRADOR DE CORINTO	29	MINUTO DE DIOS	9
EL PARAISO DE CORINTO	10	OASIS	10
EL PROGRESO	6	SAN RAFAEL	4
JULIO RINCON I	1	SANTO DOMINGO	10
JULIO RINCON III	2	VILLA MERCEDES I	9
LA CAPILLA	54	VILLA MERCEDES II	6
LA ISLA	1	VILLA SANDRA	27
LOMALINDA	2	VILLAS DE CASALOMA	8
LOS BALKANES	5	ZONA INDUSTRIAL DE CAZUCA	1
LOS PINOS	9	outside of the study area	35
		TOTAL	597

Table S5-2-5 Historical Records of Slope Disaster in Study Area

Barrio	Year	Month	Day	Type of slope disaster	Area (m²)	Damage to House		Evacuation	
						Total	Partial	Families	Persons
Casaloma	2001	6	29	Earth Flow	7,200		45		
Casaloma - Flanco derecho	1998			Debris Flow	4,500		20		
Cazucá	2001	6	29	Debris Flow	750		0		
Divino Niño	2001	6	29	Rock Fall	24,000		100		
Julio Rincon - Tercera etapa	1989			Earth Flow	6,000		90		
Julio Rincon - Tercera etapa	2001	6	29	Earth Flow	8,500		3		
La Capilla	2000	6	13	Rotational Landslide	3,500	10	13	10	50
La Capilla	2000	10		Translational Landslide	12,000	1	42	1	3
Lomalinda	2001	6	29	Earth Flow	12,000		15		
Rincón de San Mateo	1998	8		Rock Fall	200	3	7	5	20
Villa Esperanza	2000	1	3	Rotational Landslide	6,500	4	21	25	130
Villa Esperanza - El Barreno	2001	6	29	Debris Flow	6,000		30		
Villa Mercedes	2001	6	29	Earth Flow	12,000		38		
Villa Mercedes	2001	6	29	Rotational Landslide	2,400		5		
Villa Sandra	2001	6	29	Debris Flow	4,800		8		

(Source: Ingeniería y Geotecnia Ltda., compiled for JICA study, 2001)

2.3 Study Results (Hazard Maps)

2.3.1 Inventory Survey

Classification of landslides by Vernes (1978, Verns Classification) shown in Table S5-2-6 is commonly used for classification of landslide in the field of landslide study. Rock fall, collapse, rock and earth slide and mudflow in the table are especially seen in the study area, Altos de Cazuca and El Divino Nino. It is sometimes difficult to discriminate between rock slide and earth slide, the word of "mass movement" is used for rock slide or earth slide as far as they are not identified. Figure S5-2-5 is typical slope disasters around Soacha Municipality.

Table S5-2-6 Classification of Landslide (Verns 1978)

Material	Types of Movement		
	Fall / Topple	Slide / Spread	Flow
Rock	**Rock Fall / Toppling**	**Rock Slide**	Rock Avalanche
Earth	**Earth Fall (Collapse)**	**Earth Slide**	**Earth Flow (Mudflow)**
Debris	Debris Fall	Debris Slide	Debris Flow

Rock : *A hard or firm mass that was intact and in its natural place before the initiation of movement*

Earth : *describes material in which 80% or more of the particles are smaller than 2mm, the upper limit of sand sized particles*

Debris : *Contains a significant proportion of coarse material; 20% to 80% of the particles are larger than 2mm, and the remainder are less than 2mm*

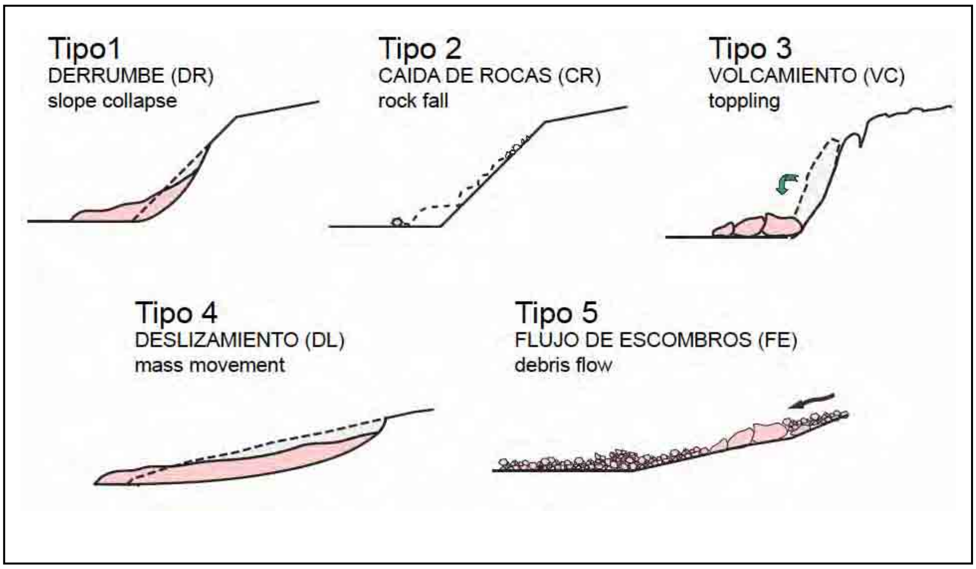


Figure S5-2-5 Typical Slope Disasters around Soacha Municipality

<u>Existing slope disasters</u>

Disaster inventory survey in Altos de Cazuca and El Divino Nino has been carried out by aero photo analysis and site reconnaissance. The results of the disaster inventory survey are seen in Disaster Inventory Map as shown in Figure S5-2-6. The map shows existing steep slopes, mass movement, traces of collapses and traces of mud flows as shown in Table S5-2-7. Mass movement is active mass movement only. Steep slopes which formed in abandoned quarry themselves and with 30 degree inclination are not disasters, however, rock falls and surface collapses occur frequently on the steep slopes.

Table S5-2-7 Classification of Inventory Survey

Topographic Feature		Classification	Type of Disaster
I. Steep Slope	I-1	Steep Slope (Active)	Rock Fall, Slope Collapse
	I-2	Steep Slope formed by quarry	Slope Collapse
	I-3	Steep Slope >30 deg	Slope Collapse
II. Mass movement	II-1	Mass movement (Active)	Mass Movement
III. Collapse	III-1	Trace of Slope Collapse	Slope Collapse
	III-2	Trace of Slope Collapse(Old)	Slope Collapse
IV. Mud Flow	IV-1	Mud Flow	Mud Flow
	IV-2	Mud Flow (Potential)	Mud Flow

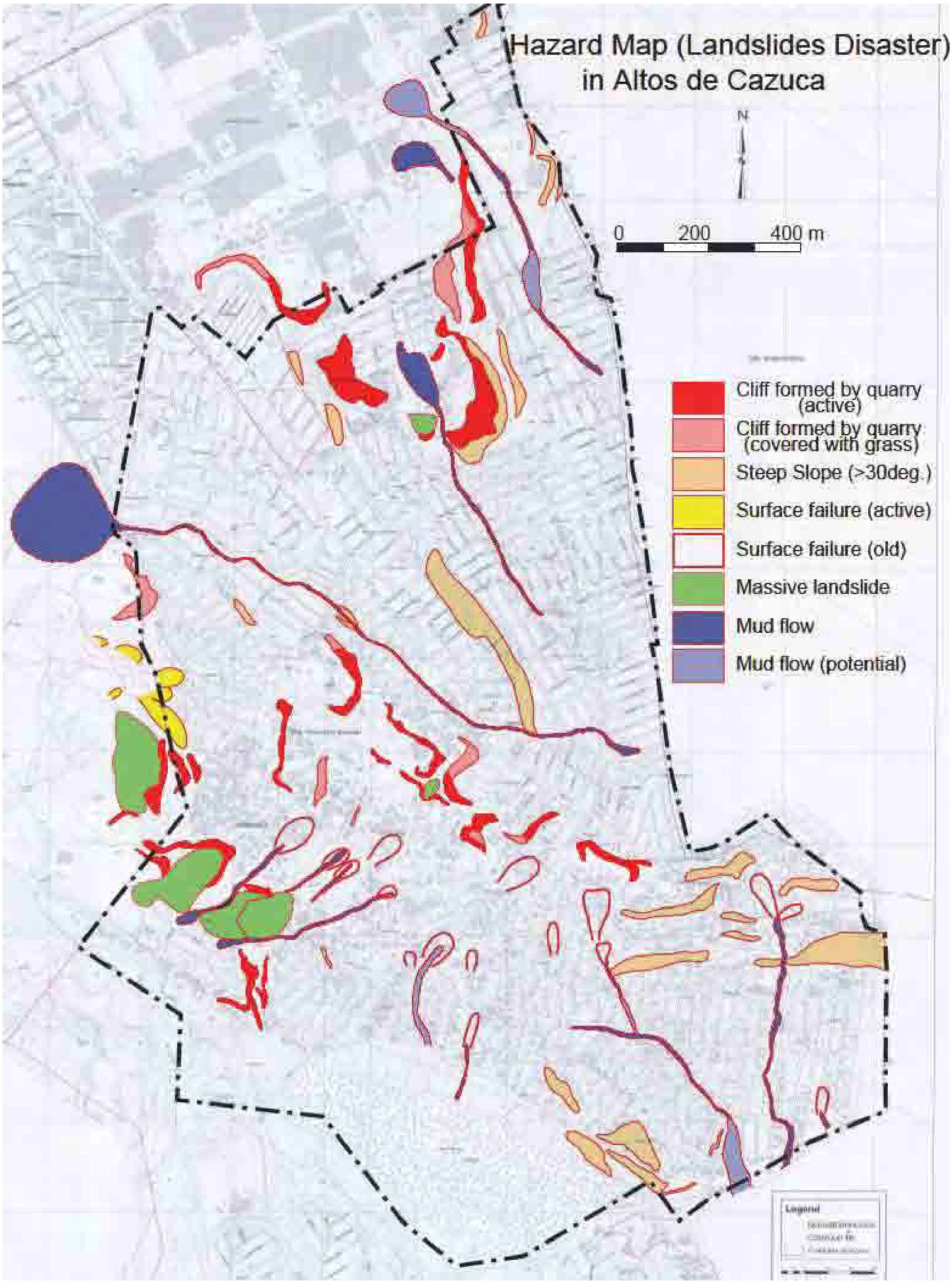


Figure S5-2-6 Disaster Inventory Map in Altos de Cazuca

2.3.2 Steep Slopes in Abandoned Quarry

Steep slopes in the abandoned quarries are the most critical conditions among many disasters in Altos de Cazuca. In this project, only steep slopes in the abandoned quarries are the object of the studies, since INGEOMINAS is studying comprehensive landslide disasters in the areas, and steep slopes in the abandoned quarries are most critical areas comparing mass movements and others.

Phenomenon on Steep Slopes

The features of the steep slopes in abandoned quarries are as follows;

a) Quarries which were operated in 1950"s and 1960's were open cut to obtain sand and clay from geological layers, therefore slopes in abandoned quarries are mostly very steep, and above and below the slopes are mostly gentle.
b) Because above and below the slopes are gentle, it is easy to build houses there. Therefore there are many residential houses close to steep slopes. Most of these residential houses are illegal, and most of residents in the houses are not well-off economically.
c) Small rock falls and small collapses occur frequently on the slopes.

Photo S5-2-2 Rock Falls from Steep Slopes

d) The areas are underlain by alternation of sandstone and mudstone as base rocks in the areas. The base rocks exposed on the steep slopes are soft rocks (geotechnical term; compression strength (qu) < $40N/mm^2$) with cracks. It easy for soft rocks to be weathered, and sometimes gully erosion can be seen on the slopes.
e) Therefore rock falls or small collapses could occur in future and larger collapse or mass movement may occur on steep slopes. The residents close to the slopes are put in jeopardy.

Surface Collapses (La Capilla)

Many Cracks (Divino Nino)

Gullies (La Capilla)

Photo S5-2-3 Steep Slopes with Surface Collapses, Many Cracks, and with Gullies

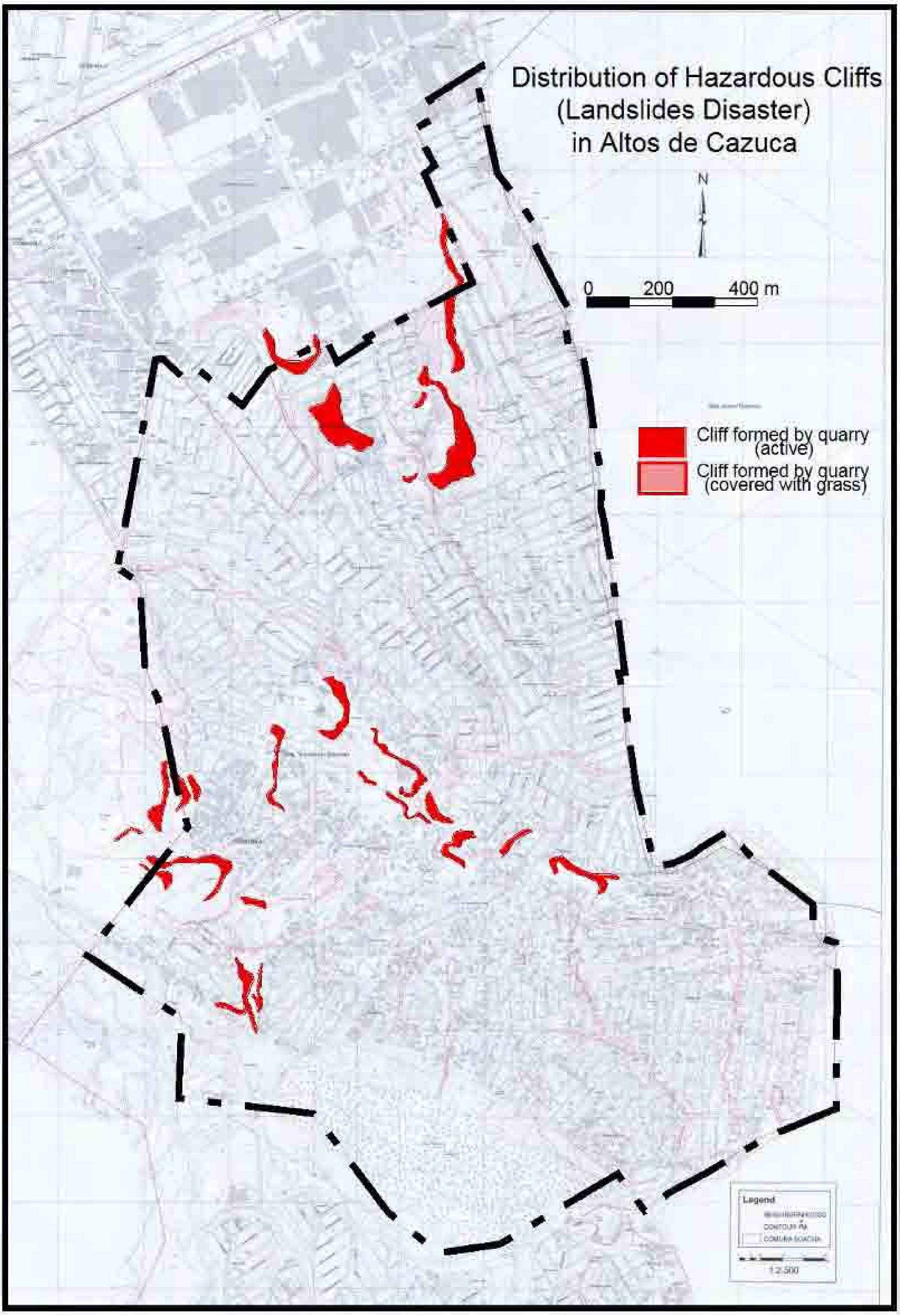


Figure S5-2-7 Distribution of Hazardous Steep Slopes

2.3.3 Critical Zones in El Divino Nino and La Capilla

In the study area, Critical Zones has been set to verify the critical area in the barrios, Barrio La Capilla in Altos de Cazuca and El Divino Nino where houses are dense, slopes are high and landslides occur frequently.

<u>Setting of Critical Zones</u>

Critical Zones are set above and bellow steep slopes. Steep slopes are defined in this project as steep slopes of over 5 m in height with an incline of over 30 degrees formed by quarrying. Critical Zone is defined as the area within the distance of 2 times of the slope height (2h) from toe of the slope and the area within same distance as the slope height from top of the slope as shown in Figure S5-2-8.

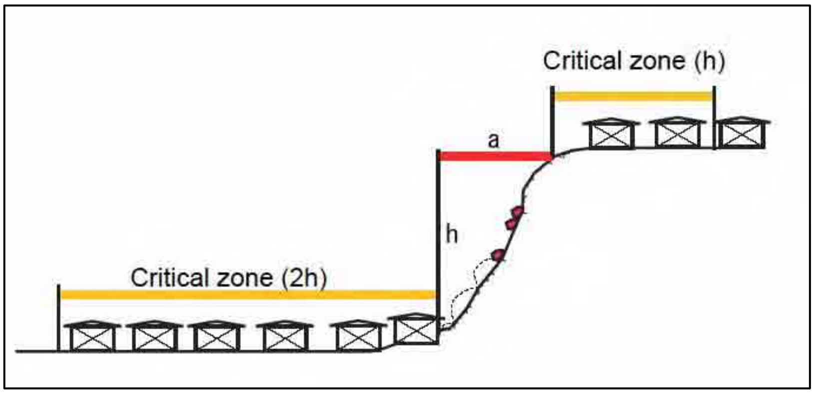


Figure S5-2-8 Definition of Critical Zone of Steep Slope

The case as shown in Figure S5-2-9, the slope height is considered as follows.

L > 2Hb: Consider Slope A and Slope B to be individual
L ≤ 2Hb: θ > 30 deg. : consider Slope A and Slope B to be combined
θ < 30 deg. : consider Slope A and Slope B to be individual

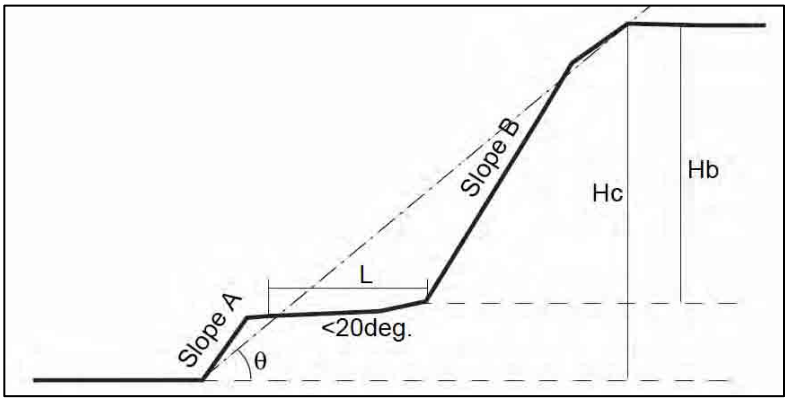


Figure S5-2-9 Definition of slope height in case of step in the slope

The reasons why Critical Zone set 2h from toe of the slope are;

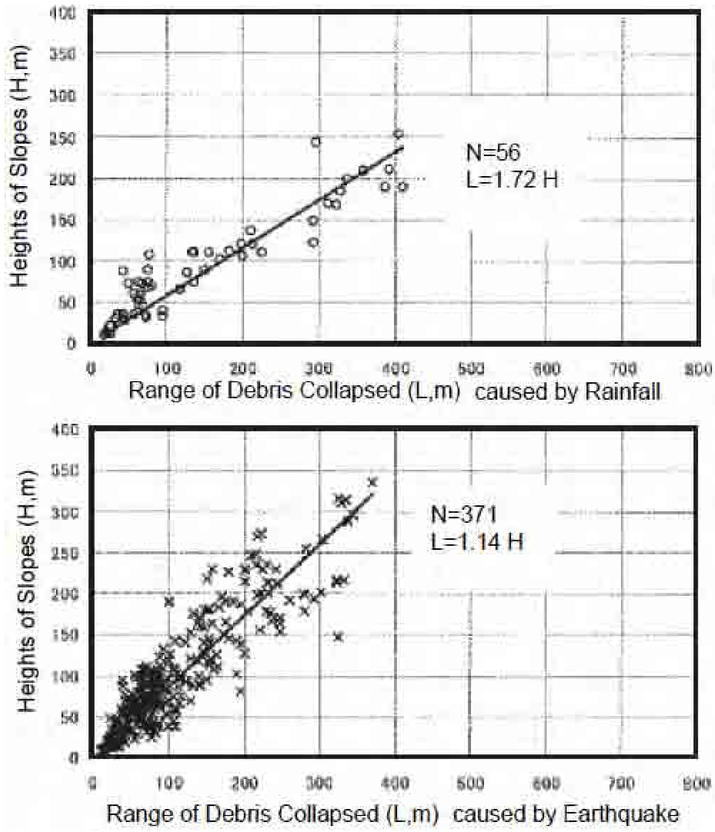
a. Critical Zones are set 2h from toe of the slope in Japan as shown in Figure S5-2-10, and

b. Existing collapses on slopes in abandoned quarry in Soacha city show that debris reach almost 1 h to 1.5 h of slope heights from the slopes as shown in Photo S5-2-4.

The reason why Critical Zone set 1h from top of the slope is existing collapses show that collapses invaded into top of the slope till 0.5 h of slope heights.

