SUPPORTING REPORT

S8

COMMUNITY SURVEY

TABLE OF CONTENTS
OF
S8 COMMUNITY SURVEY

List of Tables

List of Figures

List of Photos

CHAPTER 1 LANDSLIDE

1.1 Bogota

1.1.1 Purpose of Monitoring

The purpose of the monitoring is to verify the residential areas regarded as safe area are still in safe status. If the any doubt excited by the monitoring, the areas should be reconsidered. Object areas of the monitoring are the residential area (Phase III area and the areas out of the landslide area) only. Any landslide monitoring is not proposed in Phase I and II, since there are no houses to be protected in the areas of Phases I and II. The locations of monitoring are

a. boundaries between Phase II and III
b. the areas above the heads of the main landslide in Phase II
c. the house in which cracks and distortions were found.

With reference to "b" above, new collapses occurred recently near the heads of the main landslide blocks may show expanding of the landslide upward (toward Phase III). In order to ascertain the movement of the ground above the main landslide blocks, the monitoring is carried out in the area above heads of the main landslide blocks in Phase II. With reference to "c" above, some cracks and deformations of a house in safe area were found recently. These deformations may show that the landslide has been reached to the safe areas.

1.1.2 Monitoring Equipment

The following five kinds of monitoring works are carried out.

a. Survey Points b. Crack Gauges c. Level Survey d. Tiltmeter e. Laser Distance Meter

Quantity of the monitoring is shown in Table S8-1-1 and conceptual diagrams of above works are shown in Figure S8-1-1.

Table S8-1-1 Quantity of Monitoring

Location	Monitoring	Item	Quantity
Boundary between the Landslide and the Residential Area	Survey Point	Survey Points	15
		Fix Points (Bench Marks)	5
Phase II	Crack Gauge	Crack Gauges	3
		Pegs (4 pegs for 1 set)	3 set
Uplift and Deformed House	Level Survey	Survey Points	3
	Tiltmeter	Sensor	1
		Logger	1
	Distance Meter	Laser Distance Meter	1
		Target Plate	2

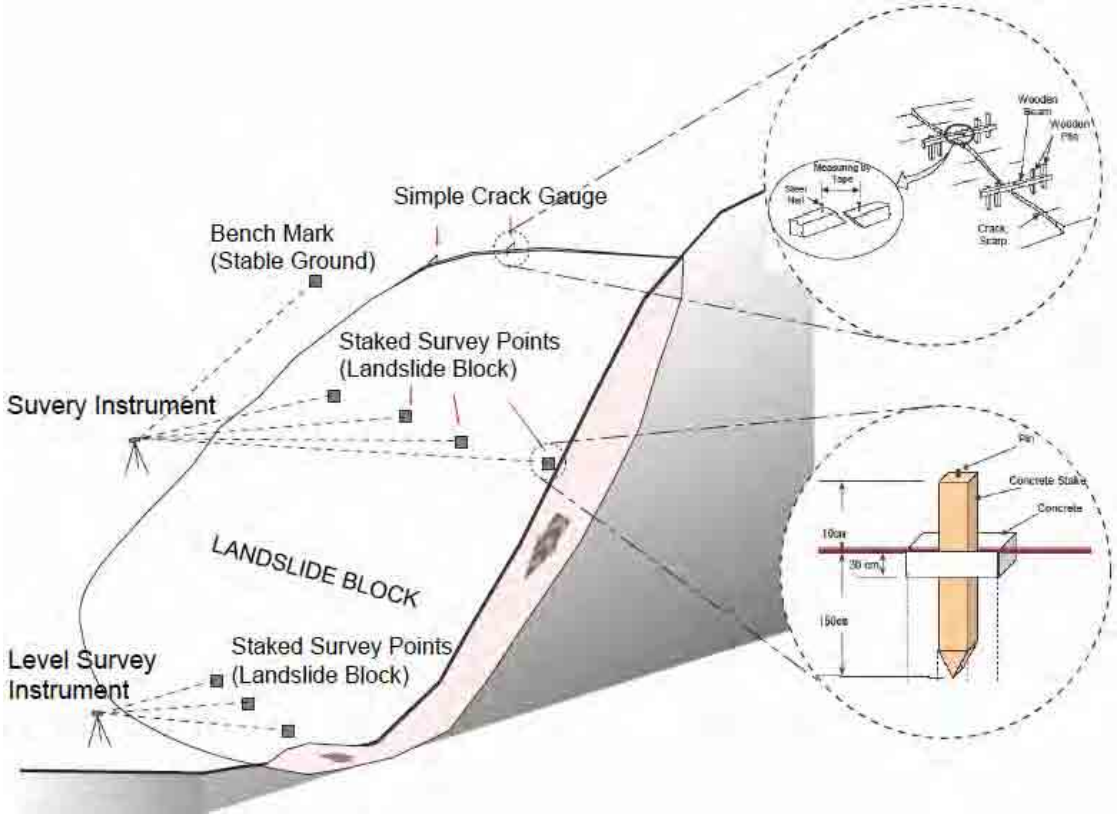


Figure S8-1-1 Conceptual Diagram of Survey Points, Crack Gauges, Level Survey Points

1.1.3 Installation Points of Monitoring Equipment

Survey Points

To confirm the safe areas are still in safe, the survey points were installed along the boundary between the residential area and the Landslide. The details of the each point are described as followings.