Small rocks reaches till 1 h – 1.5 h (h : slope height)

Photo S5-2-4 Collapse on steep slopes in abandoned quarry (near Llano Grande, Comuna 6, Soacha)



(Fukuda et al., 2005, Journal of Engineering Geology)

Figure S5-2-10 Relation between Slope Heights and Ranges of Debris Collapsed in Japan

Critical Zones in El Divino Nino and La Capilla

Critical Zone in El Divino Nino is shown in Figure S5-2-11. Maxim height of the steep slope is about 40 m, and Critical Zone is extended to a maxim of 80 m from the slope. Many houses are involved in Critical Zones.

Critical Zone in La Capilla is shown in Figure S5-2-12. Maxim height of the steep slope is about 40 m, and Critical Zone is extended to a maxim of 80 m from the slope. Many houses are involved in Critical Zones.

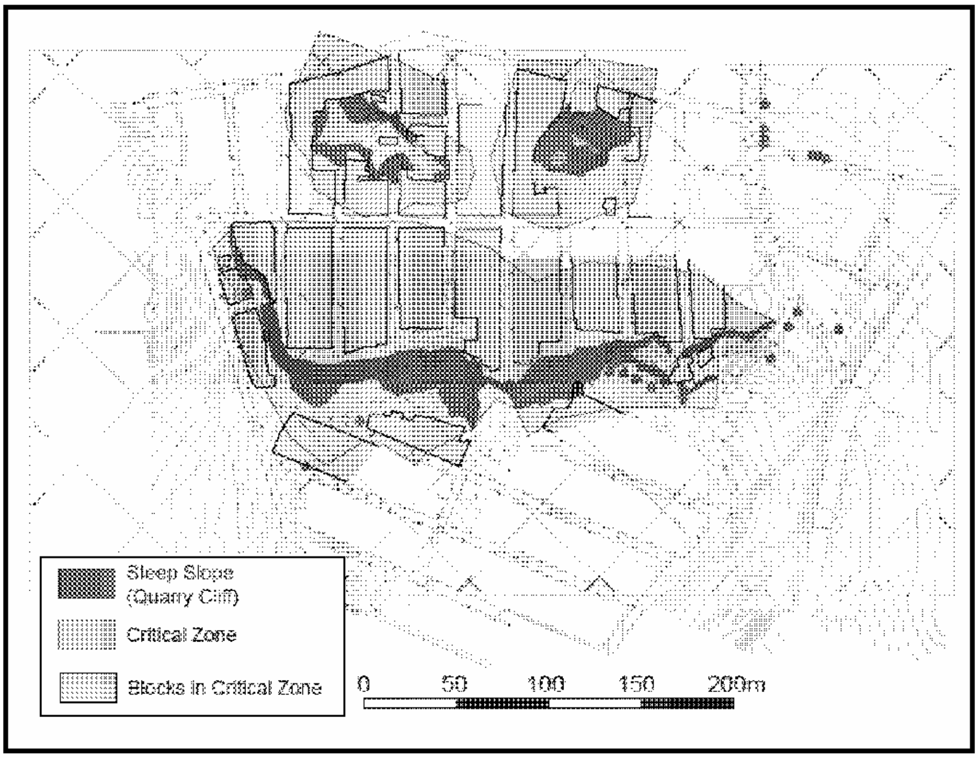


Figure S5-2-11 Critical Zones in El Divino Nino

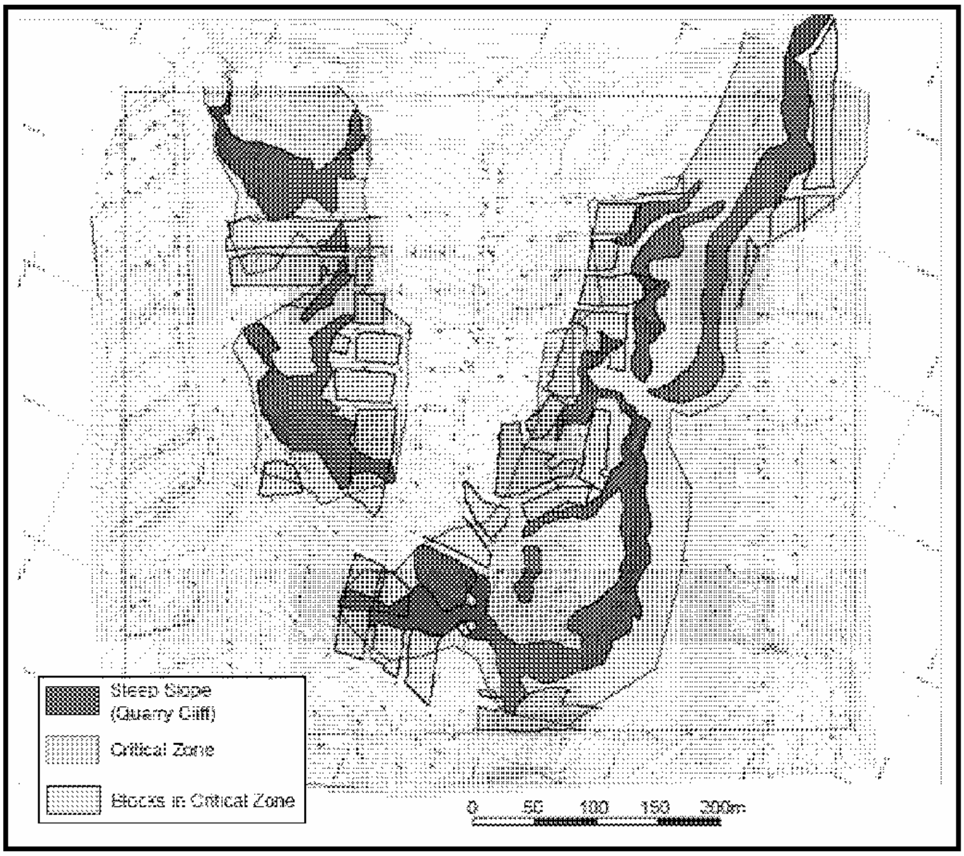


Figure S5-2-12 Critical Zones in La Capilla in Altos de Cazuca

Setting of Emergency Zone

Soacha Municipality has a scheme for relocation of houses from high risk areas as a disaster prevention program. Critical Zone maps shown in Figures S5-2-11 and S5-2-12 could provide useful information for Soacha Municipality's relocation scheme. It is obvious, however, that the relocation of houses in Critical Zones in El Divino Nino and La Capilla so soon is difficult, since many houses are involved in Critical Zones. As the information for relocation scheme of Soacha Municipality, Emergency Zone is set in Critical Zones in El Divino Nino where is the most serious area in Soacha city. Emergency Zone is more serious zone in Critical Zone, and houses in Emergency Zone should be evacuated immediately. The criterion of Emergency Zone is within the limits of 10 m or 2 houses from toe of the slope as shown in Figure S5-2-13, however, final decision of Emergency Zone in El Divino Nino was done by JICA Study Team with site survey. Emergency Zone in El Divino Nino is shown in Figure S5-2-14.

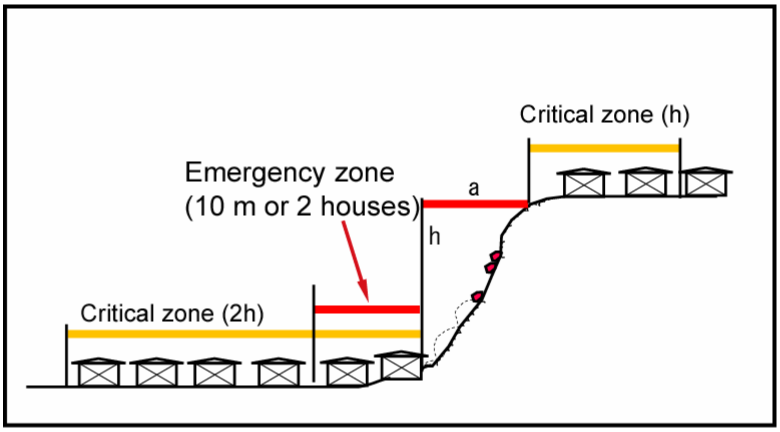


Figure S5-2-13 Definition of Emergency Zone of Steep Slope

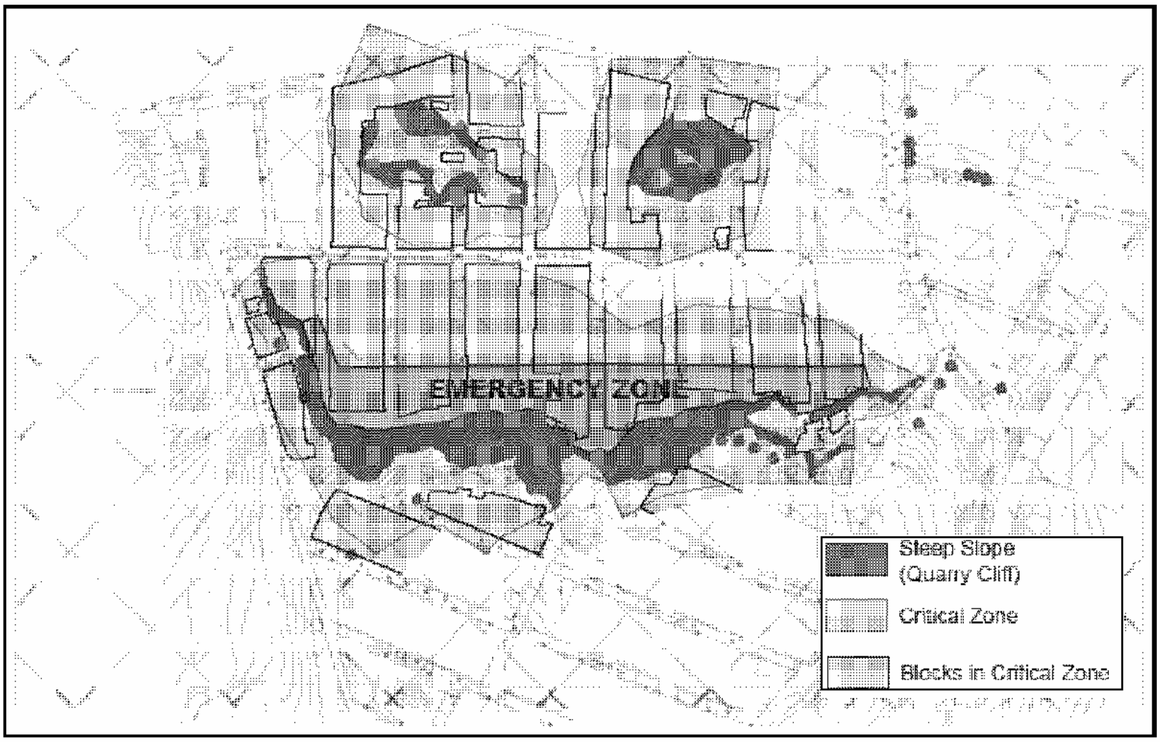


Figure S5-2-14 Emergency Zone in El Divino Nino

2.3.4 Community Hazard Map

In the process of the relocation program in Divino Nino, it is realized that relocation of all people from Critical Zones and even Emergency Zones could take long time. Therefore, it is important to protect the peoples who stay in Emergency Zones and Critical Zones until they relocate. To do so, most important thing is the people should know whether they are in the zones or not by the maps shown in Figures S5-2-7, S5-2-11 and S5-2-12. The people in the zones should be educated following things referring to Figure S5-2-15 Community Hazard Map.

a) People in Emergency Zones and Critical Zones are always exposed to danger.
b) People should always watch any unusual things on the slopes.
c) People should care the slopes when it is rain.
d) If people find any unusual things on slopes in rain or even in fine weather, they should inform Soacha Municipality and take refugee on their own judgments.

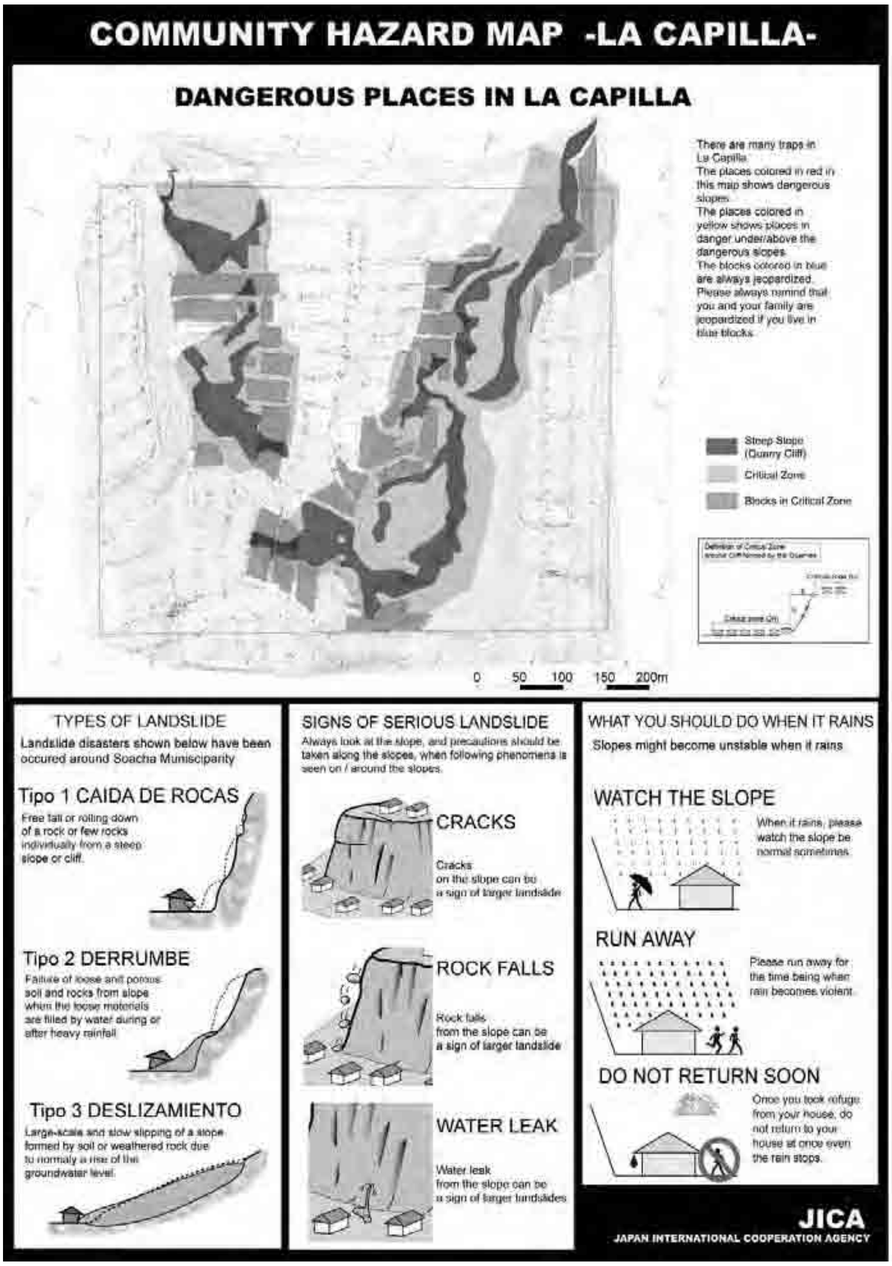


Figure S5-2-15 Community Hazard Map

2.4 Measures for Critical Zones

2.4.1 Consideration of Structural Countermeasures

Many houses were built and many people lives near the toe and upper part of steep slopes formed by the activity of mining in Soacha Municipality. Rock falls and slope collapses frequently occur in this area even in fine weather as well as in rainy weather. These areas have suffered from not only rock falls and slope collapses but also large mass movements. It is known that quarries, which was carried out until about 50 years ago, triggered the mass movement in Altos de la Estancia in capital district of Bogota. In Villa Esperanza in Soacha Municipality, to prevent the movement of mass movement occurred at the abandoned quarry, earth-filling works was implemented by the army. It is quite difficult to stop the movement of landslide once activated by human activities because the imbalance of landslide body is substantially bigger than natural case. For example in Divino Nino, the steep slopes are covered by clayey material which was created in process of weathering of sandstone and mudstone. Cuboid blocks and boulders by development of cracks on outcrops can be observed on the slope. These blocks and boulders can fall as rock fall or slope collapses. In addition, open cracks observed on the slopes indicate that the entire body of the slopes have been continuously moving from the past, therefore, it is necessary to pay attention to the phenomena of transition to mass movement.

It is carefully recognized that small-scale slope cut and excavation can trigger mass movements in which slopes have similar topographical and geological conditions to Altos de la Estancia. In realty in Altos de La Estancia, slope cutting and excavation by human activities promoted transition phenomena, and finally triggered mass movement. Consequently, further cutting on steep slopes in abandoned quarries should not be carried out because the slope is regarded as in unstable condition by the former quarry activities. To plan the emergency protection works for rock fall and slope collapse, it is effective to form the slopes to gentle because the scales of the rock falls and slope collapses phenomena are comparatively small. However, forming the slopes to gentle is equal to removal of toe of the slope and this activity increase the risk of mass movement. Thus it is impractical from the viewpoint of prevention of landslide. It is obviously difficult to stop mass movement once after the occurrence by human activities as mass movement which is relatively small seen in Villa Esperanza. It is theoretically possible to form steep slope to gentle slope after landslide prevention works like piling works and anchors, but these stabilization works are quite expensive. It is a basic rule that these expensive works should be done after completion of counter-weight filling works at the toe of landslide. The counter-weight filling works would be large-scale works on flatland where many houses exist at present and it would be similar to recovery works to the original land shape. Therefore the “emergency protection works” on steep slopes in abandoned quarries in El Divino Niño and Altos de Cazuca is impracticable to implement from the technical viewpoints.

2.4.2 Recommendation to Mitigate Landslide Damages

It is recommendable to evacuate from Critical Zones as measures against slope disasters on steep slopes in abandoned quarries. The houses close to the steep slopes should be relocated to safe areas, out of Critical Zones. But it could take long time to evacuate from Critical Zones because there are many steep slopes in abandoned quarries and houses in Critical Zones. The following measures are recommended.

a) People in Critical Zones should be evacuated. Priority of evacuation should be given to the people in most danger in Critical Zones.
b) Until all the people in Critical Zones relocated, Soacha Municipality should take care of safety of people remaining in Critical Zones.
c) People remaining in Critical Zones should be known that they are in Critical Zones and always put in jeopardy even in fine weather.
d) In heavy rain, Soacha Municipality should be on the alert for people in Critical Zones
e) To obtain the basic information about alert level of rain fall, Soacha Municipality should collect rain fall data.

2.4.3 Process for Evacuation

Evacuation from all Critical Zones in Soacha Municipality is necessary to protect the people's lives and properties. It could take long time to complete the plan, evacuation from more danger area with following steps is necessary.

a) Complete the relocation program from Emergency Zone in Divino Nino
b) Set up Emergency Zones in La Capilla. (Critical Zones in La Capilla have been set up in the study. Figure S5-2-12).
c) Proceed relocation program from Emergency Zones in La Capilla in accordance with the process in El Divino Nino.
d) Set up Critical Zones and Emergency Zones in El Arroyo (Villa Esperanza) where is surrounded by steep slopes formed by mining activities too.
e) Proceed relocation program from Emergency Zone in El Arroyo (Villa Esperanza) in accordance with the process in El Divino Nino.
f) Set up Critical Zones and Emergency Zones in other areas where steep slopes in abandoned quarries are exist (refer Figure S5-2-7), and proceed relocation program from Emergency Zones.
g) After completion the relocation program from Emergency Zones, proceed relocation program from Critical Zones in El Divino Nino, and continue same orders as relocation program from Emergency Zones.

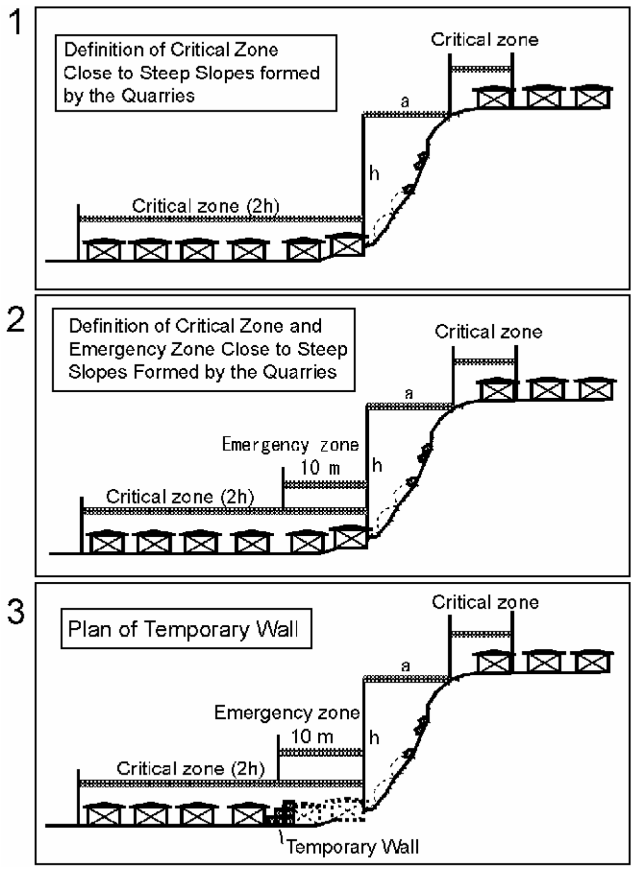


Figure S5-2-16 Process of Relocation from Emergency Zones

2.4.4 Measures until Completion of Evacuation Program

In the process of the relocation program in Divino Nino, we found that relocation of people could take long time. Therefore, it is important to protect the peoples who stay in Emergency Zones and Critical Zones using Community Hazard Map as mentioned in Section 2.4.2.

SUPPORTING REPORT

S6

FLOOD STUDY

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CHAPTER 1 GENERAL DESCRIPTION OF STUDY AREA

1.1 Rivers related with the Study Area

The Bogota River is the primary tributary of the Magdalena River. The Magdalena River is the largest river system in Colombia. The Magdalena River is originating from the Andes Highland near Ecuador and going through the Colombian territory toward the Caribbean Sea. The catchment area and the length of the Magdalena River are 262,075 km2 and 1,505 km, respectively[1].

The Bogota river is originating from Guacheneque (Villapinzon Municipality) and joining the Magdalena river near Girardot. The total length of the Bogota River is 255 km. There is a waterfall called "Tequendama Waterfall (the height is 157 m) "located in San Antonio Municipality. The catchment area of the Bogota River is 6,107 km^2 and at the point of the waterfall it is divided into two (2) catchments, namely "the upper basin" and "the lower basin".

The Study area is included in the upper basin. So the following description is focused on only the upper basin of the Bogota River[2].

In the upper basin of the Bogota river catchment, the tributaries of the Bogota river are Chicu river, Frio river, Muna river, Neusa-Barandillas river, Sisga river, Subachoque-Balsillas river, Teusaca river, Tomine river and Tunjuelo river.

Table S6-1-1 Bogota River System

Sub Area	Reach	Area	Tributaries	Area (km^2)
Upper Basin	From origin to Tequendama Waterfall (Sabana de Bogota)	4,321 km^2	Bogota	1,705
			Chicu	148
			Frio	199
			Muna	132
			Neusa-Barandillas	474
			Sisga	154
			Subachoque-Balsillas(including Soacha river)	633
			Teusaca	334
			Tomine	220
			Tunjuelo(Tunjuelito)	414
Lower Basin	From Tequendama Waterfall to confluence of Magdalena river	1,786 km^2		
Total		6,107 km^2		

1 INTERMEDIO, Gran atlas y geografia de Colombia, P.41
2 Cundinamarca Gov.,Cuenca alta del rio bogota, plan de ordenamiento territorial, P.29

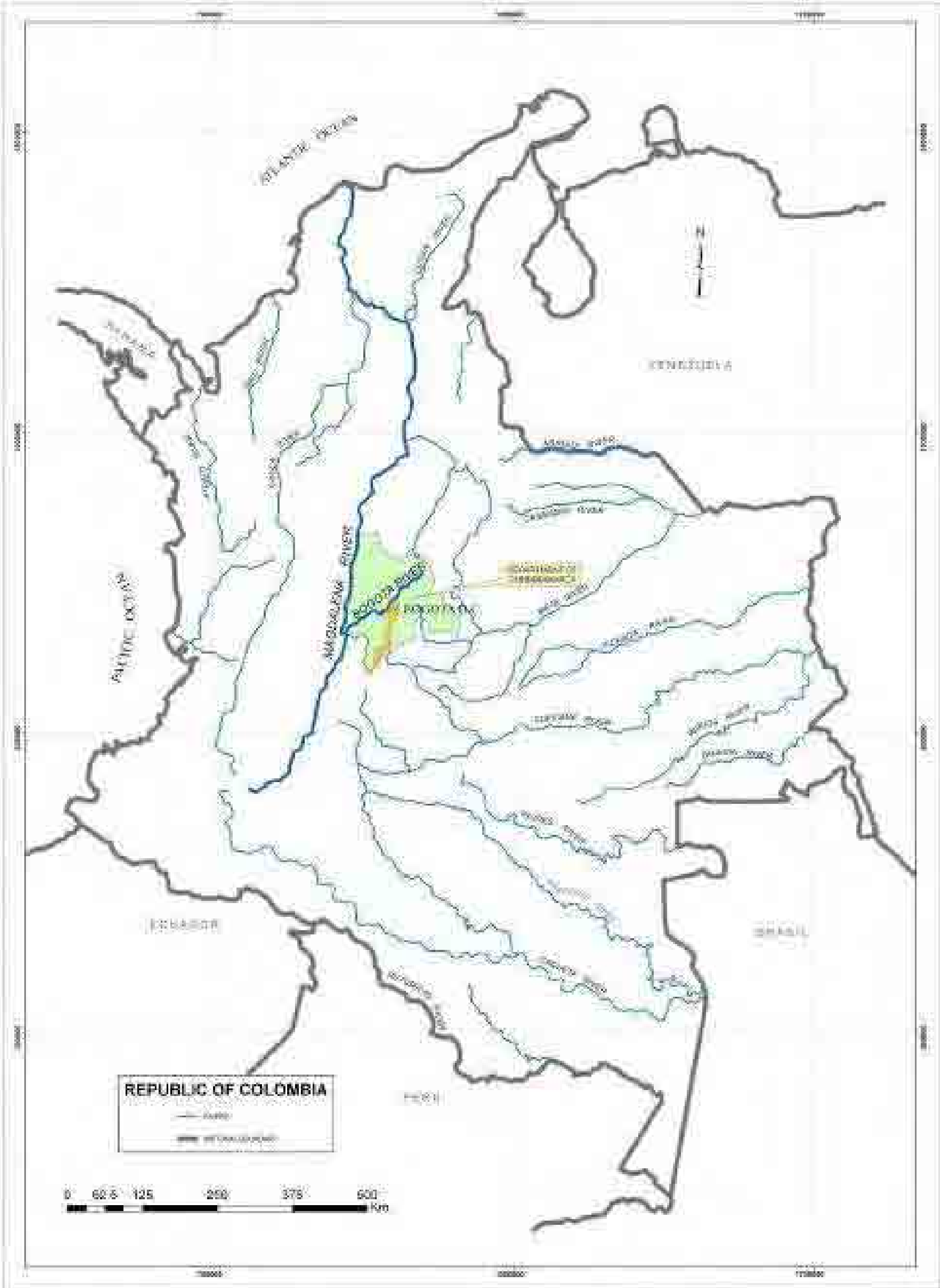


Figure S6-1-1 Location of Bogota River in Colombia

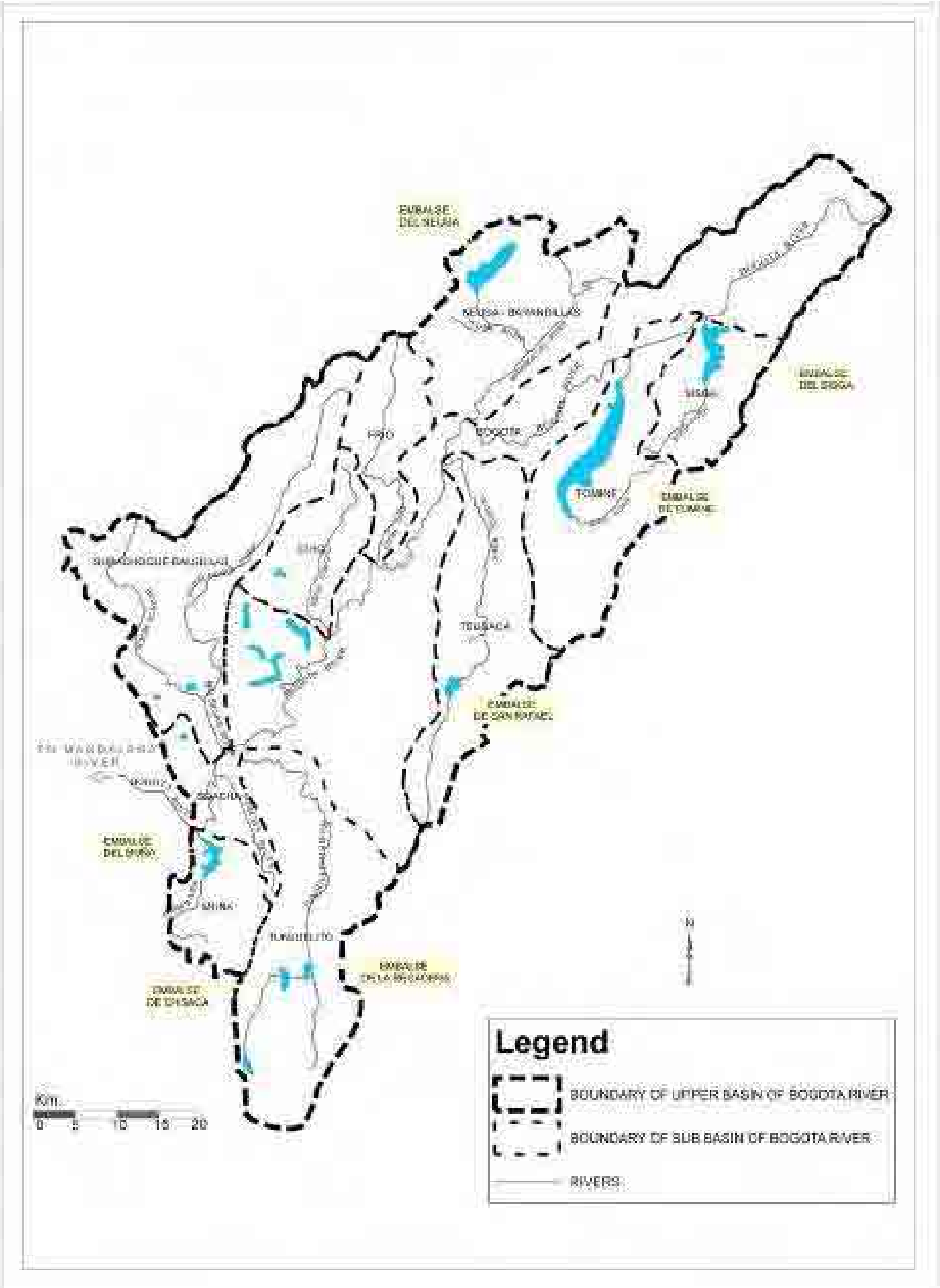


Figure S6-1-2 Sub-basin in Upper Basin of Bogota River

1) Tunjuelo River

The Tunjuelo River, which is a tributary of the Bogota River, is located in the southern part of the Metropolitan District of Bogota. The Study Area of the Bogota is inside the Tunjuelo River Basin (Figure S6-1-3).

The catchment area of the Tunjuelo River is 388.13 km^2, whose the highest point is 3,850 m and the lowest point is 2,536 m at the confluence to the Bogota river. The basin can be divided into the upper part, middle and lower part (Figure S6-1-3).

The upper and middle parts have the area of 254 km^2 at Cantarrana Dam site. In the upper catchment there are the Chisaca river and the Curubital river. There is the La Regadera Dam at the confluence of those rivers. The Tunjuelo river is going down collecting other some tributaries to the Cantarrana Dam.

The lower part can be defined for the reach from the Cantarrana to the Bogota river confluence. The lower catchment has eight (8) main tributaries such as Yomasa, Santa Librada, La Fiscala, Chiguaza (the right bank tributaries) and Botello, Trompeta, La Estrella and Limas (the left bank tributaries). Among these, the Chiguaza, Santa Librada, Yomasa and La Estrella-Trompeta creels are the Study Area.

The annual rainfall in the upper part is 1,122 mm at Los Tunjos station and 1,002 mm at La Regadera station. The monthly rainfall distribution has mono-mode, in which there is a dry season between December and March whereas between April and November is wet season.

The annual rainfall in the lower part is less than that of the upper part. At Dona Juana station the annual rainfall is 644 mm having bi-mode, in which there are wet seasons between March and May, and October and November whereas between December – February and June – September are dry seasons.

The Study Area's catchment belongs to the Tunjuelo River Basin except for the Soacha River. The Soacha River is directly confluencing to the Bogota River at just upstream of Las Huertas.

Cantarrana Dam

The Cantarrana Dam is located at the most downstream point of the middle part of the basin. The dam (flood control purpose, return period 100 years and its storage volume is about 2,500,000 m^3) has been constructed since last year and April 2007 it was announced that the dam is completed by EAAB.

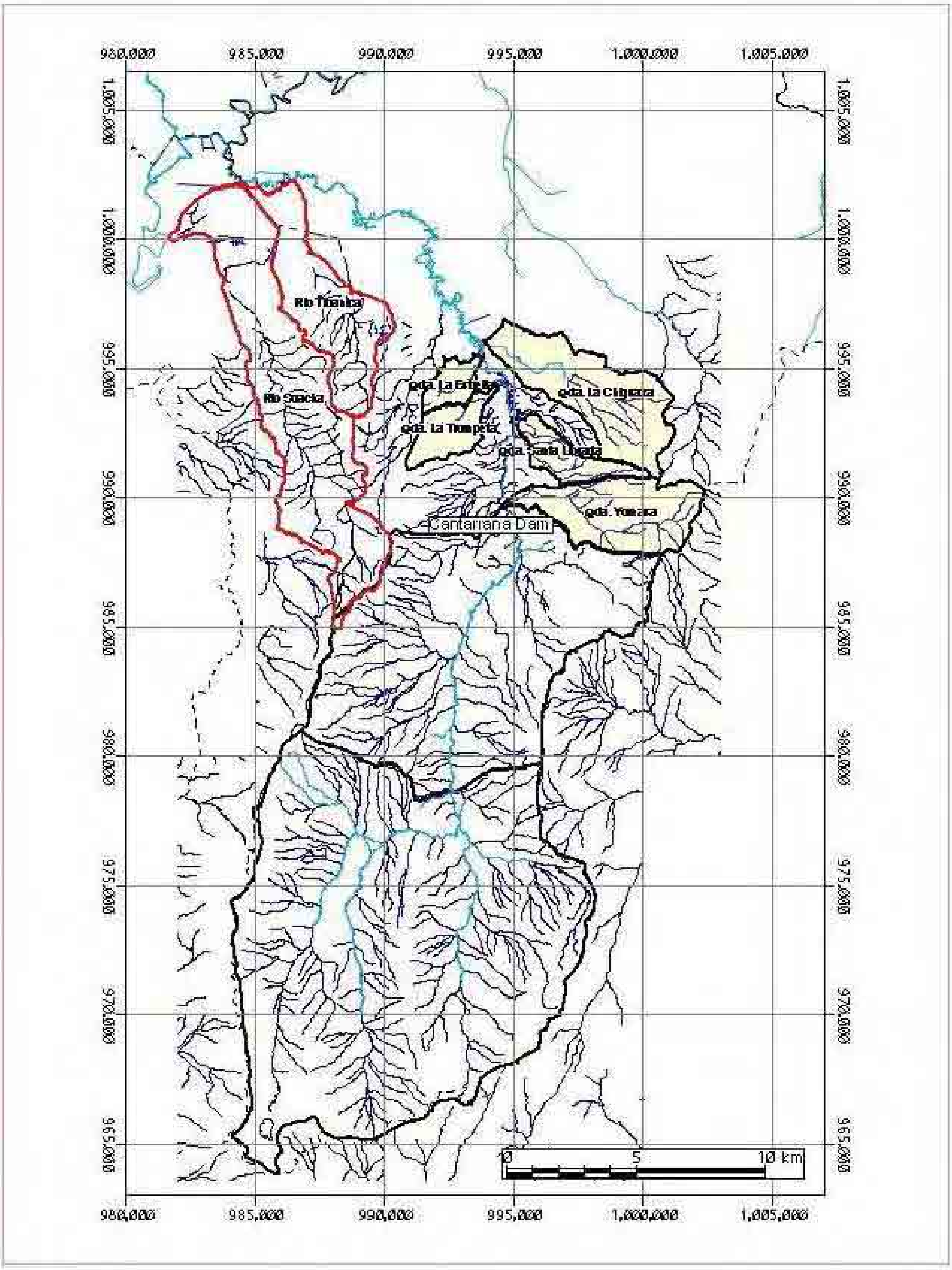


Figure S6-1-3 Catchment of Tunjuelo River

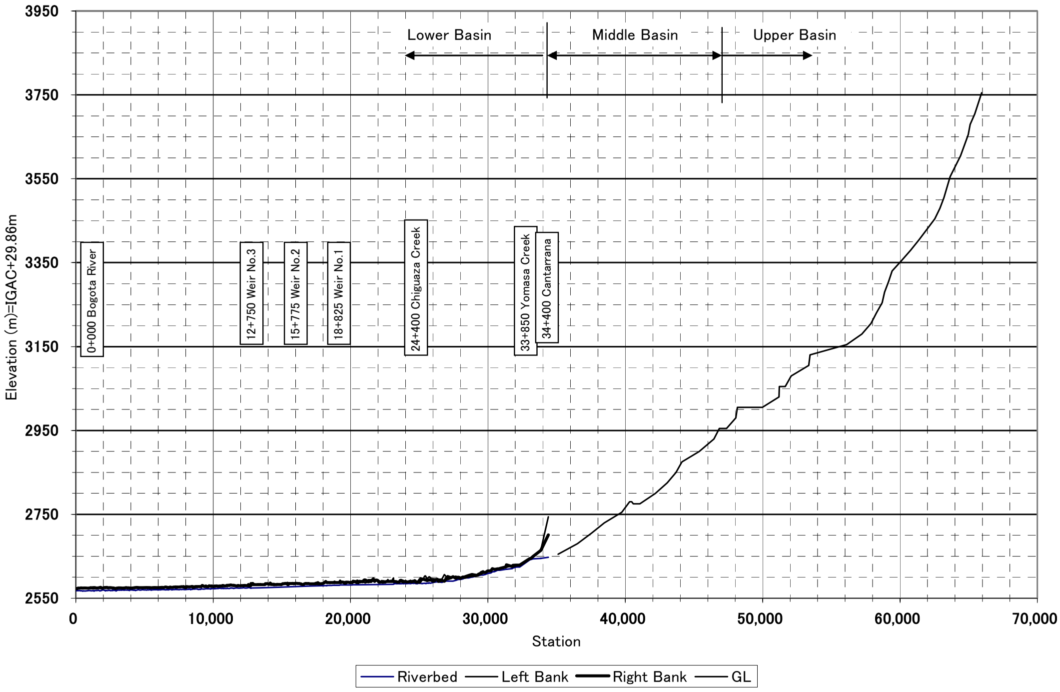


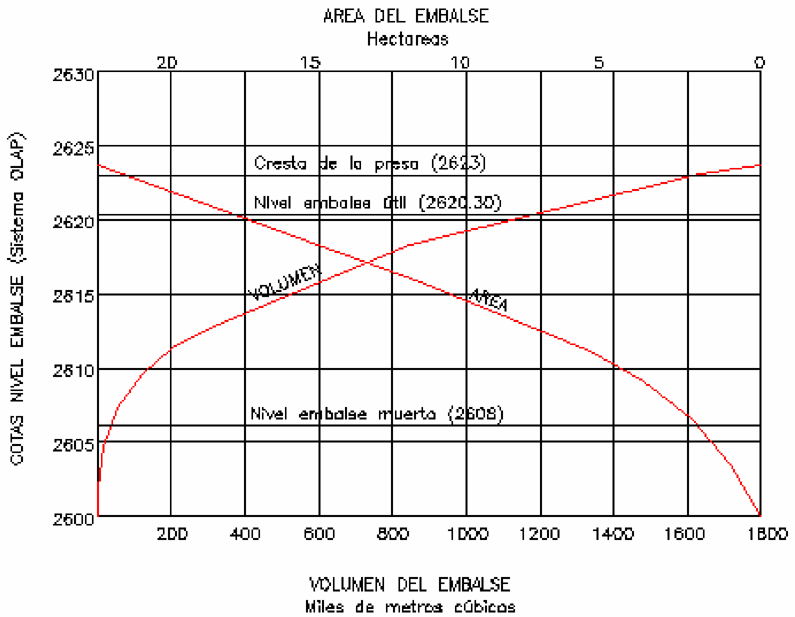
Figure S6-1-4 Longitudinal Profile of Tunjuelo River

The rivers in the Study Area are divided into the tributaries of the Tunjuelo river and the tributaries of the Bogota river. The tributaries of the Tunjuelo river are the Chiguaza, Santa Librada, Yomasa and Tibanica creeks, and the tributaries of the Bogota river is the Soacha river.

Table S6-1-2 Localities in Each Stream Basin of the Study Area

River System	Stream Basin in the Study Area	Catchment Area	Locality
Tunjuelo River	Chiguaza	18.9 km^2	Usme, San Cristobal, Rafael Uribe Uribe, Tunjuelito
	Santa Librada	5.5 km^2	Usme
	Yomasa	15.4 km^2	Usme
	La Estrella	3.0 km^2	Ciudad Bolivar
	Trompeta(El Infierno)	5.3 km^2	Ciudad Bolivar
	Tibanica	19.2 km^2	Ciudad Bolivar, Bosa
Bogota River	Soacha	44.3 km^2	Soacha Municipality

In Tibanica river in the upstream there is Tererros Dam, which was constructed in 1950's for irrigation purpose. Figure S6-1-5 is volume and area curve of the Dam taking from Soacha Sewage System Master Plan by EAAB.