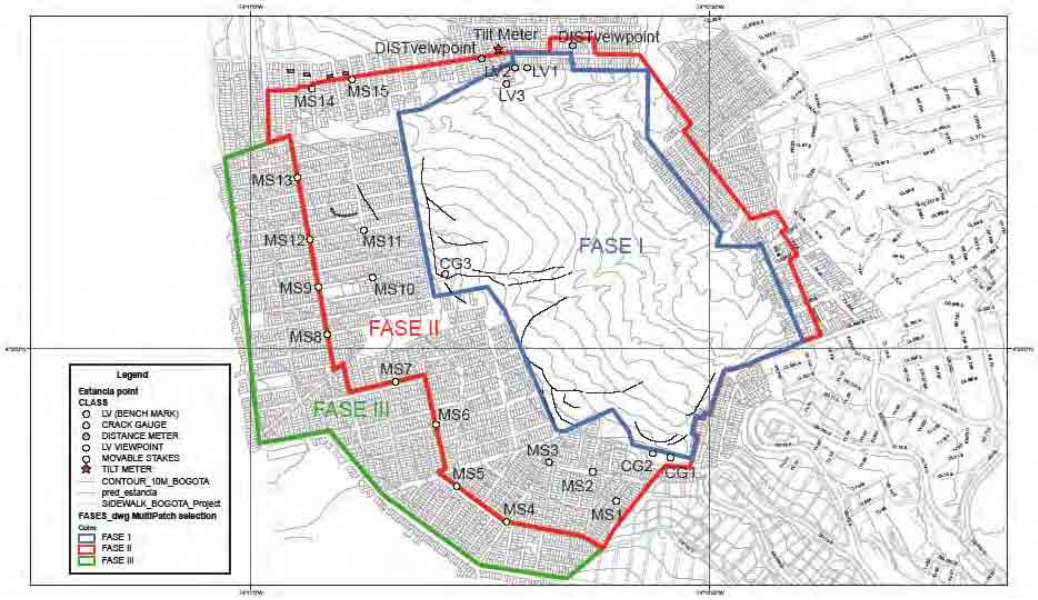
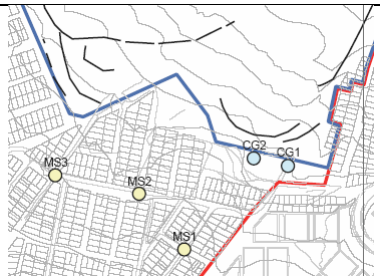
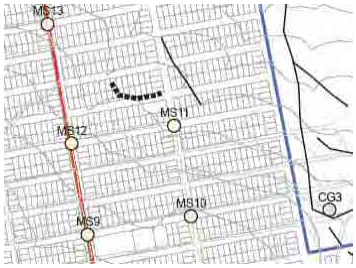


Figure S8-1-2 Location of Survey Points and Other Monitoring Equipments

In case any movement on some survey points is observed by the monitoring, the area around the survey points might be affected by the landslide. Exploration of the area is necessary to find any damages, distortions and cracks on the ground, houses or structures. If the influence of the landslide on the area is found out, it is necessary to reconsider the area of Phase III. Total 15 numbers of the survey points were installed, and 5 numbers of Fix points are installed as bench marks.

Table S8-1-2 Details of Survey Points

Points	Description	Map
MS4, MS5, MS6, MS7, MS8, MS9, MS12, MS13	To confirm the safety of Phase III, the points was installed on the boundary lines between Phase II and Phase III.	
MS1	As small landslide above head of the main landslide blocks occurred recently is close to the safe area, the point was positioned.	
MS2, MS3	New collapse occurred near the head of Carbonera Landslide may show expanding of the Carbonera Landslide upward (toward Phase III). In order to ascertain the movement of the ground above the Carbonera landslide, MS2 and MS3 were positioned near the head of Carbonera Landslide.	MS1, MS2, MS3 
MS10, MS11	New collapse occurred near the head of Espino Landslide may show expanding of Espino Landslide upward (toward Phase III). In order to know the movement of the ground above Espino landslide, MS10 and MS11 were positioned near the head of Espino Landslide.	MS10, MS11 
MS14, MS15	Recently some distortions of houses which are in safe area were found. These deformations may show the activity of the landslide has been reached the area of the houses. To confirm that, MS14 and MS15 were positioned near the houses.	MS14, MS15 *Red marked lots are the location of houses in which the deformations were found.*
Fix Points	Five numbers of fix pints are installed on stable ground in order to monitor 15 numbers of the survey points.	

Actually the survey points made of concrete with brass points were installed so that they are not taken away.

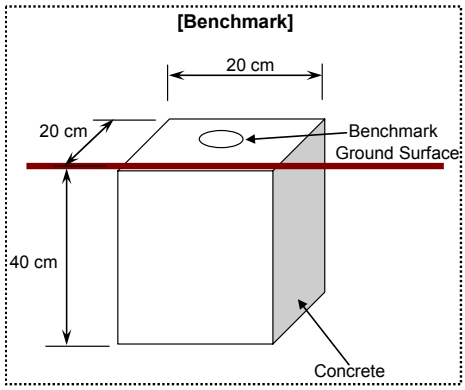


Figure S8-1-3 Dimension of Survey Points and Fix Points

Crack Gauges

The movement of the cracks monitored by the crack gauges can be summarized in graphs which show relations between time and movement. The graphs can show the movement of the head of landslide block, and then the velocity of the landslide movement may be estimate. Sign board as shown in Figure S8-1-10 are installed at the crack gauges to inform the meaning of the monitoring to the residential people around.

Crack gauges installed on the site are quite bigger and stronger than normal in Japan since they might be destroyed as shown in Figure 6. However the crack gauges were destroyed few times by somebody after installation on the site, then they were changed to stakes as shown in Figure S8-1-5.