(Source: Drawing Curvas TEMPO.dwg Redes Sanitarias Construidas-Proyectadas, Plan Maestro de Alcantarillado para el Municipio de Soacha, July 2000)

Figure S6-1-5 Volume and Area Curve of Tererros Dam

1.2 River Characteristics

1.2.1 Longitudinal Profile

The Study Team conducted the river cross section survey for the Chiguaza, Santa Librada, Yomasa and La Estrella-Trompeta creek, Soacha river and Tibanica river from January 2007 to July 2007. In the Chiguaza, some main tributaries were also surveyed while for the other creeks only main reaches were surveyed. Figure S6-1-6, Figure S6-1-7 and Figure S6-1-8 show the longitudinal profiles for the Chiguaza, Santa Librada and Yomasa. Figure S6-1-9, Figure S6-1-10 and Figure S6-1-11 show the longitudinal profiles for the La Estrella, Trompeta and Infierno. Figure S6-1-12, Figure S6-1-13, Figure S6-1-14 and Figure S6-1-15 are the catchment of these creeks indicating the distance from the Tunjuelo river.

The longitudinal profile and catchment of the Soacha river and Tibanica river are shown in Main Report Chapter 9.

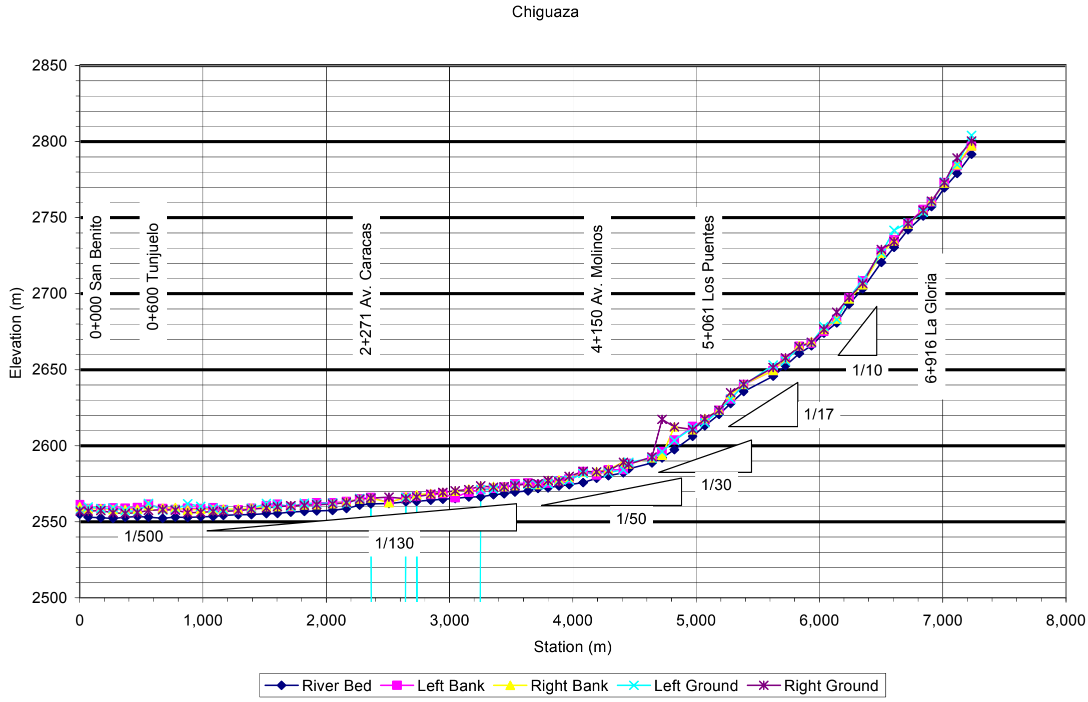


Figure S6-1-6 Longitudinal Profile of Chiguaza Creek

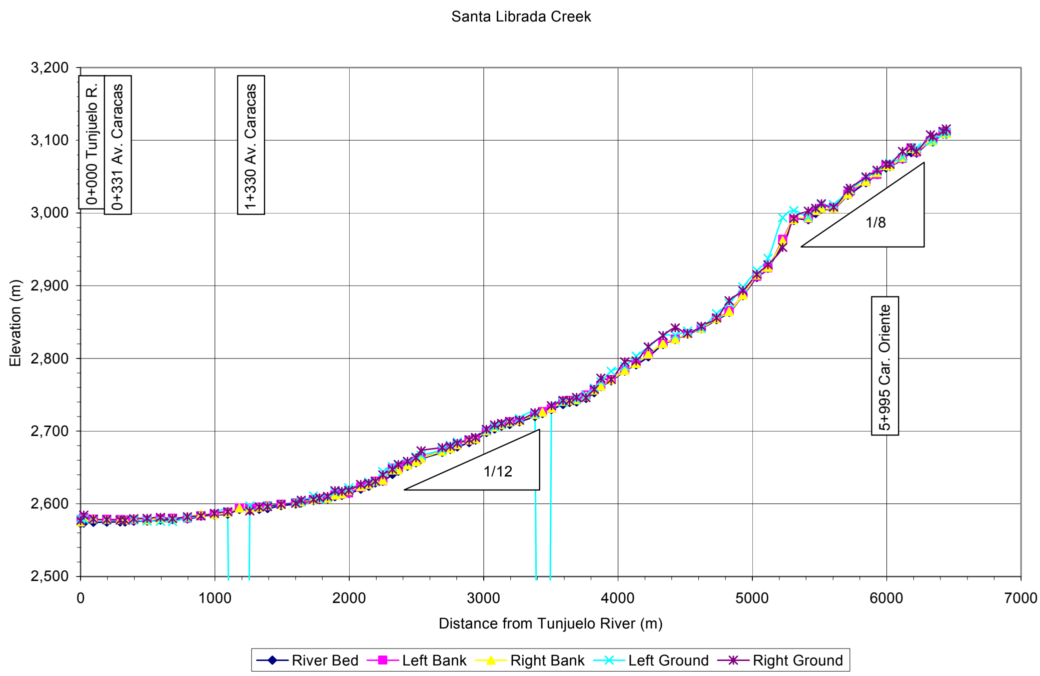


Figure S6-1-7 Longitudinal Profile of Santa Librada Creek

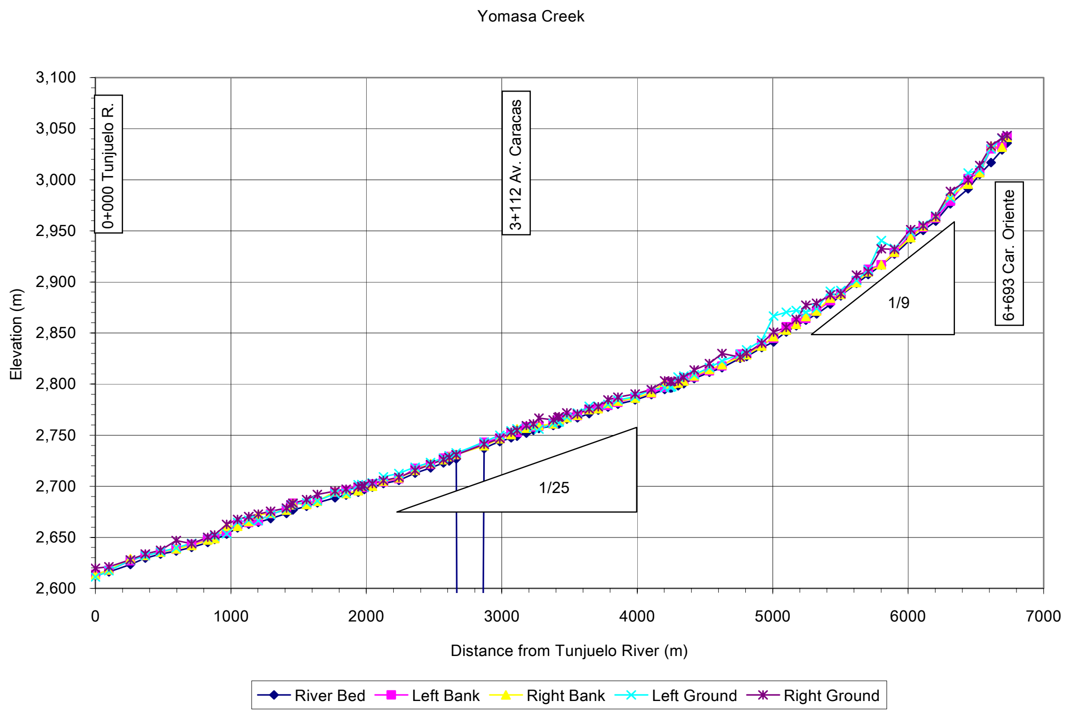


Figure S6-1-8 Longitudinal Profile of Yomasa Creek

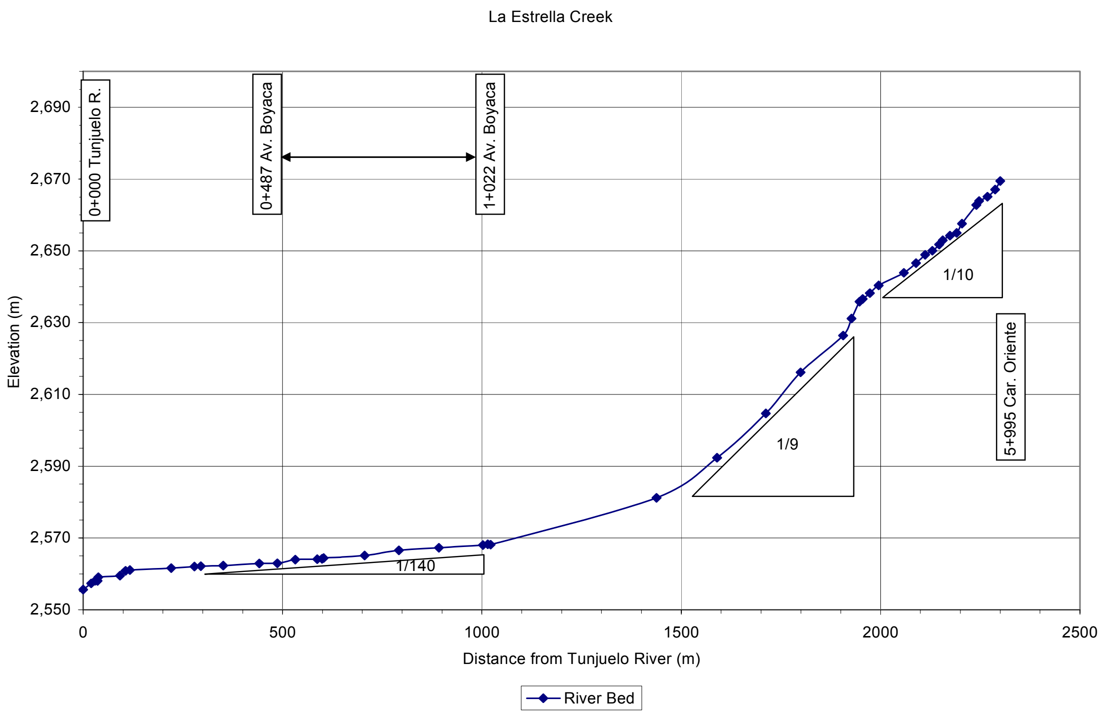


Figure S6-1-9 Longitudinal Profile of La Estrella Creek

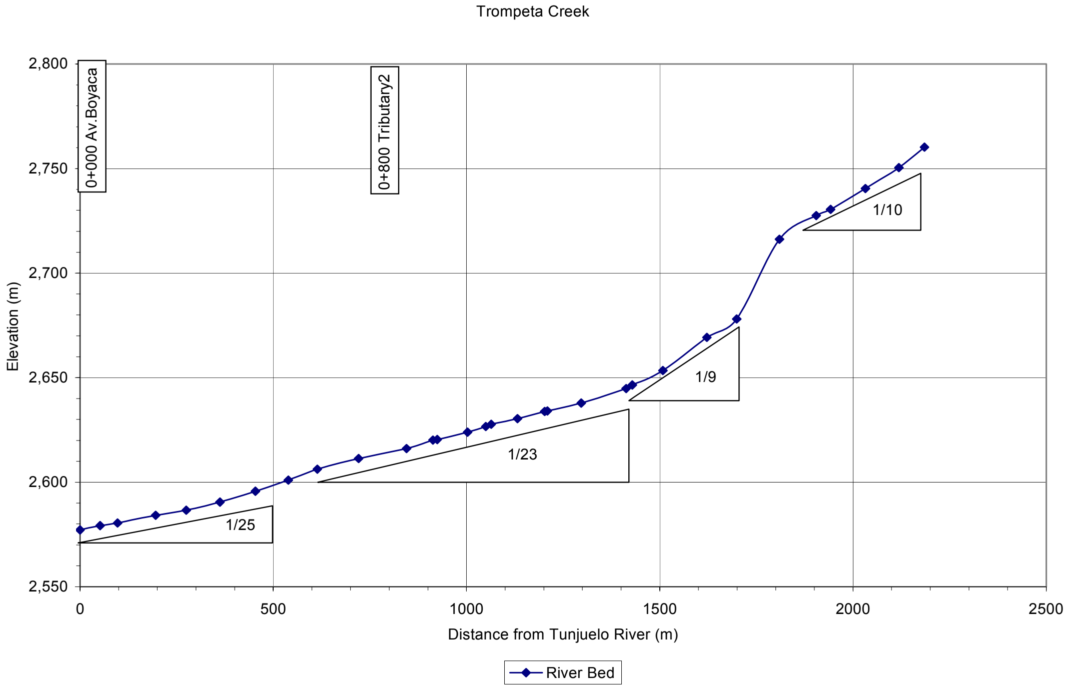


Figure S6-1-10 Longitudinal Profile of Trompeta Creek

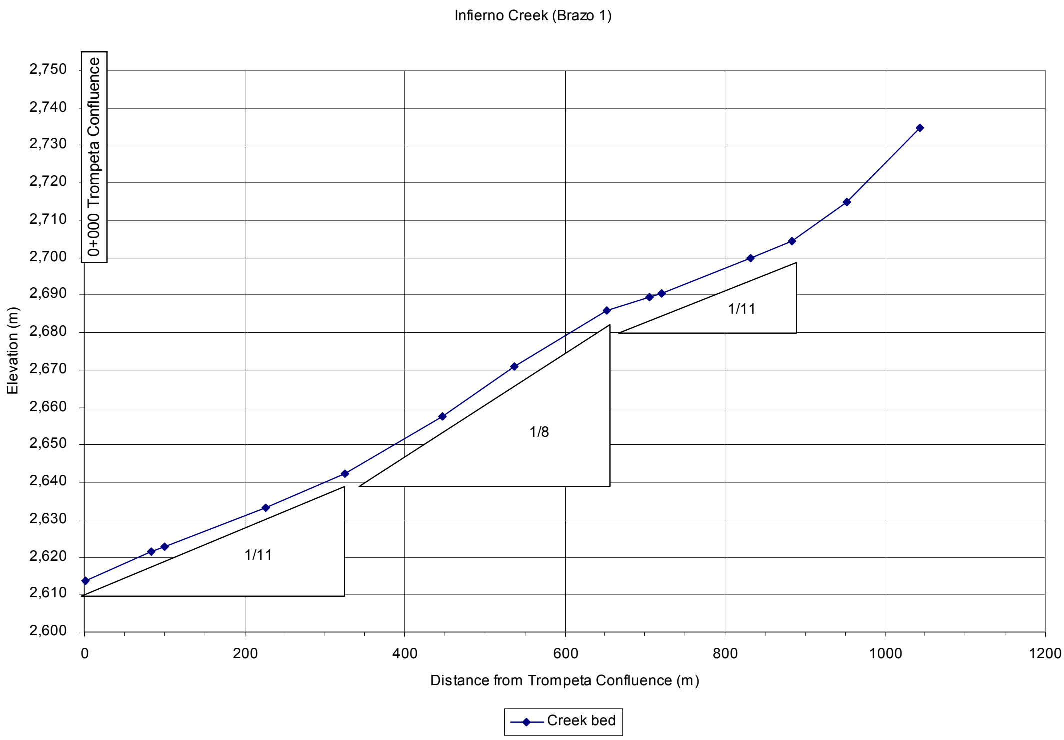


Figure S6-1-11 Longitudinal Profile of Infierno (Trompeta Tributary)Creek

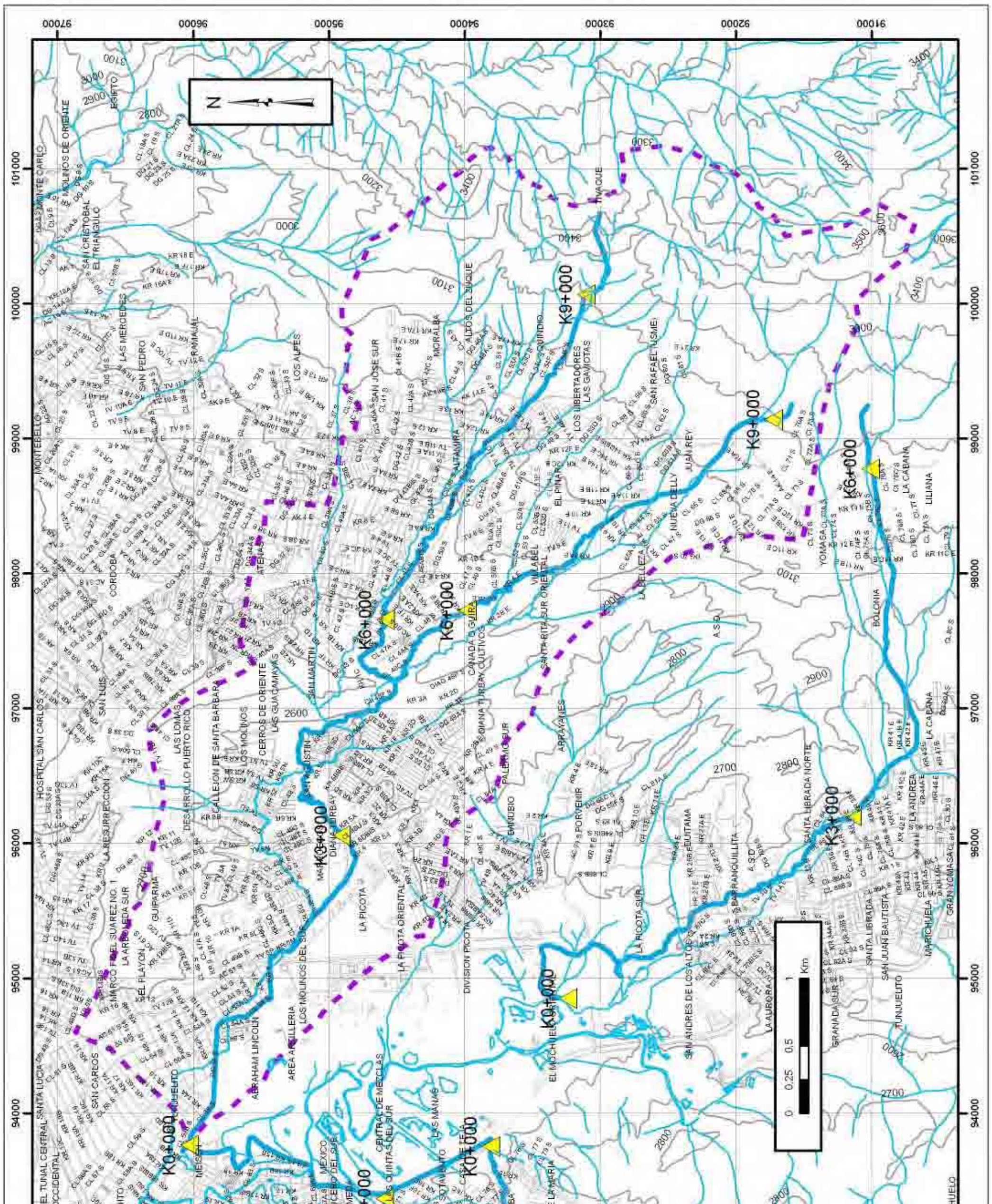


Figure S6-1-12 Catchment of Subjective Creek (Chiguaza)