Crack Gauge installed on the Site

Normal Crack Gauge in Japan

Figure S8-1-4 Crack Gauges

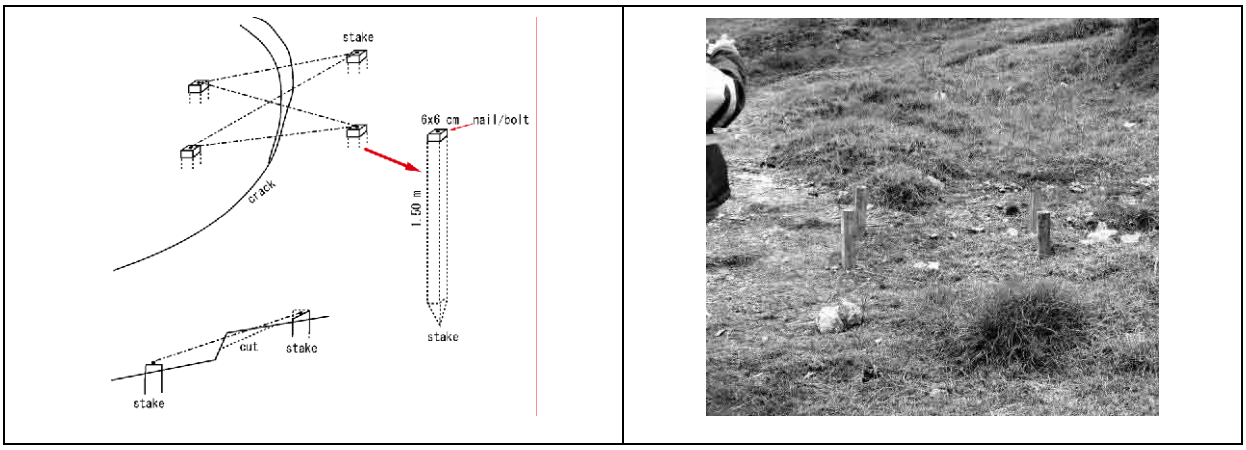


Figure S8-1-5 Stakes for Monitoring on Cracks

Monitoring for the House

In the house which is object of the monitoring, some cracks were found by residents of the house in October 2006. The house locates at the boundary between evacuation area and safe area and at the place close to the uplift formed by the landslide movement.

The following equipments were installed in and around the house to monitor slow progress of tilting of the house and slow movement of uplift.

a. Tiltmeters on the basement floor of the house
b. Laser distance meter to monitor the distance between the house and the uplift
c. Logger which connected to the tiltmeters in the house
d. Level survey points to monitor uplifting of the uplift

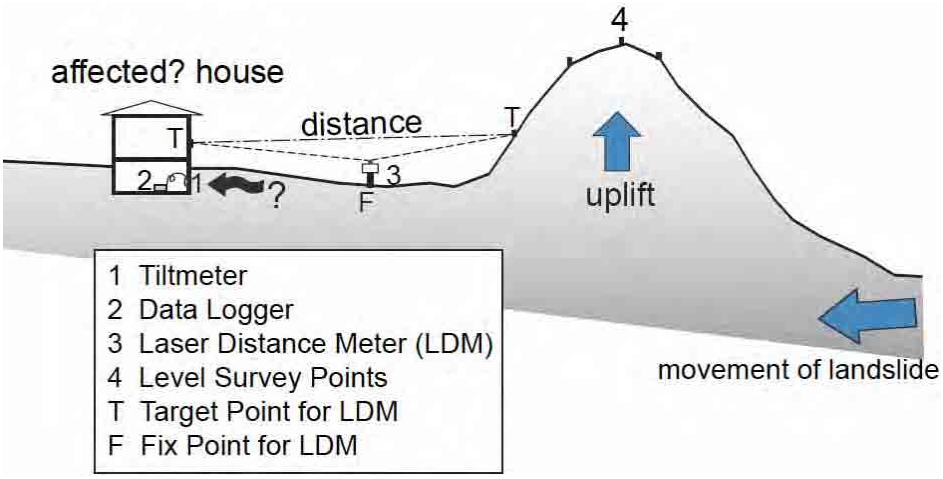


Figure S8-1-6 Monitoring Equipments for the House

For the monitoring of distance between the house and the uplift, laser distance meter is employed. The distance is not monitored directory using laser distance meter, but monitored indirectly using laser distance meter which on the fix point, and three numbers of target points installed one at the house and two on the uplift.

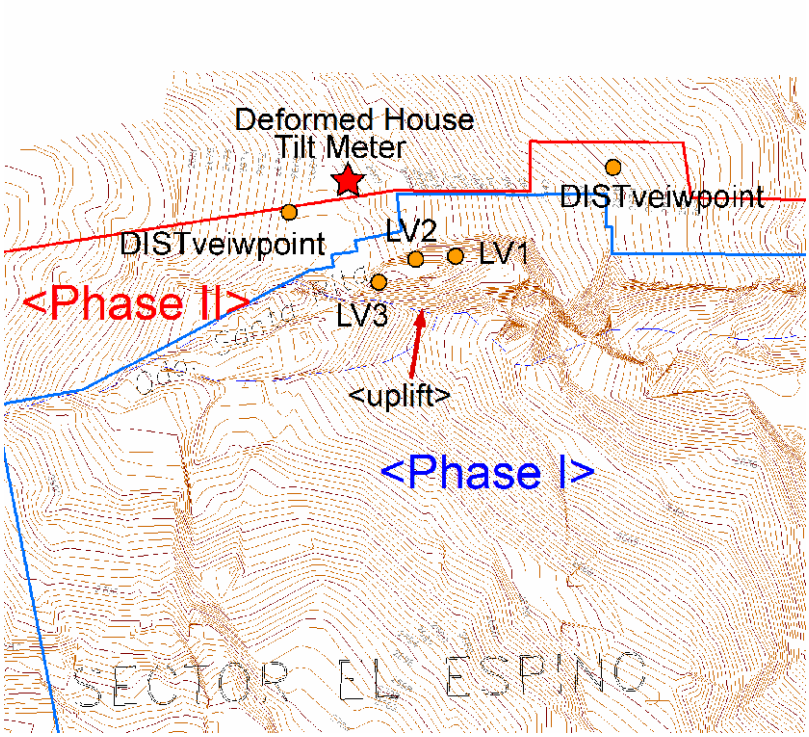


Figure S8-1-7 Positions of Monitoring Points for the House

Level Survey

To monitor the rising of the uplift, the level survey is employed. The results are analyzed with another monitoring such as the distance meter and the tilttmeter.

Distance Meter

In case the distance between the house and the uplift is being short, the landslide may be getting close to the house, and extension of Phase II area should be discussed. One portable laser distance meter is employed for the monitoring, and its specification is as follows;

Maximum distance to measure: 100 m or farther,
Measuring accuracy: ±1.5 mm (up to 30 m in distance),
Tilt sensor accuracy to laser beam: ±0.15°, to the housing: ±0.3°

Two (2) numbers of target plates for the laser distance meter were installed on the uplift ground

Tiltmeter

If the tiltmeter installed in the house show the house is tilting, the landslide may influence on the house. The influence of the landslide shall be analyzed comparing with the result with the distance meter. If we find the landslide is imminent to the house, the house should be object of relocation.

To monitor the tilting of the house, one automatic tiltmeter is installed with data logger on the wall of the basement in the house. Specifications of the tiltmeters are as follows;

- Standard Range: ±10° or more precisely,
- Sensitivity: ±10 arc seconds or more precisely, and

A single channel type data logger was employed to collect the tiltmeter data. Specifications of the tiltmeters are as follows;

Available to change any measurement interval (selectable every 1 sec, 1 min, 1 hr, 1 day),
Data memory: more than 1,000 data

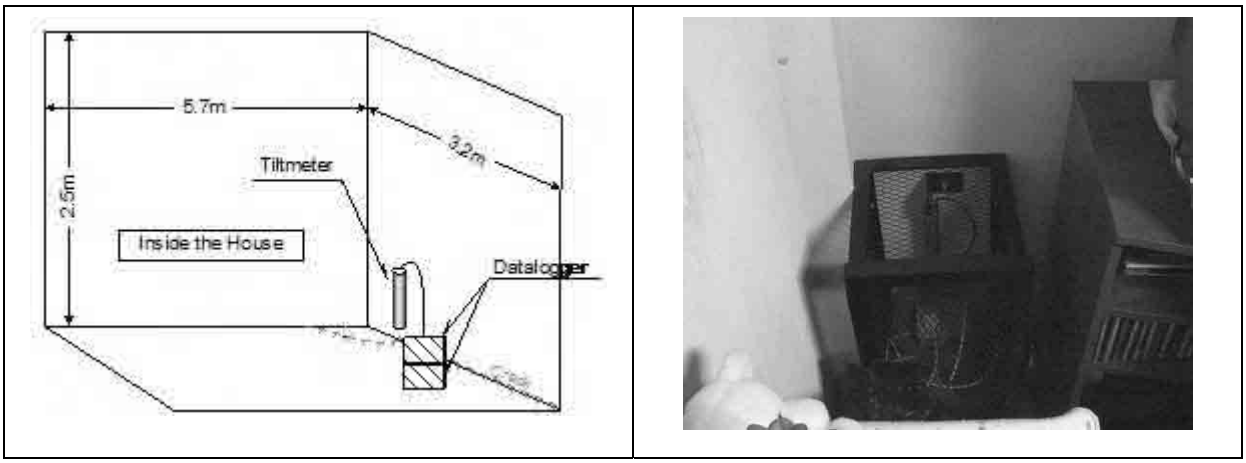
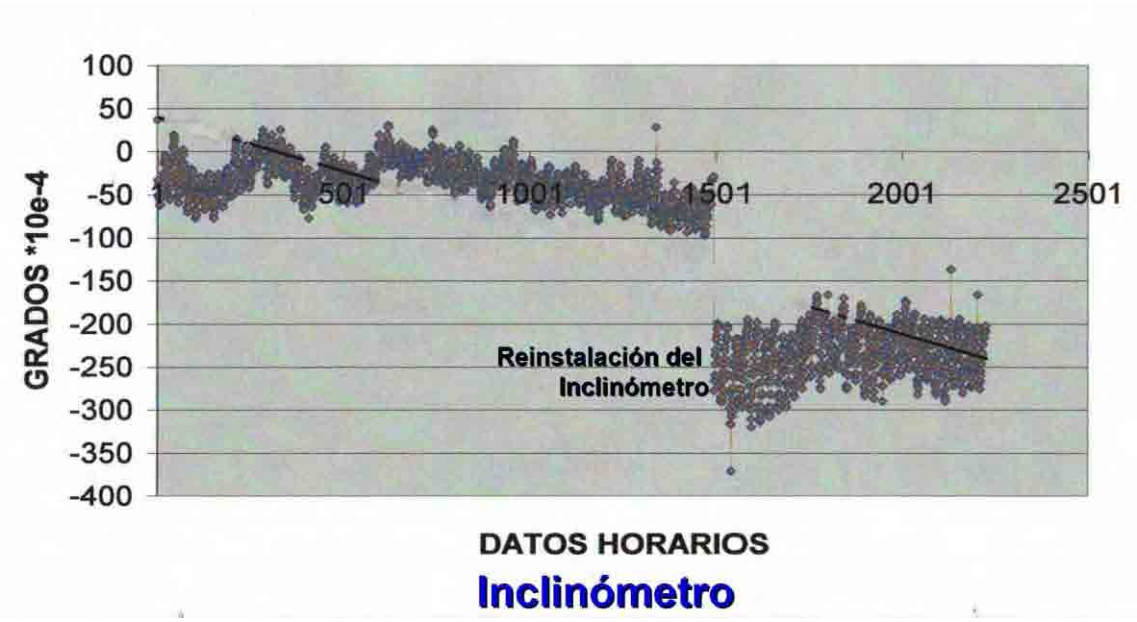