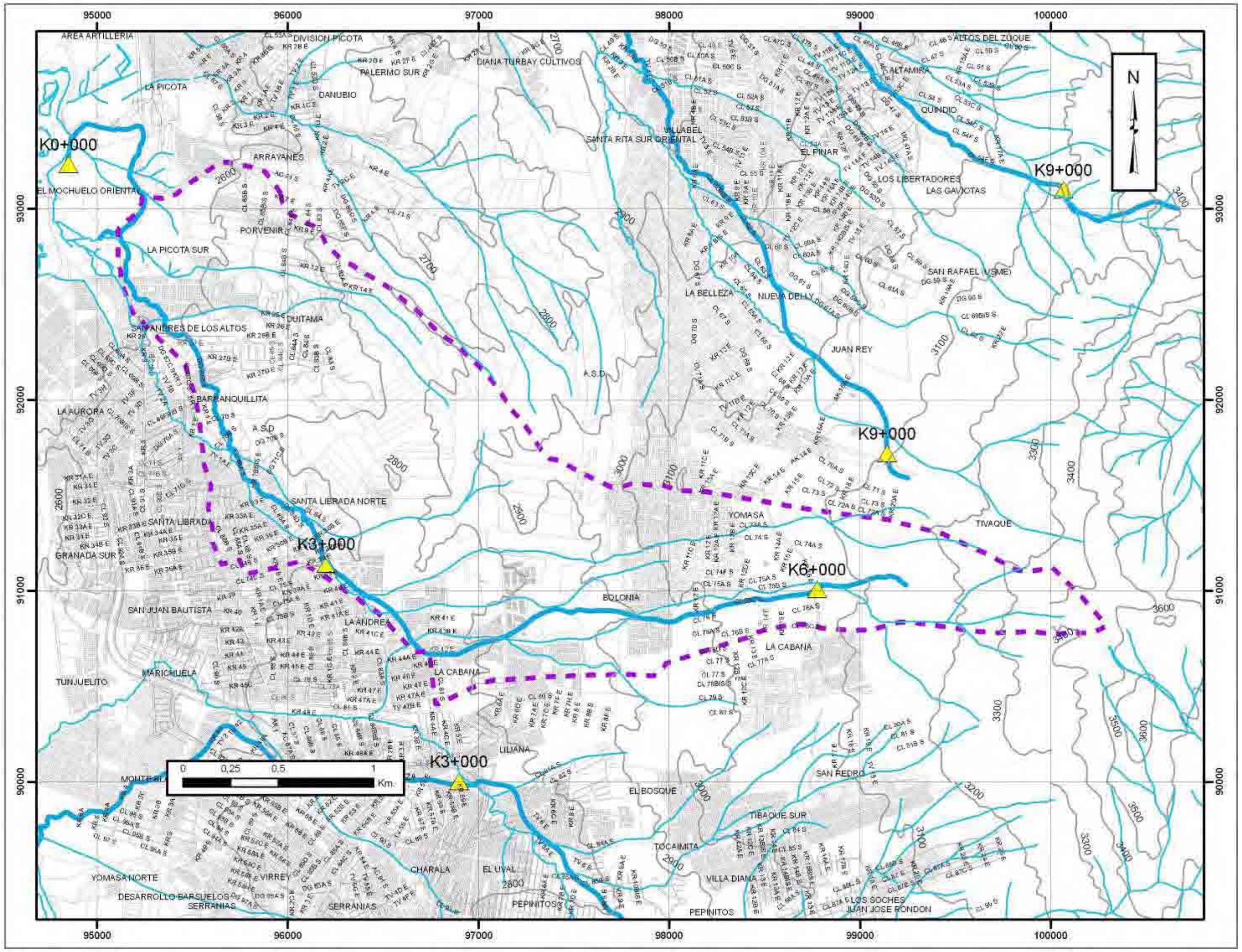


Figure S6-1-13 Catchment of Subjective Creek (Santa Librada,)

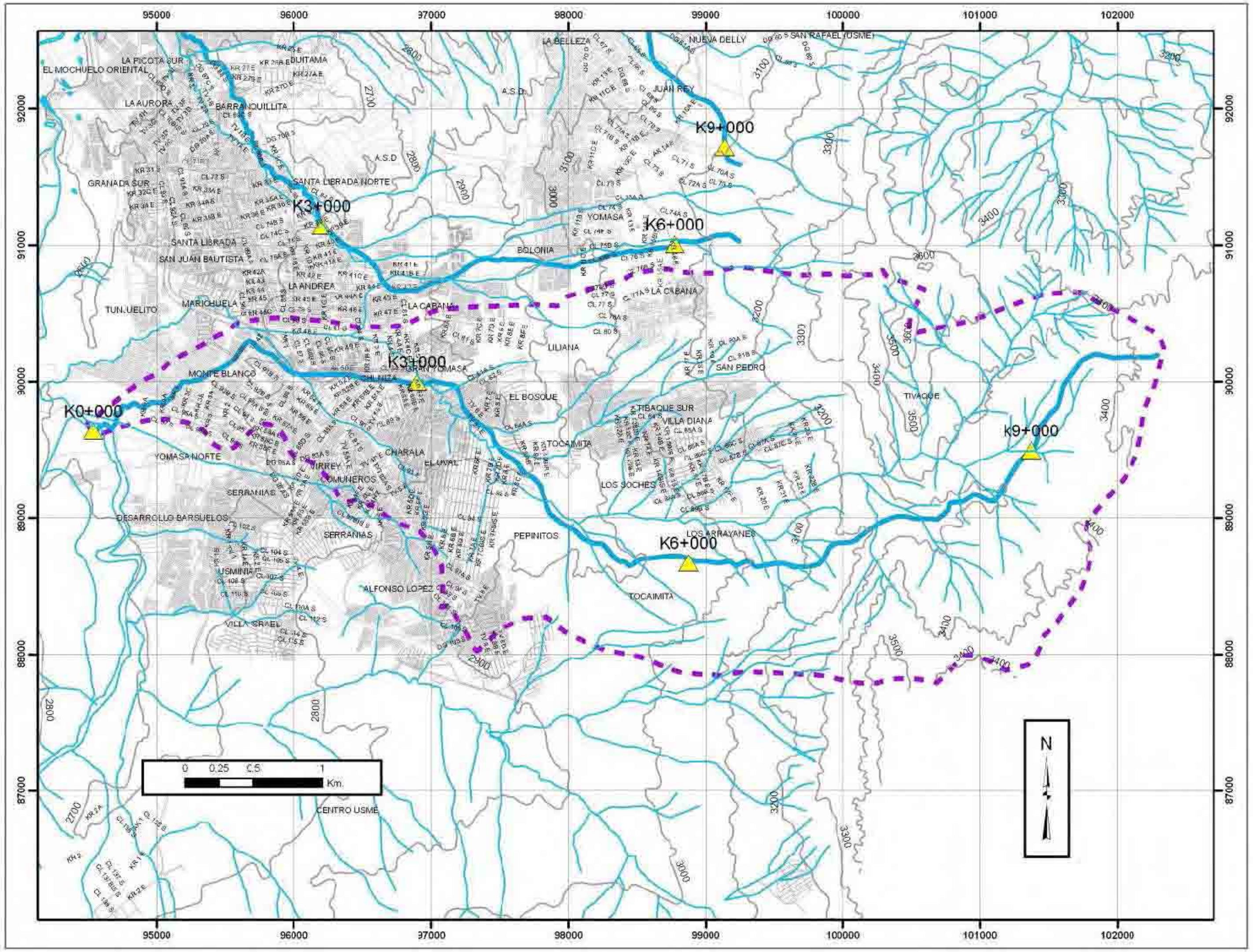


Figure S6-1-14 Catchment of Subjective Creek (Yomasa)

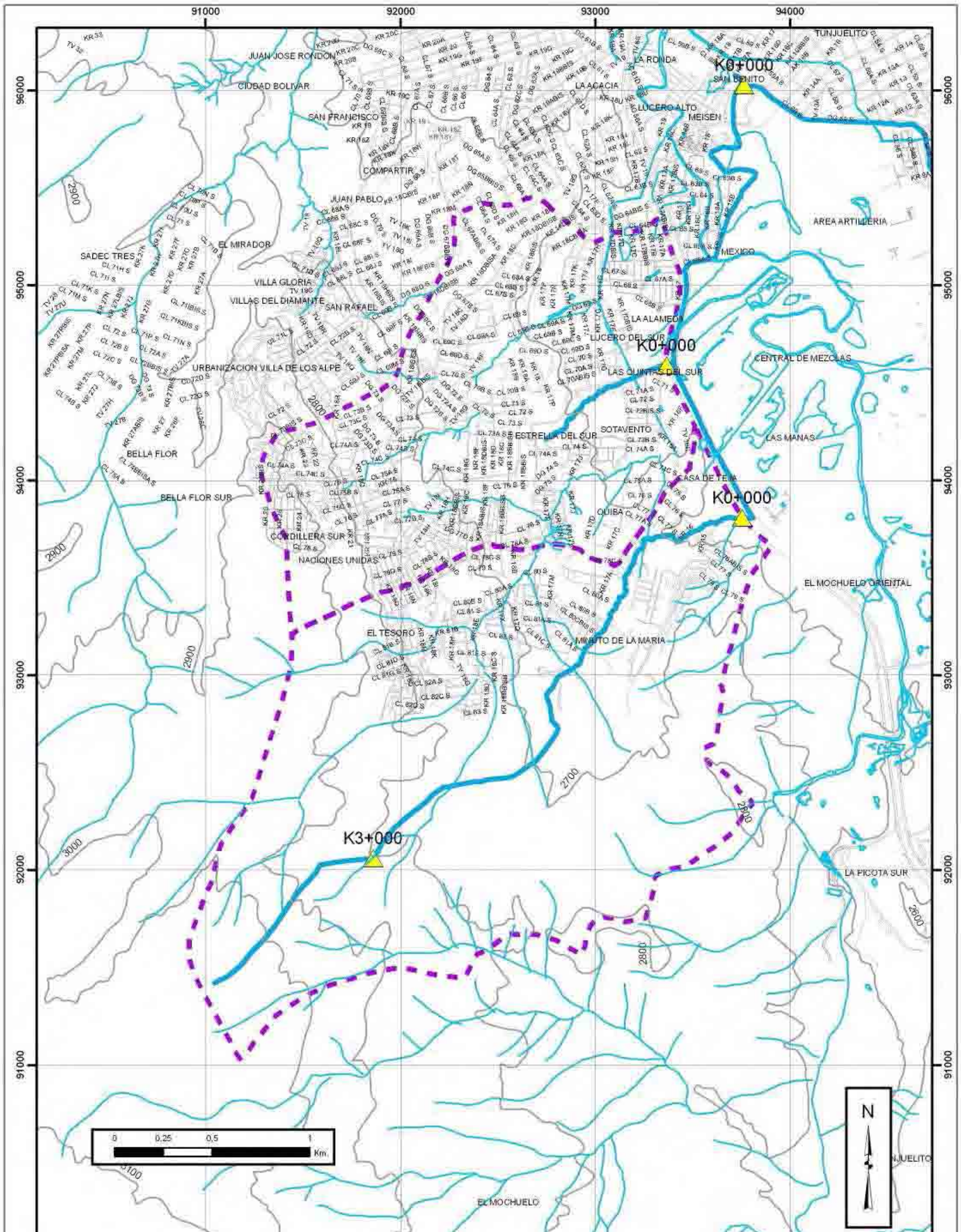


Figure S6-1-15 Catchment of Subjective Creek (La Estrella-Trompeta)

Figure S6-1-16 is the profile of Chiguaza creek depth and width. The width of the creek is defined between the left bank and right bank.

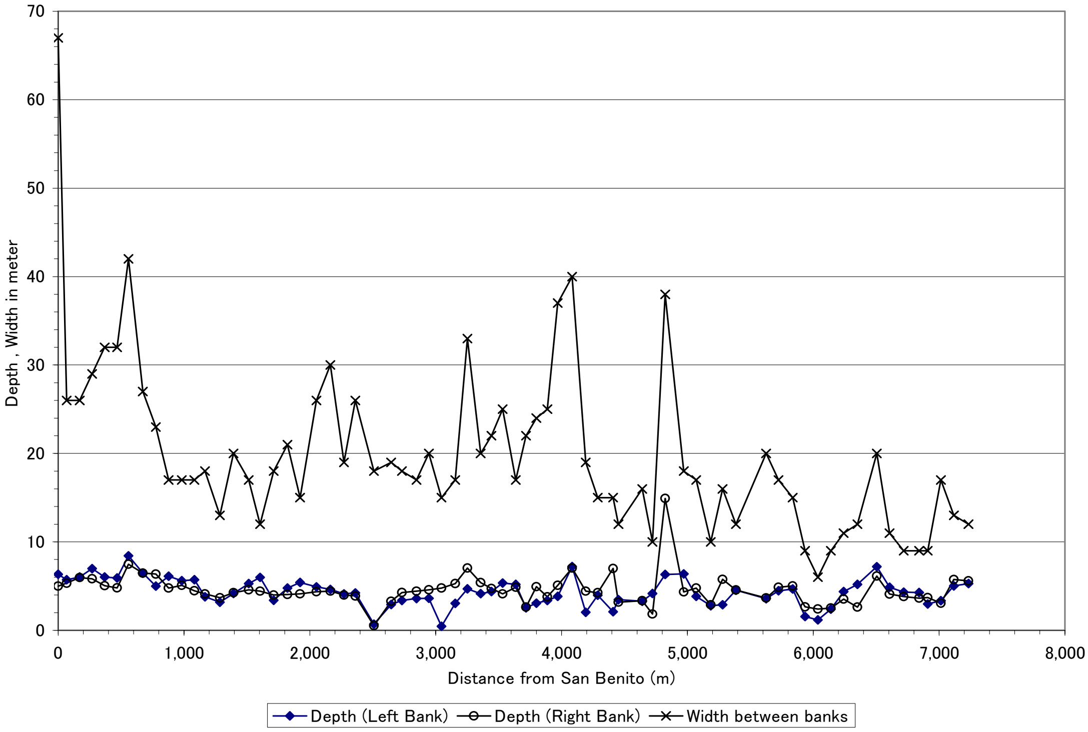


Figure S6-1-16 Longitudinal Profile of Creek Depth and Width of Chiguaza Creek

Basically the bed slope of the Study Area is quite steep. In the Chiguaza, the area Los Puentes upstream has the slope of 1/30. In the Yomasa, the main reach is connecting to the confluence of the Tunjuelo by the slope 1/25 constantly.

Steep slope creek could generate flash flood associated with sediment, depending on the potential of debris flow occurrence in catchment. Whether debris flow occurs or not depends on slope of catchment, history of slope failure, sediment deposit on the creek as well as rainfall amount. However, first of all it is important to see the possible behavior of debris flow based on the slope of the creek in order to consider the appropriate early warning planning in a catchment.

Generally the relation between the debris flow generation and the stream bed slope is said as follows,

Slope Category in degree	Slope Category in fraction	General Description of Section
$20^{\circ} < \theta$	$1/2.7 < \theta$	Generation
$15^{\circ} < \theta < 20^{\circ}$	$1/3.7 < \theta < 1/2.7$	Generation and Transport
$10^{\circ} < \theta < 15^{\circ}$	$1/5.6 < \theta < 1/3.7$	Transport
$3^{\circ} < \theta < 10^{\circ}$	$1/19 < \theta < 1/5.6$	Deposition

If saying only with respect to the river bed slope, debris flow stops at a reach whose slope is milder than three (3) degree. Figure S6-1-17 shows the comparison of longitudinal profiles in the Study area. Regarding the river bed slope category, all of the creeks / rivers have potential of debris flow generation and transport, however, considering the location of three (3) degree‘s river reach and the urban area, the Chiguaza creek is more susceptible to debris flow.

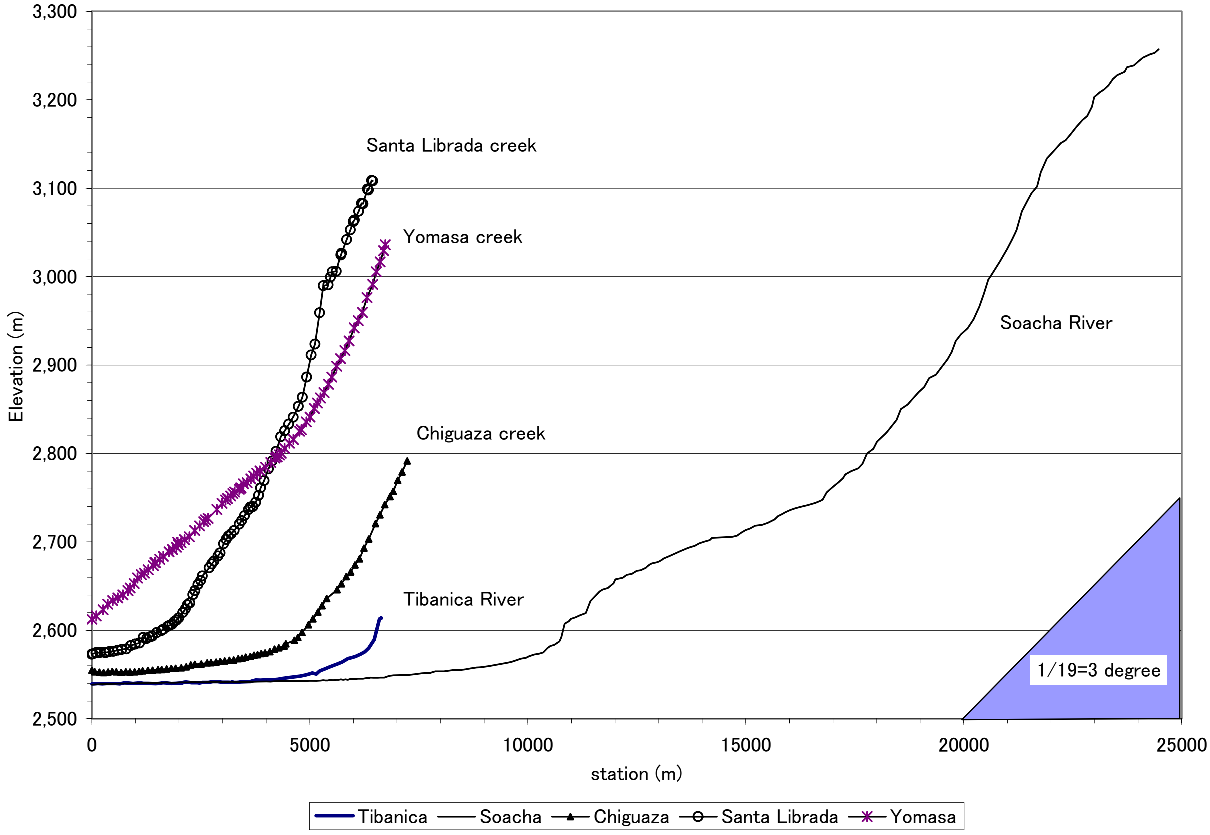


Figure S6-1-17 Comparison of Longitudinal Profiles of the Study Area

The downstream of the three (3) degree's river reach, of course, has susceptibility of flood associated with water if the channel capacity is not enough compared with the rainwater runoff.

1.2.2 Historical Change

1) Chiguaza Creek

The Chiguaza creek basin has been experiencing big change on the Tunjuelo river improvement in the downstream and rapid / substantial urbanization in the upper area.

Figure S6-1-18 is the comparison between 1956 and 2004 in San Benito-Tunjuelito. The meandering Tunjuelo river as well as the Chiguaza creek has been confined by dike to be straight channel. It is recognized that the flood-prone area in San Benito – Tunjuelito, which was affected by 2002 Tunjuelo river flood, used to be within the old river course of the Tunjuelo river and the Chiguaza creek. Generally alluvial rivers try to form the original position, therefore those urbanized areas can be always flood-prone area and the target of early warning system.

Figure S6-1-19 is the comparison between 1968 and 1998 in Upper Part of the Chiguaza creek. The urban area expanded and became dense. Some creeks were replaced by culvert in the underground. In the case of the Chiguaza creek itself, since the river bed slope is quite steep, the position of the creek has not been changed, however, it is regarded that due to the increase of rainwater runoff, the natural bank is eroded while the river bed is eroded resulting into that only big rocks which can not move by flood water remain on the river bed (Photo S6-1-1).