Figure S8-1-8 Schematic Diagram of the Installation of Tiltmeters and Data loggers

1.1.4 Results

Any significant movement has not been seen on all the monitoring at the moment. The results may show that the landslide has not been reached to the safe areas, and the residential areas may be still in safe status. However, the period of the monitoring is too short to judge the safety of the areas, the monitoring should be continued and accumulate the data to confirm the safety of the areas.



(y-axis; 1 x 10e-4 degrees, date x-axis; hour from 28 July, gap at day 1660 is because of reinstallation)
Stolen and Theft

Figure S8-1-9 Inclinometers Movement

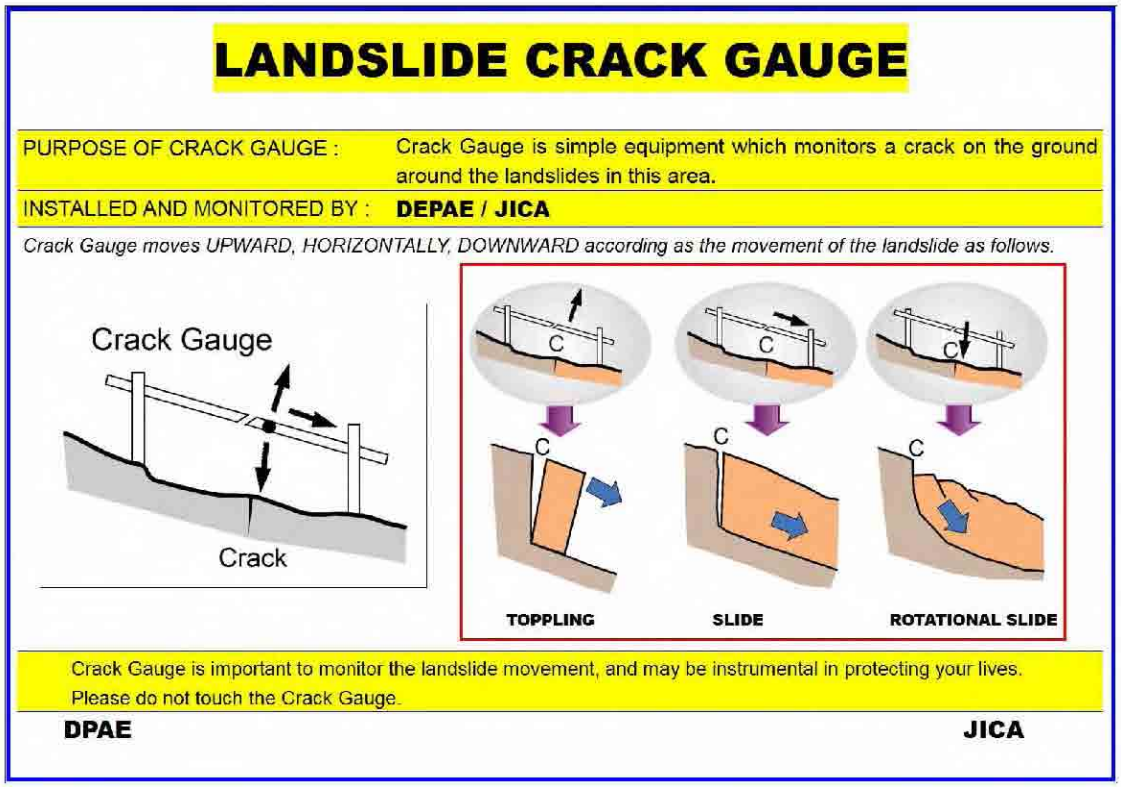


Figure S8-1-10 Sign Board of Crack Gauge

Figure S8-1-11 Photos of Sign Board of Crack Gauge

1.2 Soacha

1.2.1 Necessity of Precipitation Monitoring and Disaster Records

1) Back Ground

Many landslide disasters have occurred in or after heavy rain in Altos de Cazuca and El Divino Nino in Soacha Municipality. In May, 2006, many houses suffered from slope collapses and rock falls by heavy rain. Meanwhile, some landslide disasters occur even in dry season. It may be true that the rain fall causes many landslides in Soacha Municipality, but not certain without any support data. The information collection of precipitation and disasters are most important to take action against the

landslide disasters. The following questions should be verified to make future plan of disaster measures, such as early warning systems to the people remaining in Critical Zones.

> Is it true that landslides occur more with heavy rain fall?
> How much rain fall triggers off landslides?
> What type of landslides occurs in rain fall?
> Do the relations between ran fall and landslides differ in area by area, or barrio by barrio?
> How many landslides and what type of landslides occur in dry surroundings (without rain)?
> Does occurrence of landslides change by the way of rain fall (less and long / heavy and short)?
> Do intensities of rain fall differ from one small area (barrio) to another?

Accumulating the information about precipitation and occurrence of landslides, the relation between rain fall and occurrence of landslides should be studied. If we can solve above questions, we might be able to build early warning system with rain fall monitoring.

2) Purpose

Precipitation monitoring and record of landslides are carried out in order to collect and accumulate the basic information for analysis of the relation between rain fall and occurrence of landslide and to study landslide disaster prevention measures especially early warning systems in future. In order to install the rain gauges as many as possible for the purpose, the simple gauges which are low cost and easy to be read were installed in the pilot project area. To monitor many rain gauges constantly, the monitoring works were left to the community in where the rain gauges are installed. It is expected also that community's awareness of disaster prevention becomes higher with the monitoring works. The record of landslide is being carried out by Soacha Municipality, since recording of landslides requests more expertise.

3) Example of analysis

The several methods to evaluate the rain fall in terms of the relation between disasters such as collapse, debris flow have been applied as follows in Japan.

a) Hourly Rainfall Method

This method uses only hourly rainfall. When hourly rainfall excess certain value (e.g. 20 mm / hour), warning of danger is given. This is most simple method applicable to urgent evaluation, and is good represent well for the rainfall intensity indicator.

b) Accumulated Rainfall Method

When accumulated rainfall excess certain value (e.g. 100 mm), warning of danger is given.

$R = \Sigma Ri$ (Ri : hourly rainfall at i hours before)

(If the rainfall has been stopped for three ours Ri should be 0 .)

This is most simple method applicable to urgent evaluation, and is good represent well for the rainfall intensity indicator too. This method is widely used in road management in mountain area in Japan.

This method is more reliable than Hourly Rainfall Method, however, it has still have some error to predict the disasters.

c) Combined Method of Hourly Rainfall and Accumulated Rainfall

Combined of methods of a) and b) is more reliable than the single application.This method is adopted by Japan Railway (Figure S8-1-12).Japan Railway (JR) is using the following graph to control train system. Figure S8-1-12 shows that the example of train control based on rainfall by JR. It is based on accumulated rainfall and hourly rainfall.

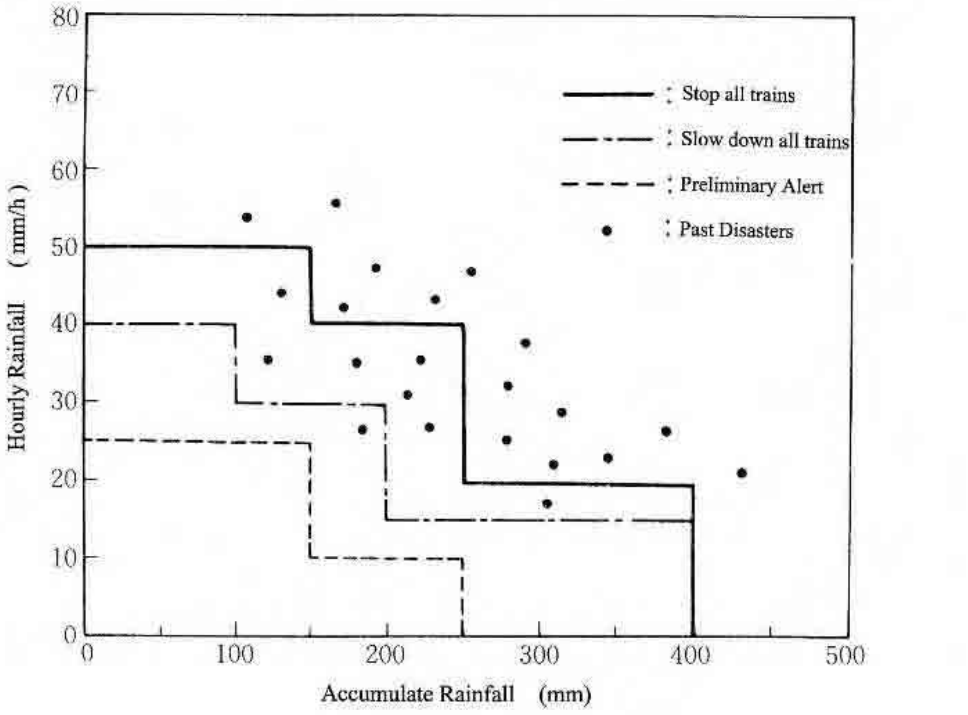


Figure S8-1-12 Train Control Based on Rainfall by Japan Railways

Figure S8-1-13 shows that the example of traffic control based on rainfall by Japan Highway. It is combination of accumulated rainfall and hourly rainfall. The shadowed area in the graph is to be considered as critical stage for the highways.