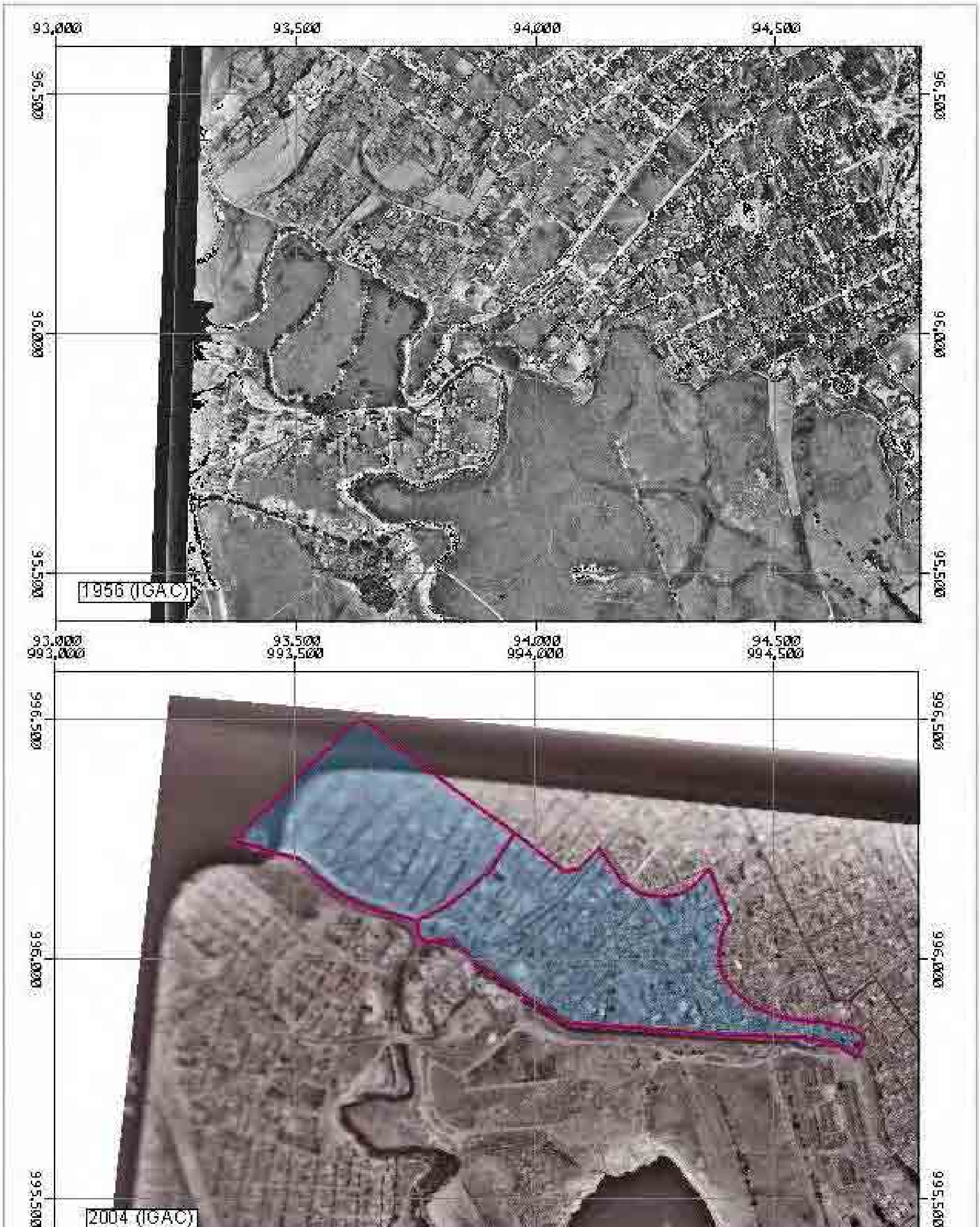


Figure S6-1-18 Comparison between 1956 and 2004 at the confluence of Chiguaza creek (San Benito –Tunjuelito Area)

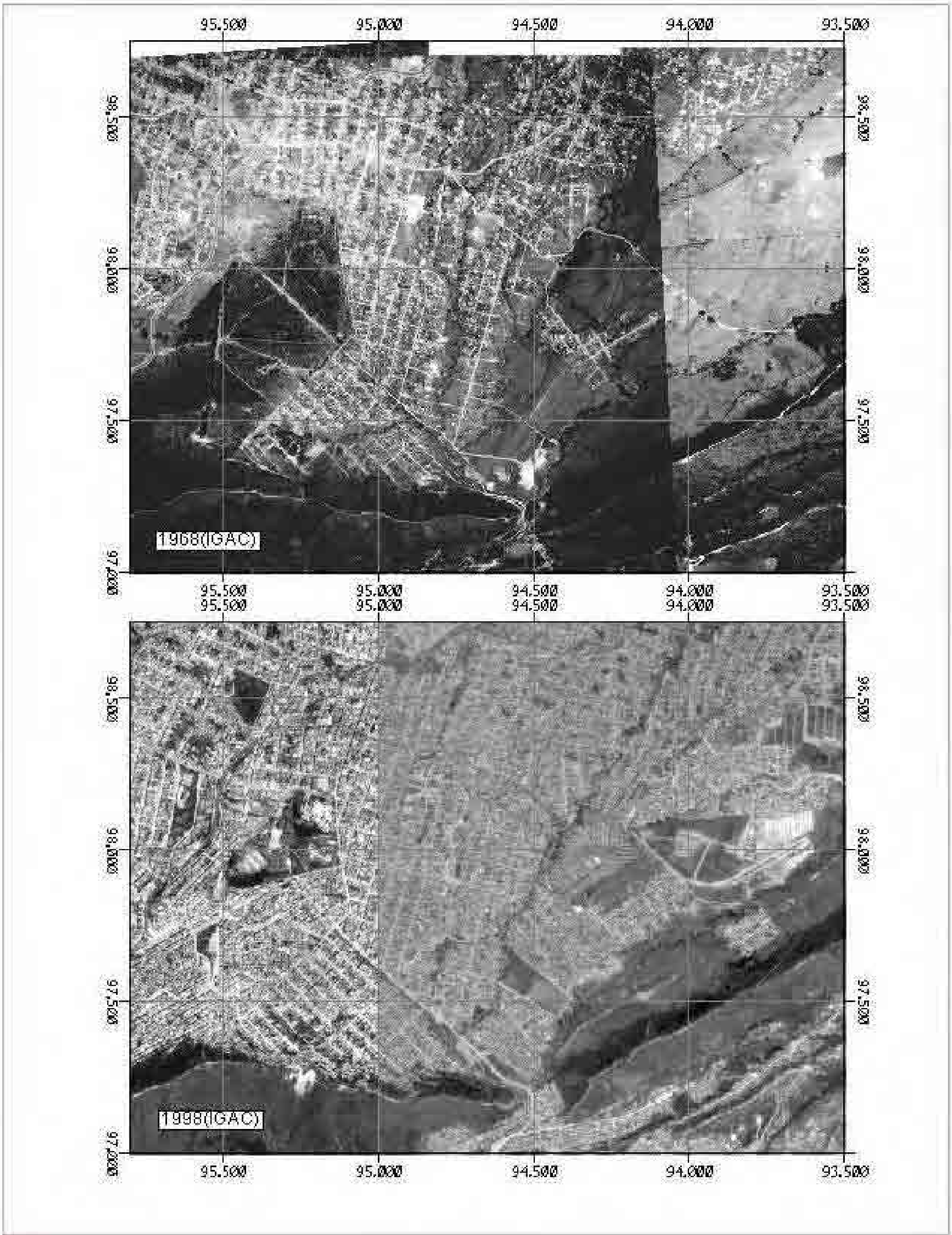


Figure S6-1-19 Comparison between 1968 and 1998 at the upper area of Chiguaza creek

Photo S6-1-1 Riverbed Condition at Los Puentes in Chiguaza creek
(Left: May 12, 2001, Right: January 16, 2007)

2) Soacha River

Figure S6-1-20 shows the Soacha river photos of 1942 and 2005. The area of these photos is the upstream of the Autopista Sur. This area is the affected area by May 11, 2006 flood and is used to be wetland of the Soacha river. The lowland area along the river has been developed by residential houses until now.

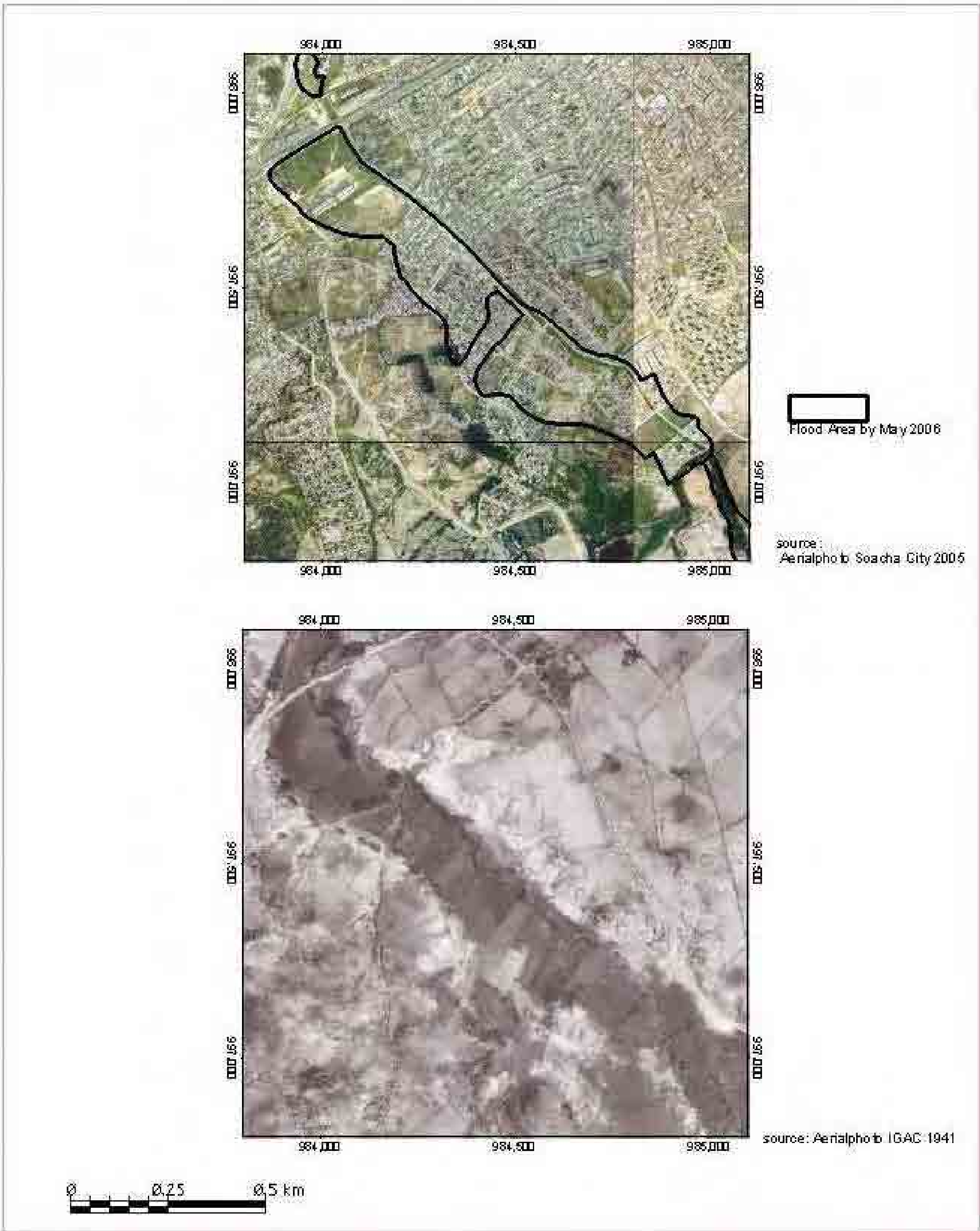


Figure S6-1-20 Comparison between 1941 and 2005 of Soacha River

1.2.3 Flow Capacity

(1) General

The flow capacity of creek and river is a fundamental index for the evaluation of critical sections along the creeks and rivers. The flow capacity is expressed by cubic meter per second for each bank height. The flow capacity will be compared with the probable water discharge and evaluated if it is critical or not.

(2) Creek / River Cross Section Survey

The Study Team conducted river / creek cross section survey in the Study Area from December 2006 to July 2007.

The interval of the cross section is basically 100 m. The bridge section was also surveyed.

Table S6-1-3 Surveyed Sections in the Study Area

Creek/River Name	Tributaries	Survey Length
Chiguaza	Chiguaza down and upstream	0+000 to 7+117
	Zuque	0+000 to 0+885
	Verejones	0+000 to 2+461
	San Camilo	0+000 to 0+932
	Nueva Delhi	0+000 to 1+504
	Silverio North	0+157 to 1+141
	Silverio South	0+000 to 1+509
	Seca	0+000 to 1+497
	Nutria	0+000 to 2+589
Santa Librada		0+000 to 6+443
Yomasa		0+000 to 6+730
Trompeta		0+000 to 2+185
La Estrella		0+000 to 2+300
Soacha River		0+000 to 24+473
Tibanica River		0+000 to 6+635

(3) Methodology

The flow capacity of river cross section is defined by passable water discharge within both banks at the bank elevation. Usually the elevations of left and right banks are different, so the flow capacity was evaluated for each bank elevation.

There are several ways to calculate the flow capacity of river cross section. The famous hydraulic software called HECRAS version 4 was used for this analysis. HECRAS has been used widely in the world and was developed by Corps of Engineers in the United States of America. Usually HEC-RAS is used for non-uniform flow analysis as well as unstable flow computation. Here the HEC-RAS was used in order to calculate the flow conveyance at specific elevations of left and right bank.

The procedure is as follows,

Each cross section (stations and elevations) was inputted into the HEC RAS, Geometry data menu and the bank elevations for both left and right banks were specified.

In the steady flow run menu, a known waterlevel option is selected. Also the bank elevations, at which the flow capacity to be evaluated are given.

After dummy simulation , for example, 0.1 m^3/s shall be given, is done, the HEC RAS output table will provide the conveyance value "K" at the given bank elevation for each cross section. The

Manning roughness coefficient is set 0.04 for conservative side.

If the river bed slope is given, the flow capacity can be calculated as follows,

$$Q_c = K \times \sqrt{S}$$

K : conveyance (m3/s)

S : River bed slope for flow capacity calculation

Qc : Flow capacity in m3/s

Bridge/Culvert

In the Study Area there are three (3) types of structure crossing the creeks. They are bridge, box culvert and pipe culvert. For bridge, Manning formula (uniform flow) is applied. The Manning coefficient was set 0.03 to 0.02 depending on the concrete condition. For culvert of box and pipe, orifice concept was applied. The following is the equation of orifice concept.

$$Q_c = C_d A \sqrt{2g(HW - b/2)}$$

C_d : orifice discharge coefficient(= 0.6)

b : culvert height(m)

HW - b/2 : head on culvert measured from barrel centerline

Qc : Flow capacity in m3/s

(4) Chiguaza

At present the reach Station 1+500 downstream has been improved by EAAB. The cross section survey was done by the Study Team in February 2007. In this reach it is necessary to confirm the channel improvement plan by Colombian side.

At 2+271 there is a bridge crossing Caracas Avenue. This is 2 box culvert type and if those 2 culverts are considered for the flow capacity calculation, the capacity is corresponding to 10 years return period. However, at the upstream side of the bridge, there is sedimentation and also in terms of the channel alignment, the right side culvert is not effective during the flood. This case the section 2+271 could be more critical.

The reach from the Caracas Avenue to Molinos, some left bank sections have lower flow capacity. However, basically the right bank side is occupied by residential and commercial areas.

At 4+723 (approx), near Molinos II (Residential complex) there is a kind of obstacle crossing the creek. Also this reach is a bed slope changing point. The topography is an alluvial fan-wise. The left bank of this reach is protected by vertical concrete wall, however, the ground elevation is same as the creek. This area should be regarded as critical point.

Los Puentes, just upstream of Nutria creek confluence is also prone to the flooding in terms of the Chiguaza creek alignment.

From “Cra. 3 Este”, “Cra. 3B Este”, “Cra. 6A Este” and Ave. Villaviciencia, the common phenomena like May 19, 1994 at Barrio Altamira can be anticipated. The flow capacity of each bridge and culvert has a wide variation; however, it is quite easy that such opening could be closed by sedimentation, tree and garbage.

Hydraulic viewpoint can say that the pipe culver at 6+504 (CRA 3B Este) is quite small (3 years return period).

Table S6-1-4 Critical Point in Chiguaza Creek

Area Name	Station	Anticipated phenomenon	Remarks
Caracas Avenue	2+271	When sedimentation proceeds at upstream side, overflow could happen toward the surrounding.	Removing of sediment of the Bridge upstream should be done.
Molinos II (Residential Complex)	4+723	Fan apex topography. The overflow due to the obstacle could spread toward left bank.	
Los Puentes (Nutria confluence upstream)	5+450	In terms of the creek alignment, the flow from the Chiguaza upstream could hit the right bank side.	
CRA3 Este	6+388	When sedimentation proceeds at upstream side, the overflow could happen toward left bank side.	Maintenance of bridge upstream side
(CRA 3B Este)	6+504	Small pipe culvert, overflow could happen toward the surrounding.	Maintenance of bridge upstream side
La Gloria (CRA 6A Este)	6+916	When sedimentation proceeds at upstream side, the overflow could happen toward left bank side.	Maintenance of bridge upstream side
Avenue Villaviciencia	0+109 (Zuque)	When sedimentation proceeds at upstream side, the overflow could happen toward left bank side.	Maintenance of bridge upstream side