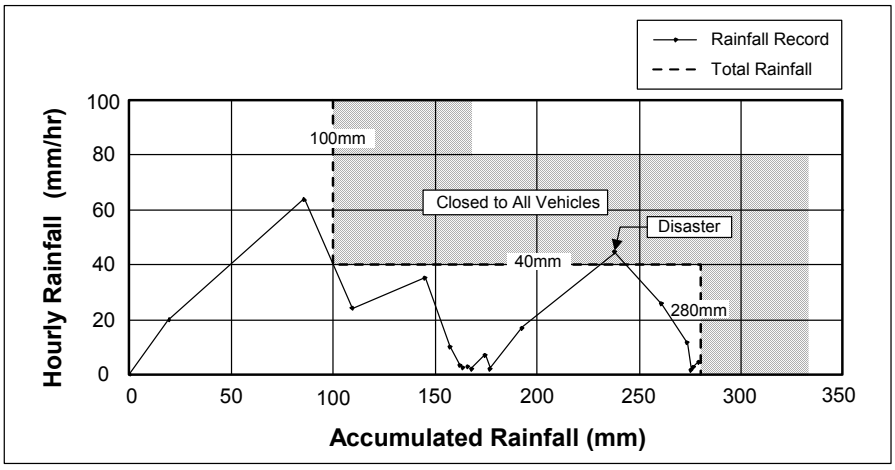


Figure S8-1-13 Train Control Base on Rainfall by Japan Highway Corporation

d) fective Rainfall Method

Effective rainfall is defined as the accumulated rainfall with attenuation by run-off effect of precedent rain. It is explained by following formula.

$$R = \Sigma AiRi$$

($Ai = 0.5^{i/T}$, T : half life of water level in the ground (depend on geology))

e) Water Storage in-Soil Method

Change of water volume in the soil is evaluated using tank model analysis.

Being adopted in special program aerial disaster warning in use of weather forecast radar network.

1.2.2 Method of Precipitation Monitoring

i) Locations of Installation of Rain Gauges

Precipitation monitoring is carried out in the pilot project area where is Altos de Cazuca and El Divino Nino in Soacha Municipality. Five rain gauges were installed in five schools in the pilot project area as shown in Table S8-1-3 and Figures S8-1-14.

Table S8-1-3 Locations of Rain Gauges

area	gauge no.	school	barrio
Altos De Cazuca	RG1	Institution Educativa Cazuca	La Capilla
	RG2	Gimnasio Moderno Colombiano	El Mirador De Corinto
	RG3	Institution Educativa Luis Carlos Galan	Luis Carlos Galan
	RG4	Institution Educativa Antonio Narino	Sede El Arroyo
El Divino Nino	RG5	Institution Education Las Villas	Escuela La Panamericana

For the following reason, the schools are selected for the location of rain gauges installation.

- There are more than one schools in Altos de Cazuca
- Monitoring can be executed in night time by a security guard as security guards stay in the schools for 24 hours a day.
- The rain gauges can be protected from burglaries as securities of schools are adequate.
- The rain gauges may be able to be useful for a part of education for school children, and the children's awareness of disaster prevention become higher.

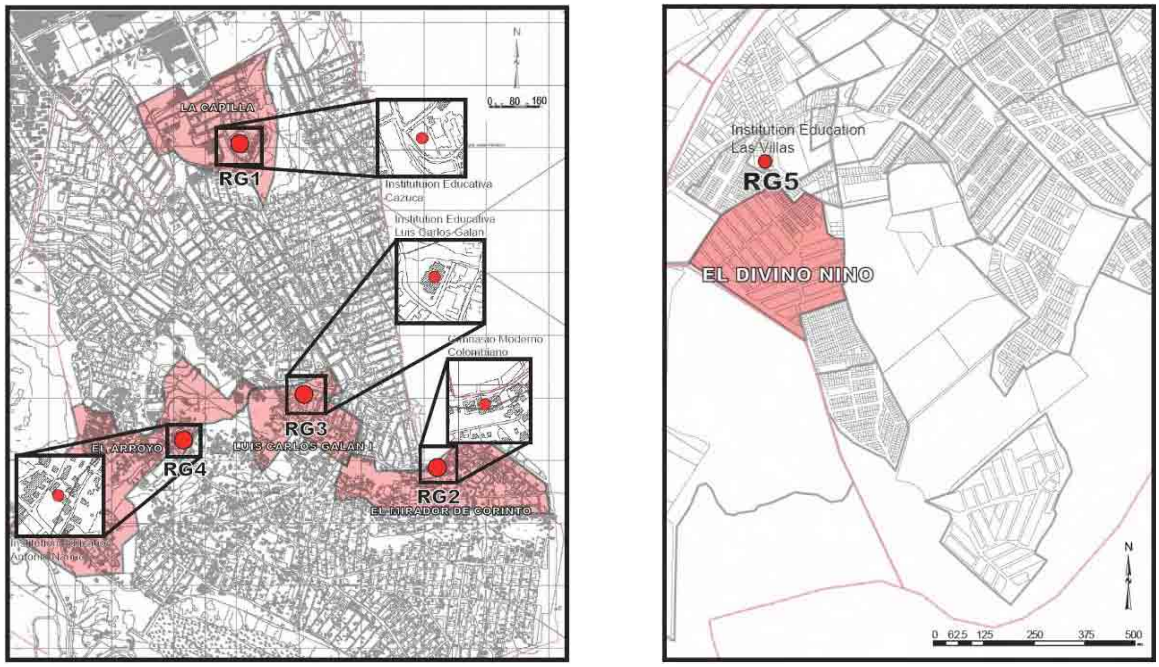


Figure S8-1-14 locations of Rain Gauges in Altos de Cazuca in Soacha Municipality (RG1 – RG4) and in El Divino Nino (RG5)

ii) Rain Gauge

The rain gauge consists of funnel and Cylinders as shown in Figure S8-1-15. Sub cylinder for reading minutely is attached. It is very simple rain gauge without any mechanical parts and electric power.