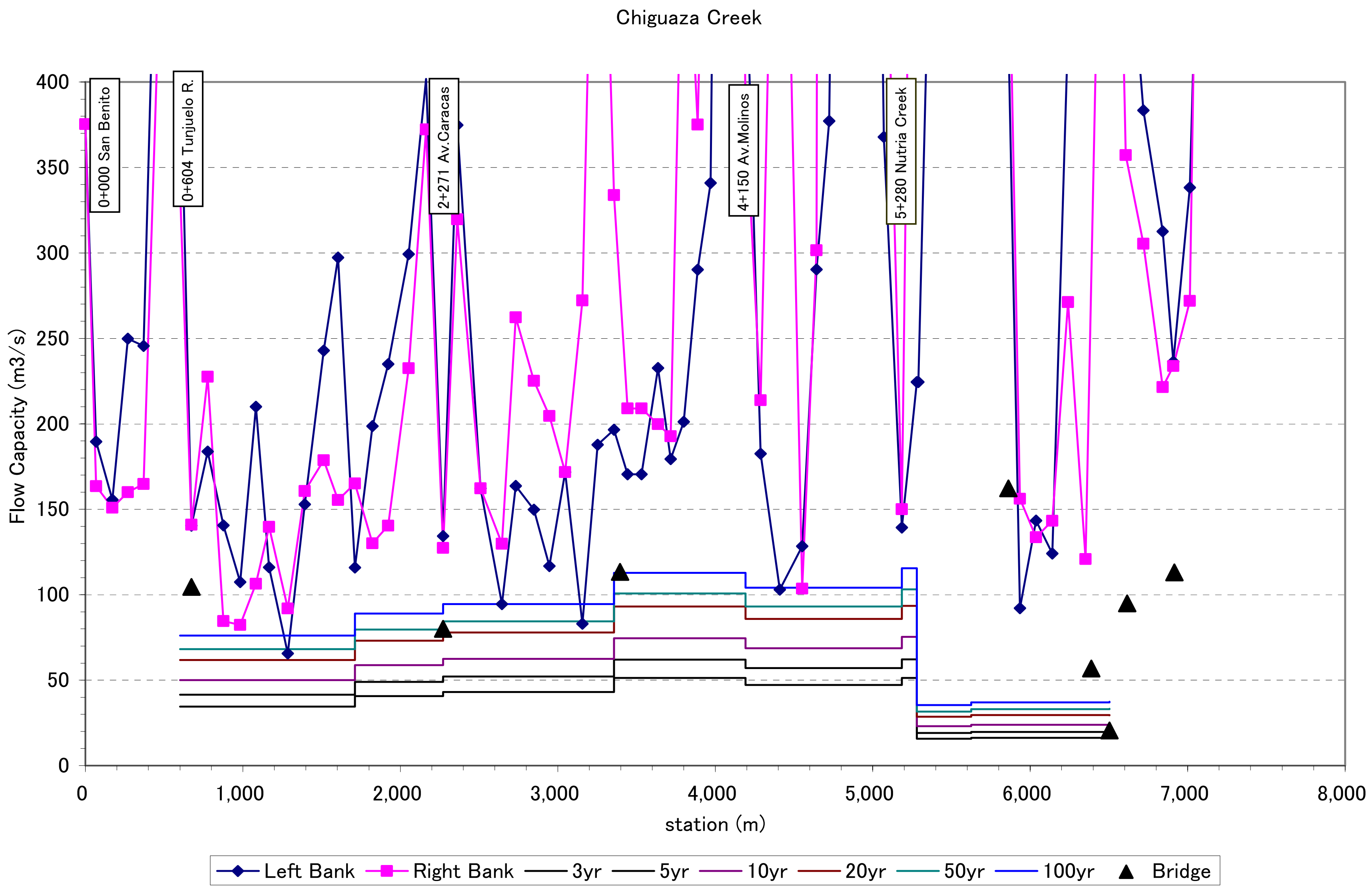


Figure S6-1-21 Channel Capacity and Probable Discharge in Chiguaza Creek

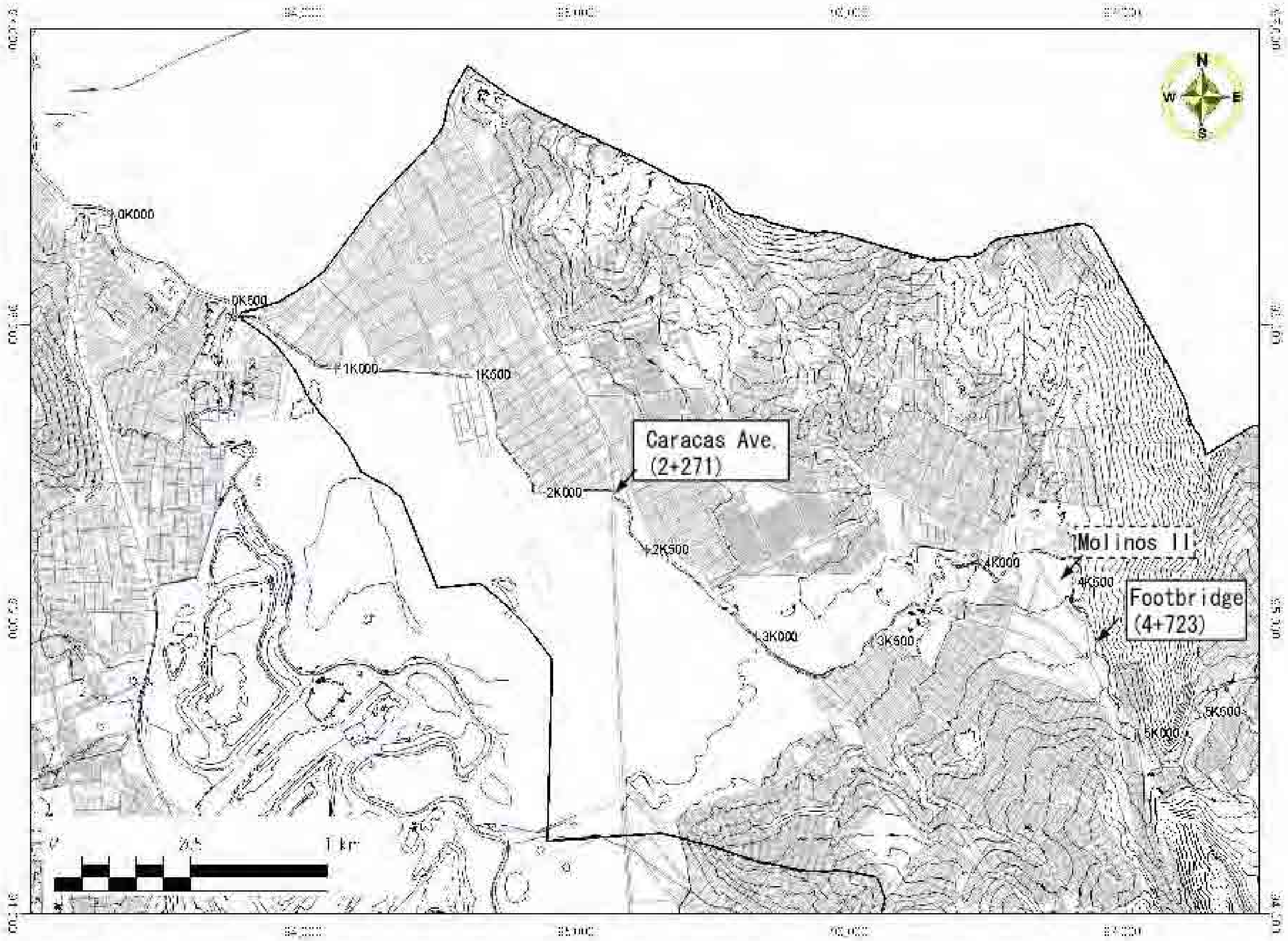


Figure S6-1-22 Critical Points in Downstream of Chiguaza Creek

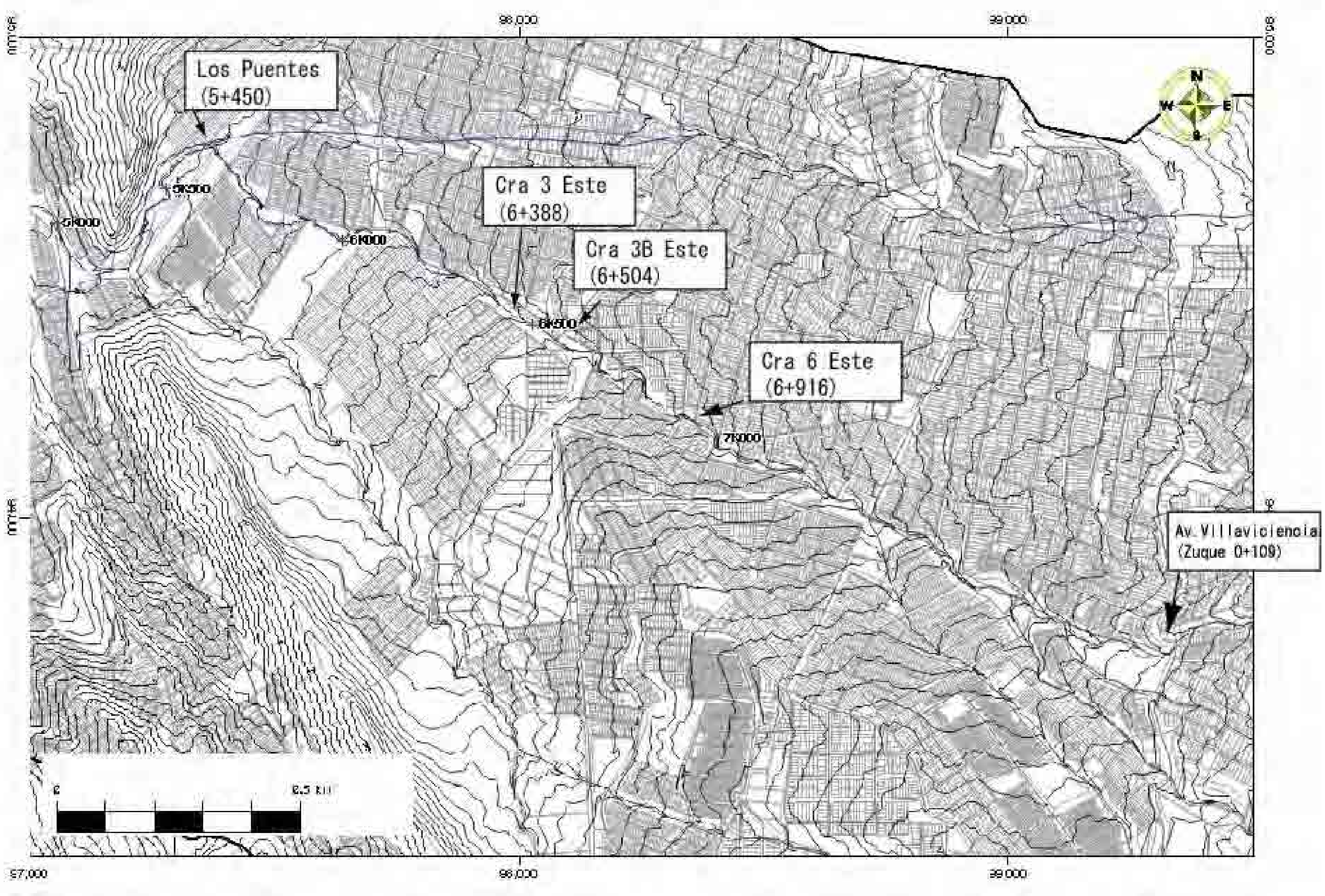


Figure S6-1-23 Critical Points in Upstream of Chiguaza Creek

(5) Santa Librada

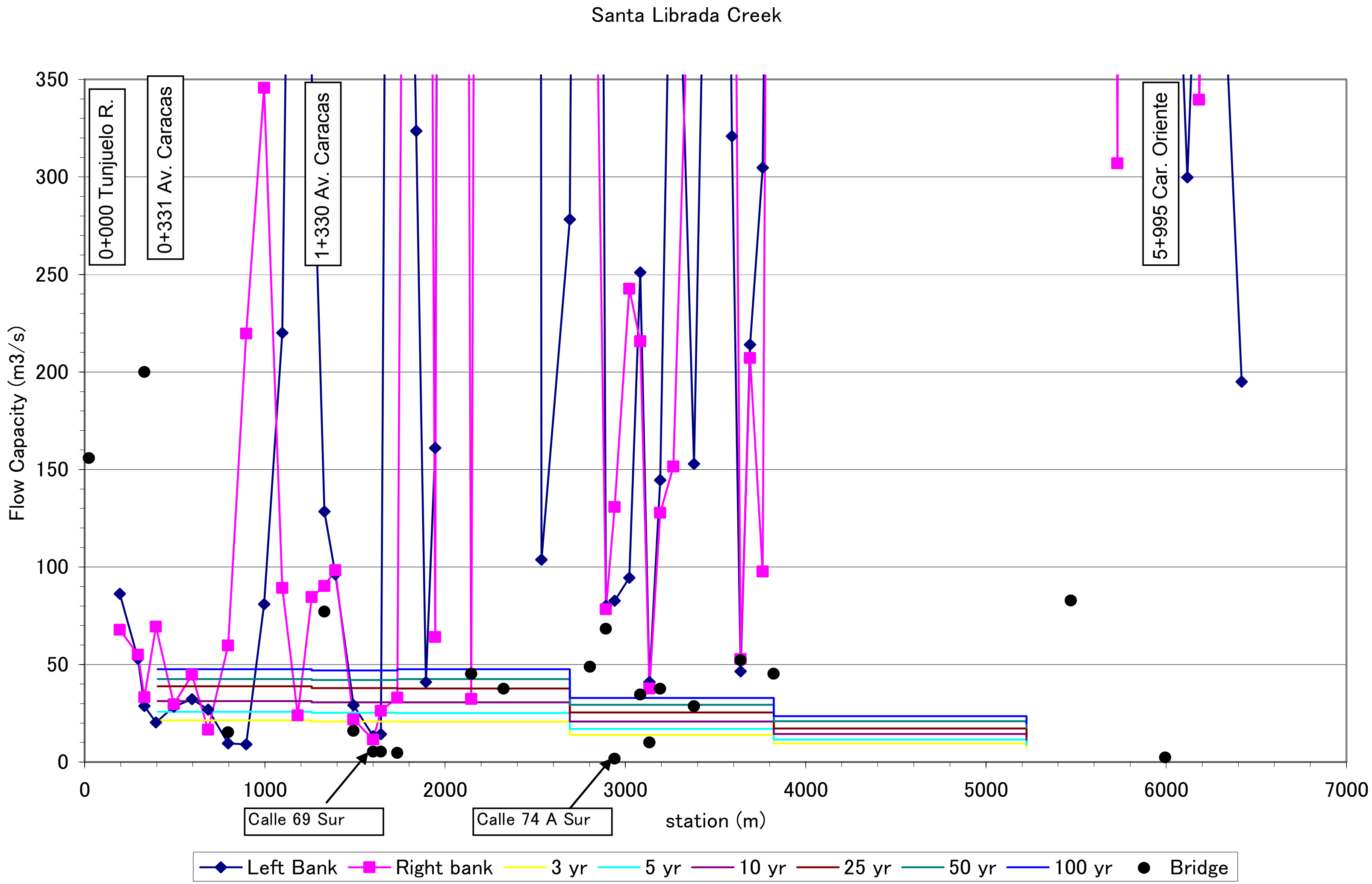


Figure S6-1-24 Channel Capacity and Probable Discharge in Santa Librada Creek

(6) Yomasa

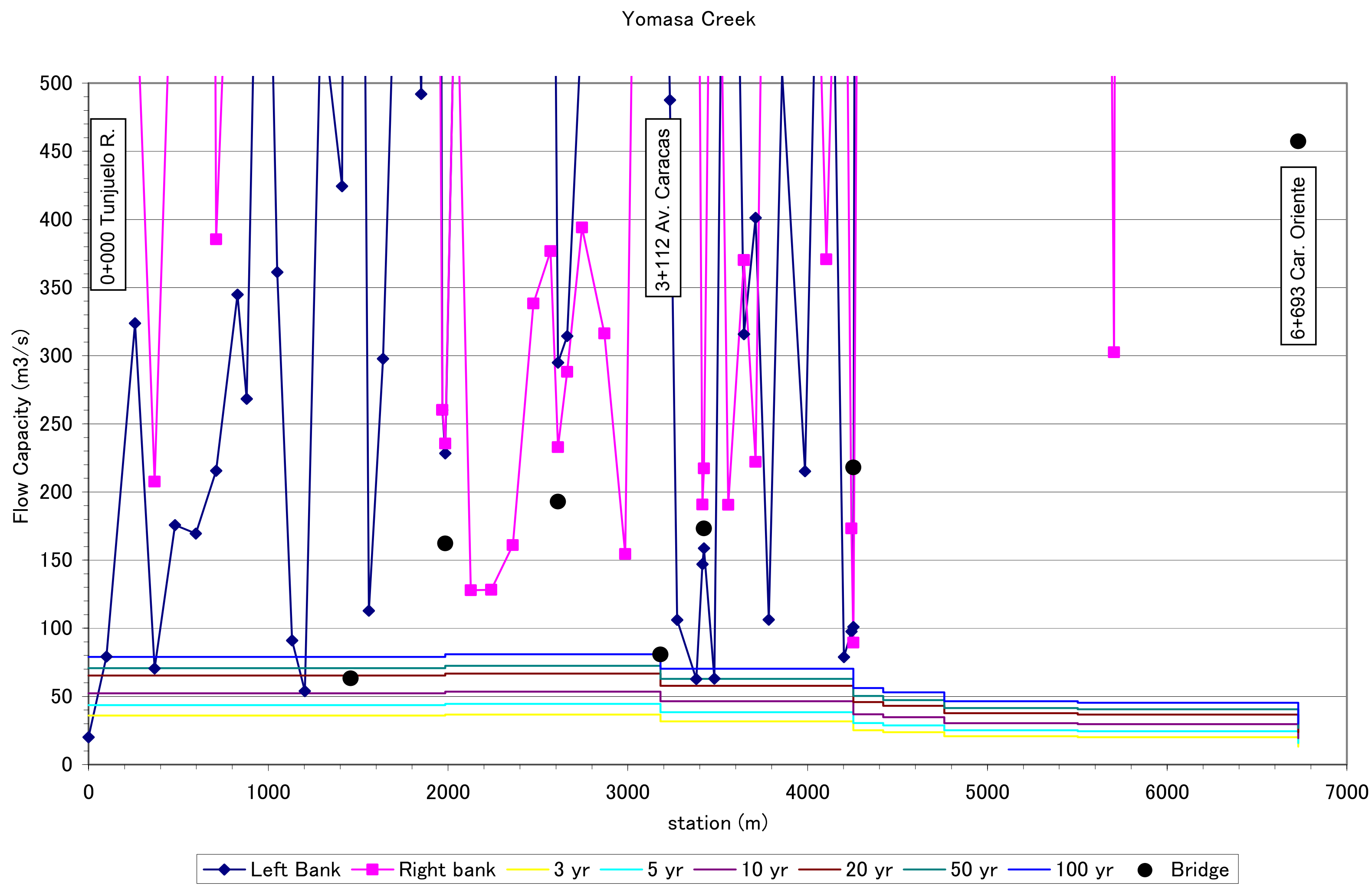


Figure S6-1-25 Channel Capacity and Probable Discharge in Yomasa Creek

(7) La Estrella and Trompeta

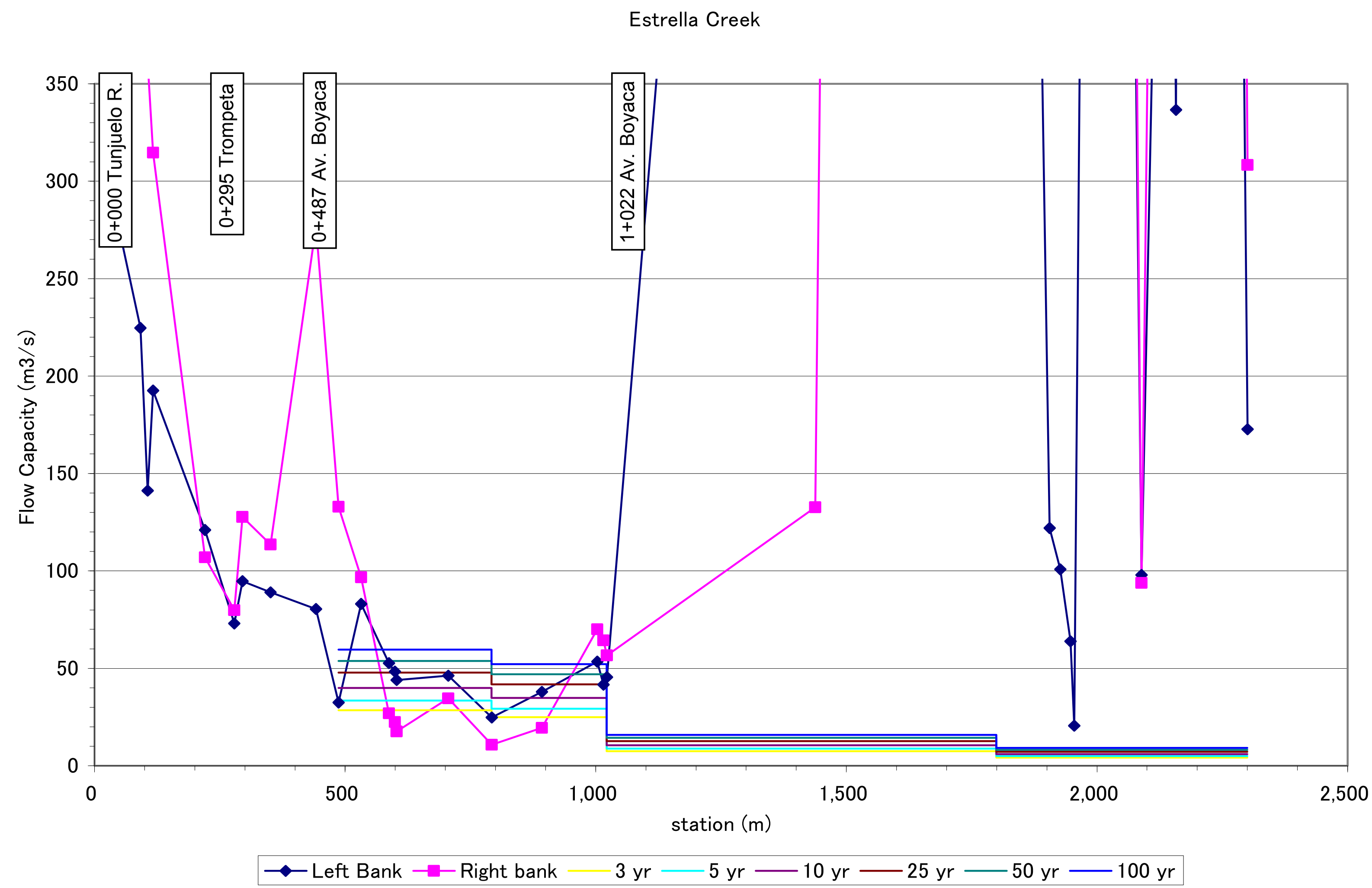


Figure S6-1-26 Channel Capacity and Probable Discharge in La Estrella Creek

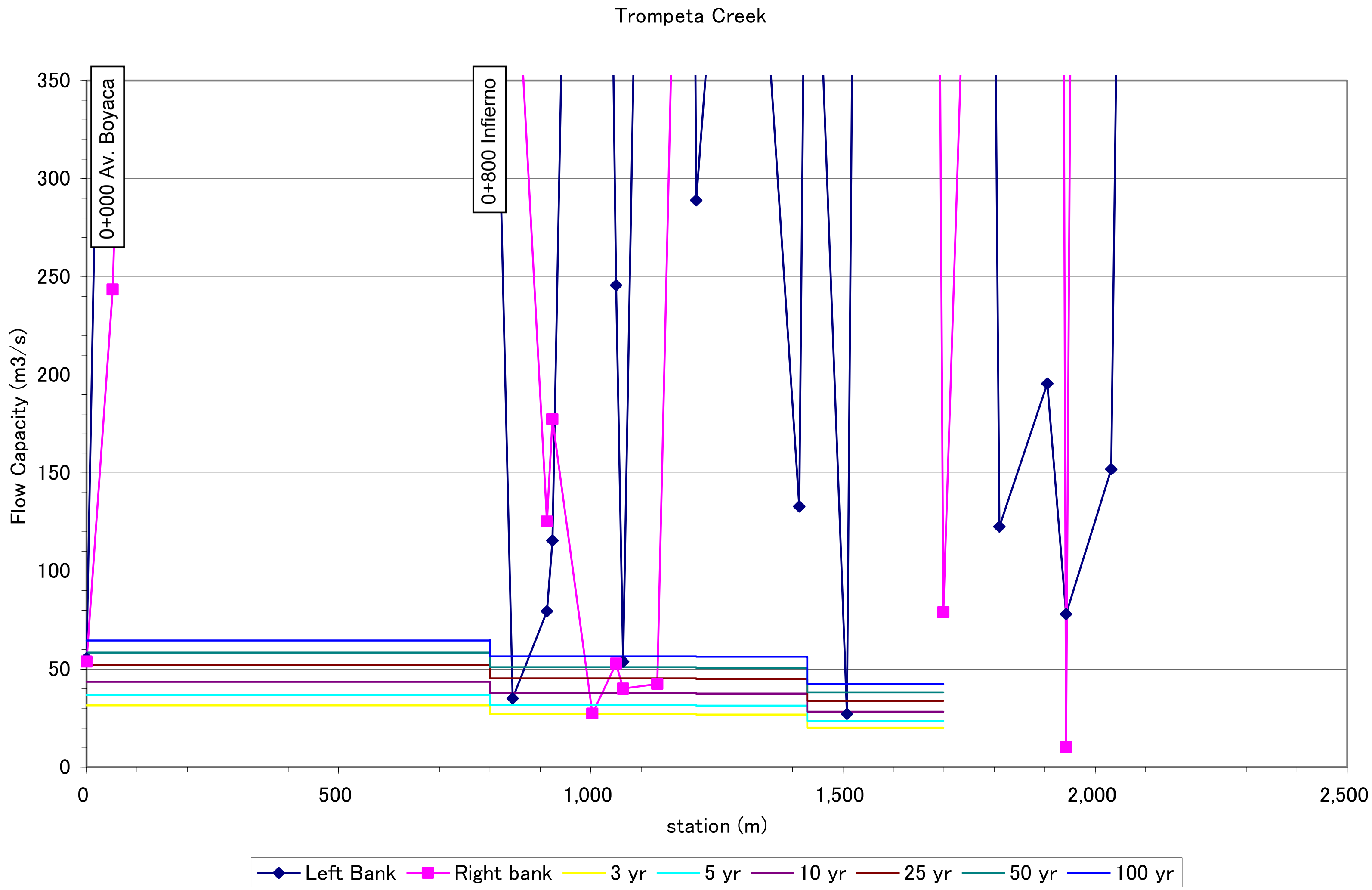
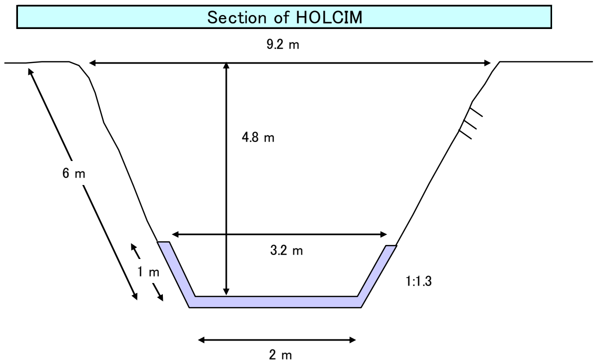


Figure S6-1-27 Channel Capacity and Probable Discharge in Trompeta Creek

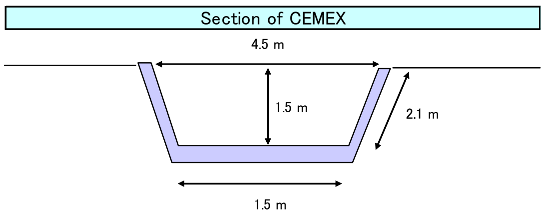
The section from 0+000 of the Trompeta to the confluence with La Estrella creek is inside of cement factories private land (HOLCIM and CEMEX). The Study Team could not send the surveyor inside area as other areas , however, the Study Team requested the factories formally and were allowed to enter and measure the channel dimension. The Study Team measured the channel dimension on site.

Figure S6-1-28 shows the typical cross section inside cement factories and calculation of channel capacity. In HOLCIM, the concrete channel is put in the bottom of 6 meter's slope length channel. The flow capacity at the earth top is 166 m^3/s. In CEMEX, there are some sections similar to that of HOLCIM, however, some sections are shown in the figure. The flow capacity is 13 m^3/s. For this calculation

The 100 year return period discharge of the downstream end of the Trompeta creek is 64 m^3/s. During flood, the flood water is distributed into both HOLCIM side and CEMEX side. The flow capacity of the HOLCIM side is enough for the 100 years return period, so the section downstream of 0+000 of the Trompeta has high safety level.



H	(m)	0.8	4.8
A	(m2)	2.1	26.9
S	(m)	4.0	14.0
R	(m)	0.5	1.9
n		0.025	0.025
I		0.007	0.010
V	(m/s)	2.2	6.2
Q	(m3/s)	4.5	166.1



H	(m)	1.5
A	(m2)	4.5
S	(m)	5.7
R	(m)	0.8
n		0.025
I		0.007
V	(m/s)	2.9
Q	(m3/s)	13.0

Figure S6-1-28 Cross Section and Channel Capacity inside HOLCIM and CEMEX

(8) Soacha

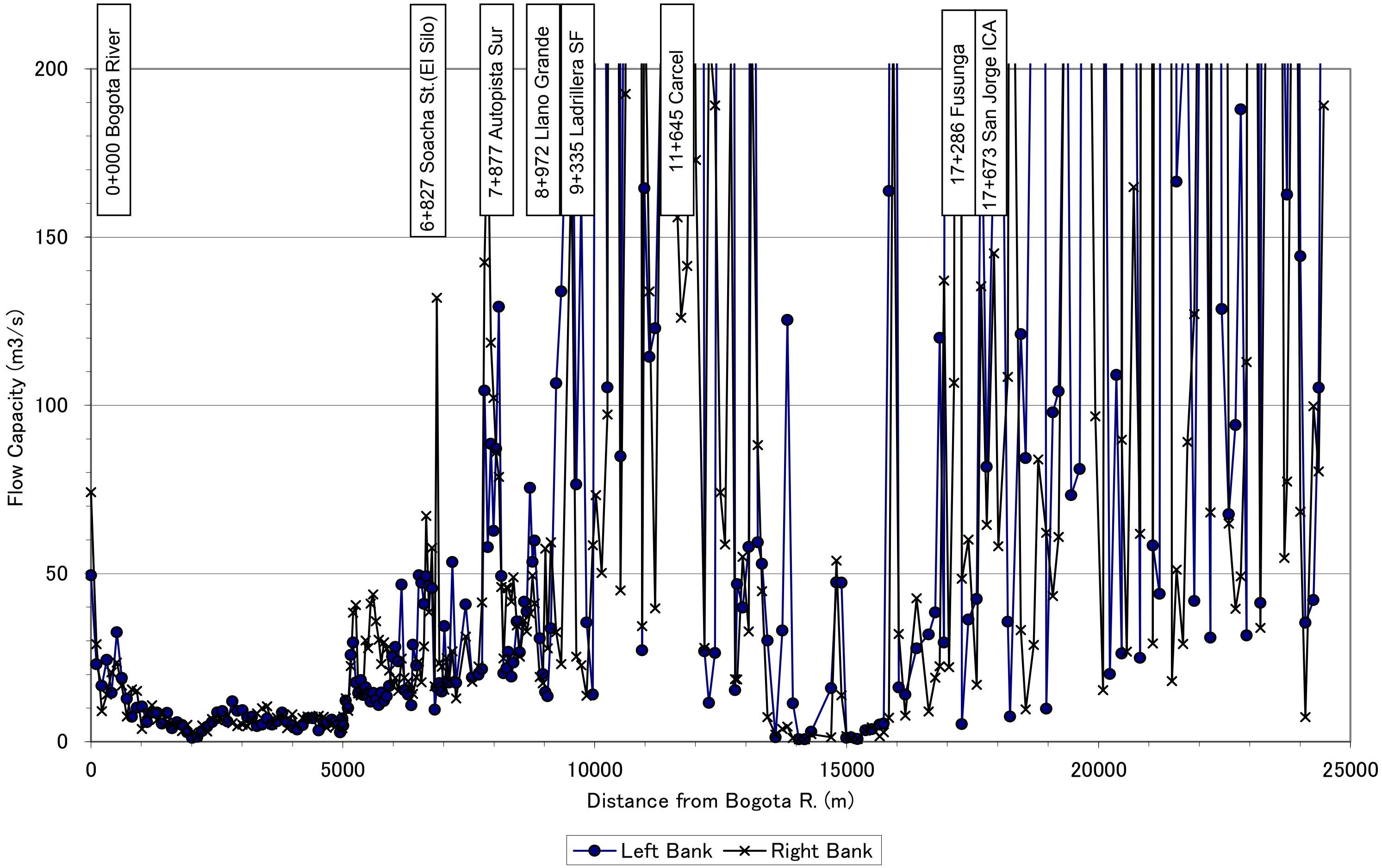


Figure S6-1-29 Channel Capacity in Soacha River

(9) Tibanica

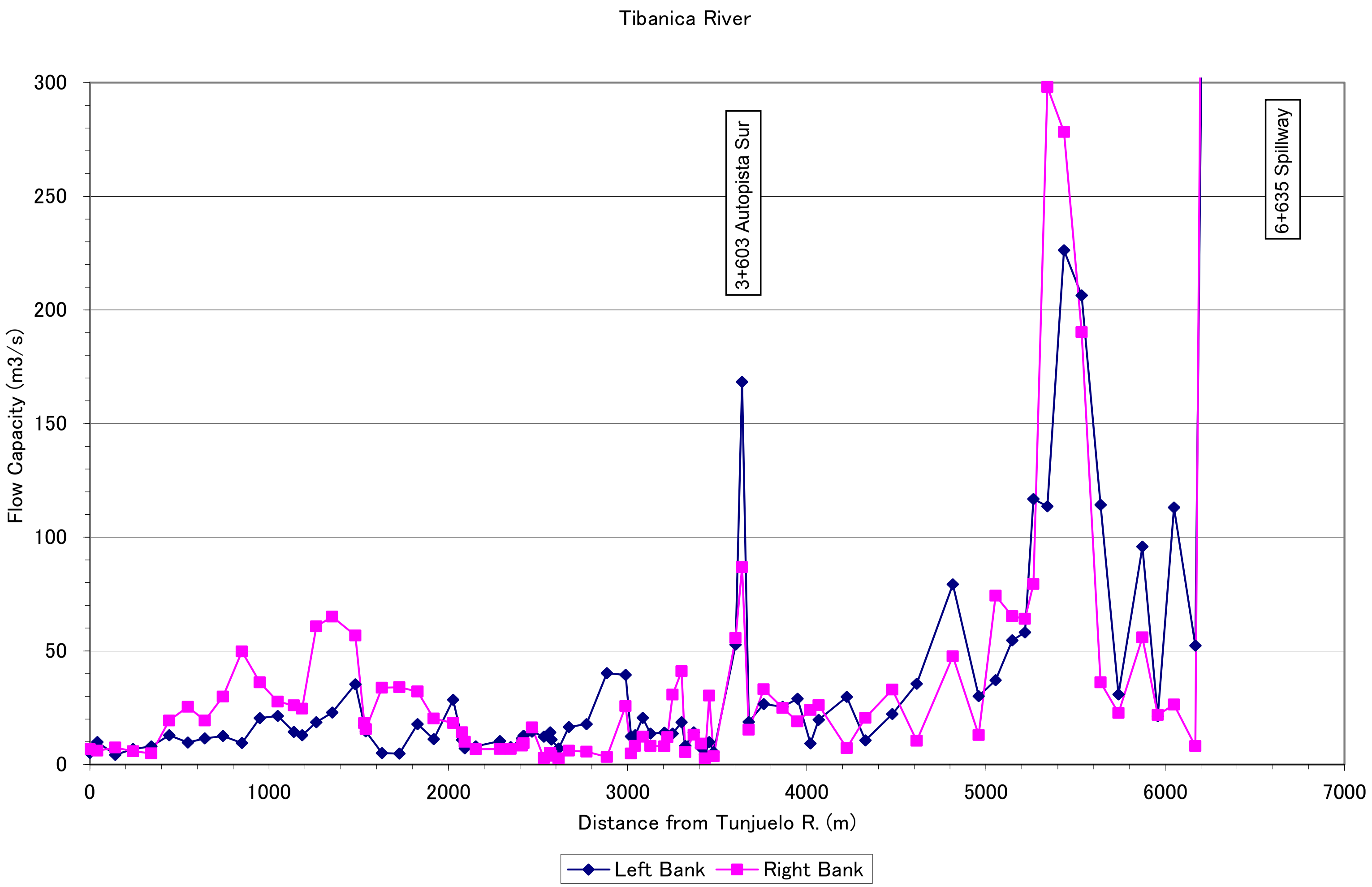


Figure S6-1-30 Channel Capacity in Tibanica River

1.3 Flood Disaster

1.3.1 Interview Survey in Bogota

The Study Team started interview survey on past major flooding in the target creeks in Bogota on September 2006. Different from the case of Soacha, the study area in Bogota did not have clear information on past flood area except the downstream of the Chiguaza and Yomasa, so the Study Team contacted JAC leaders in each creek at first and tried to obtain general information on past floods.

Regarding the Yomasa creek, the Study Team conducted the interview survey on October 2006 and January 2007 to JAC leaders and residents, respectively, in order to confirm the flood area specified by the JAC leader. According to the interview for the residents, the flood area was quite limited along the Yomasa downstream. The flood area of Yomasa downstream in Figure S6-1-31 is the area shown by JAC leaders.

Table S6-1-5 List of Barrio for Flood Interview Survey in Bogota

BARRIO NAME	No.	BARRIO NAME	No.
A.S.D	1	LA NUEVA GLORIA	4
ABRAHAM LINCOLN	7	LAS GAVIOTAS	1
ALTAMIRA	14	LOS LIBERTADORES	1
BARRANQUILLITA	1	LOS MOLINOS	1
CANADA O GUIRA	9	LOS MOLINOS DEL SUR	13
CERROS DE ORIENTE	3	MARRUECOS	2
CHUNIZA	1	MONTE BLANCO	14
DIANA TURBAY	2	PRIMAVERA	1
EL PINAR	1	QUINDIO	11
EL TESORO	1	SAN AGUSTIN	7
EL UVAL	1	SAN BENITO	15
ESTRELLA DEL SUR	1	SAN MARTIN	1
LA ALAMEDA	1	SANTA LIBRADA NORTE	4
LA GLORIA	6	TUNJUELITO	18
LA GLORIA OCCIDENTAL	7		
		TOTAL	149

Table S6-1-6 Major Inundation Events in Target Basins in Bogota by Interview Survey

Date	Chiguaza	Yomasa	Santa Librada	La Estrella & Trompeta
1978	Los Molinos (Flood)	—	—	—
1994	Altos de Zuque (Debris flow), Altamira (Debris flow), Diana Turbay (Flood & Debris flow)	—	—	—
1997	San Benito (Flood)	—	—	—
2002 May	Confluence with Rio Tunjuelo (Flood), San Benito (Flood), Tunjuelito (Flood)	—	—	—
2002 June 11	—	Monte Blanco (Flood)	—	—
2004 Oct.	—	Monte Blanco (Flood)	—	—
2004 Nov	—	Monte Blanco (Flood)	—	—
2006	Los Libertadores (Flood and Bank erosion)	—	—	
2006 May	—	—	—	Estrella del Sur (Flood)
2006 June	Canadá o Guira (Flood)	—	—	—

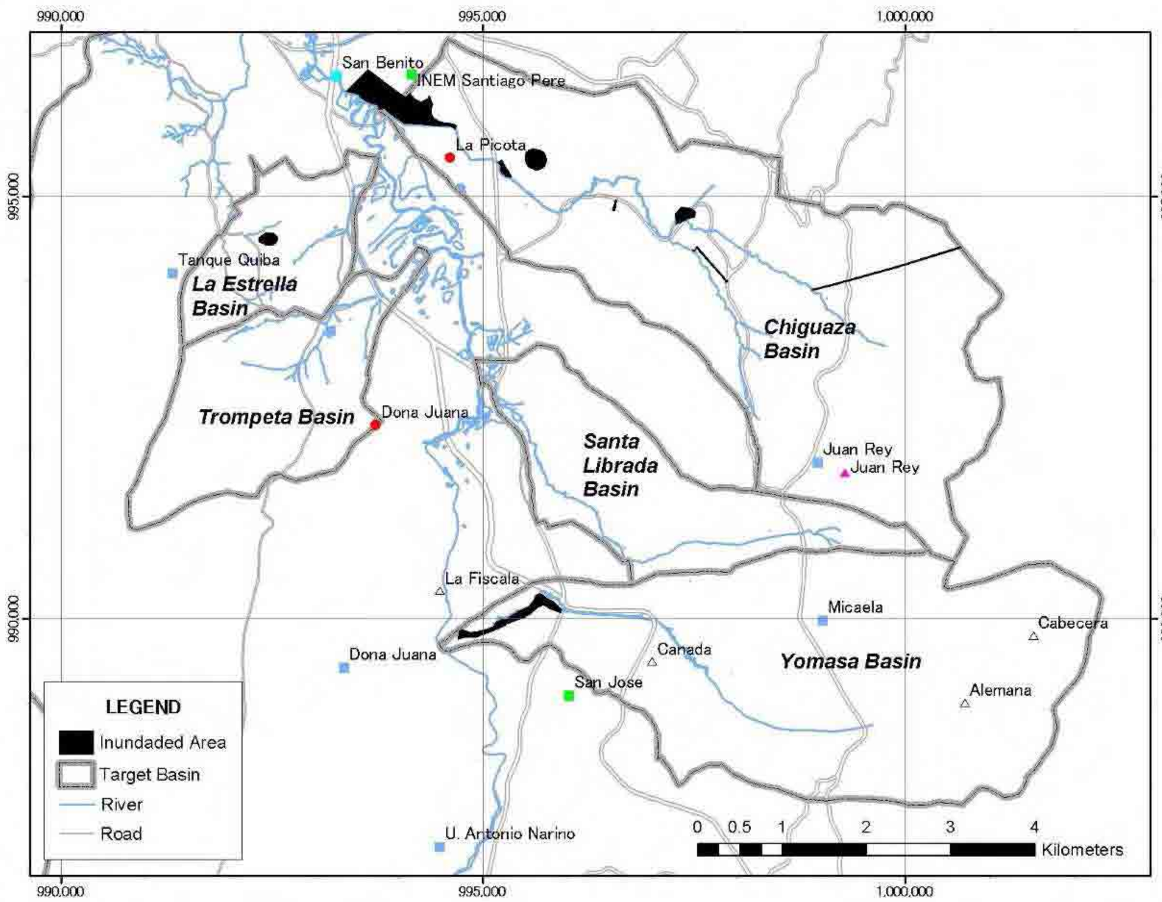


Figure S6-1-31 Major Inundation Events in Target Basins in Bogota by Interview Survey

1.3.2 Interview Survey in Soacha

The flood interview survey in Soacha was done concentrating on the May 11, 2006 flood, because it was said the flood was the maximum in recent 20 years and affected people had fresh memory about the flood phenomena.

Table S6-1-7 List of Barrio for Flood Interview Survey in Soacha

Barrio Name	No.	Barrio Name	No.	Barrio Name	No.
BARBADOS II	2	JUAN PABLO I	1	LOS OLIVOS II	1
CASALINDA XII	1	JULIO RINCON I	1	LOS OLIVOS III	4
CENTRO COMERCIAL UNISUR	2	LA ARBOLEDA	1	MIRADOR DE SAN IGNACIO V	1
CIEN FAMILIAS	3	LA CAPILLA	4	MIRADOR DE SAN IGNACIO VI	1
CIUDAD DE QUITO	1	LA DESPENSA	7	NUEVA PORTALEGRE	1
CIUDAD LATINA I	1	LA FLORIDA I	6	NUEVO COLON	8
CIUDAD LATINA II	2	LA FLORIDA II	5	PABLO VI	1
CIUDAD SATELITE	2	LA FONTANA I	1	PARQUE DE LAS FLORES	1
COHABITAR	2	LA FRAGUA	1	PARQUES DE SAN MATEO I	2
COLMENA II	1	LA MARIA	1	PARQUES DE SAN MATEO II	1
COMPARTIR	1	LA PRADERA I	2	PASEO REAL	1
EL CARDAL	12	LA PRADERA II	6	QUINTANAR DE LOS OCALES	1
EL CEDRO I	1	LAS ACASIAS I	1	QUINTAS DE SANTA ANA I	2
EL CIPRES	1	LAS ACASIAS II	1	SANTA MARIA DEL RINCON	7
EL DANUBIO	4	LEON XIII	5	SIMON BOLIVAR	1
EL PARAISO	3	LEON XIII SEGUNDO SECTOR	5	TERRAGRANDE	4
EL PRADO DE LAS VEGAS	5	LEON XIII TERCER SECTOR	5	TIERRA BLANCA	1
EL RINCON DE SANTAFE	4	LLANO GRANDE	11	UBATE	1
EL ROSAL	1	LLANOS DE SOACHA	1	VALLES DE SANTA ANA	2
EL SILO	4	LOS CEREZOS	1	VILLA ITALIA	1
EL TABACAL	1	LOS DUCALES II	1	VILLA SOFIA II	4
EL TREBOL	4	LOS OCALES	1	VILLAS DE SANTA ROSA	1
EUGENIO DIAZ CASTRO	1	LOS OLIVARES	11	ZONA INDUSTRIAL DE CAZUCA	6
HOGAR DEL SOL	2	LOS OLIVOS I	2		
				TOTAL	195

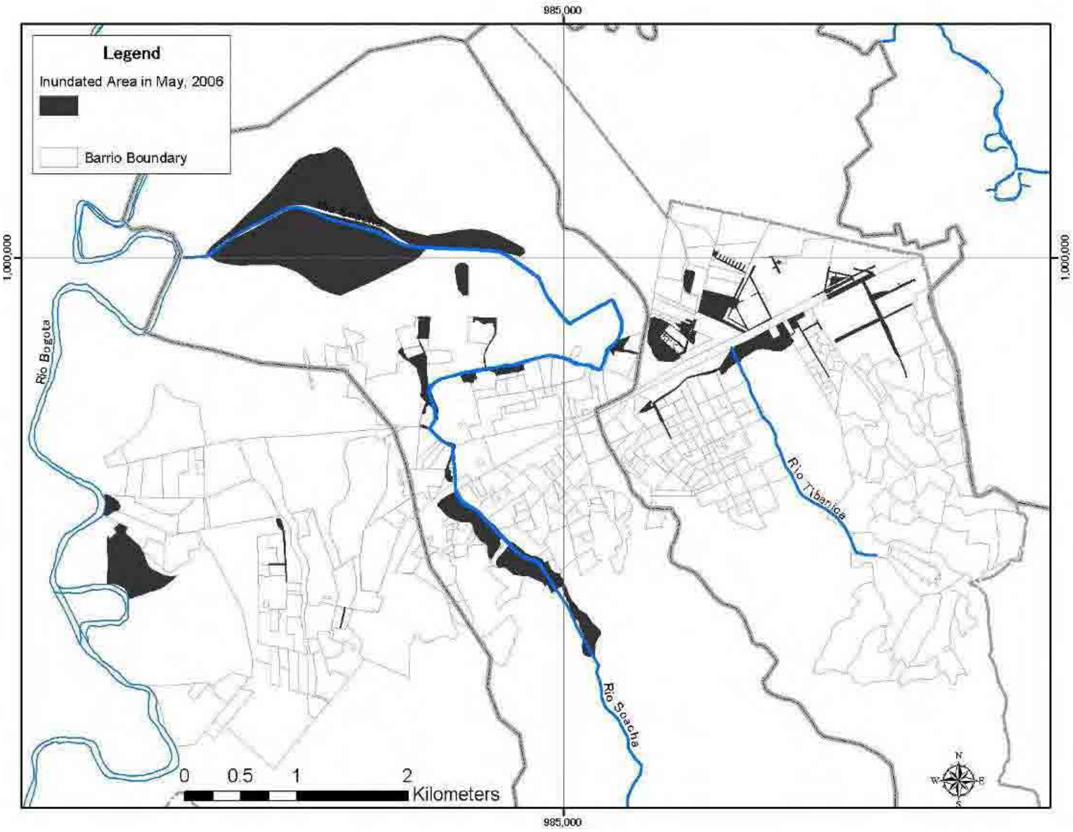


Figure S6-1-32 Inundation Area by Flood in May 11, 2006 in Soacha