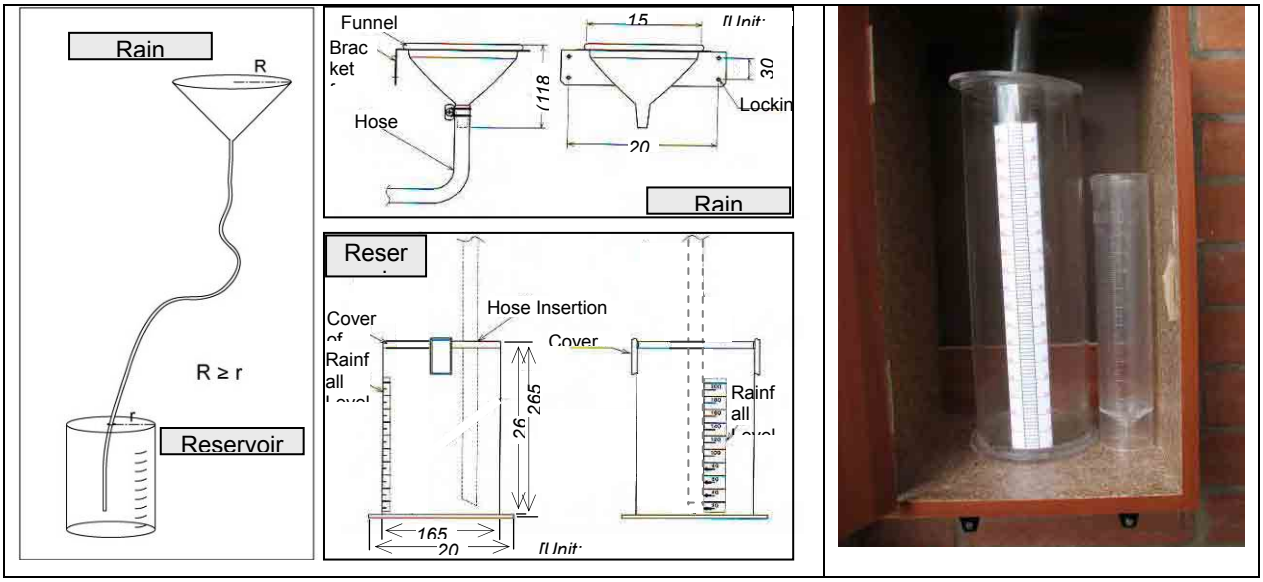


Figure S8-1-15 Configuration of Simple Rain Gauge

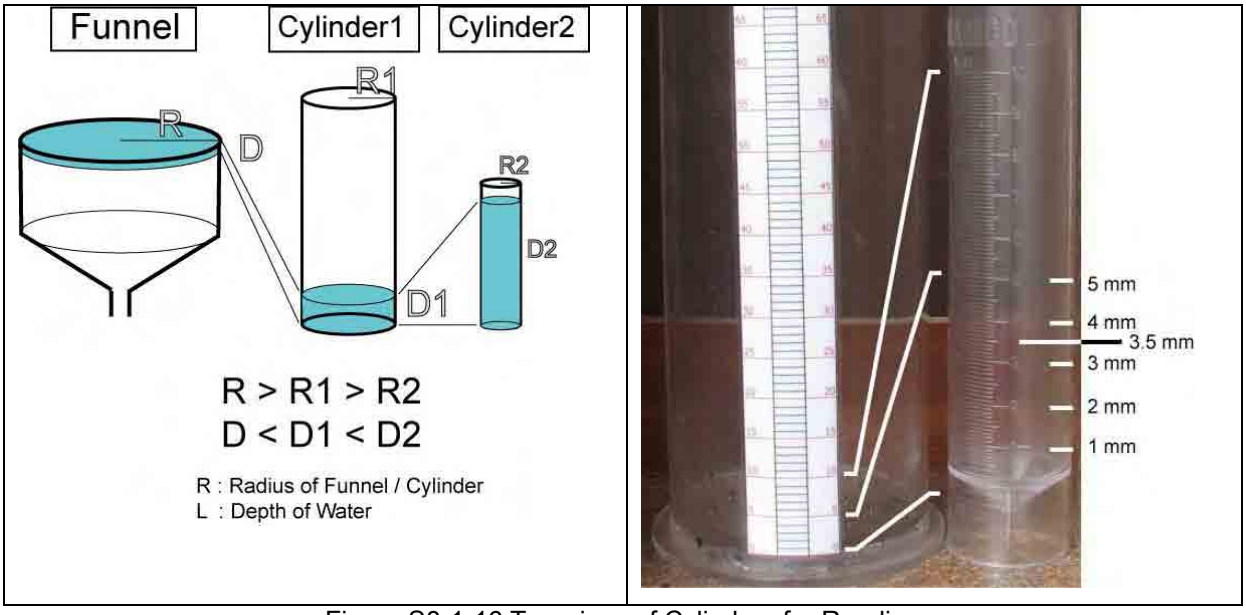


Figure S8-1-16 Two sizes of Cylinders for Reading

iii) Method of Monitoring

Person who monitor

Basically, monitoring works are carried out by the person in each school who is assigned by the principal of each school. During the school holiday, the person in charge in each school assigns and instructs a security person who stays in the school in holiday to monitor the rain gauge.

When

The rain gauges are read three times a day at 6:30, 14:00, and 18:00. The water in the rain gauge is emptied every time immediately after the rain gauge is read.

Record Format

The record format of rain gauge monitoring is shown on Figure S8-1-17.

MONITOREO DE PLUVIOMETRO

PLUVIOMETRO NO. _____ AÑO 2007

INSTITUTO _____ MES _____

DIA	HORA propuesto	HORA real	PRECIPITACION (mm)	PRECIPITACION DIARIA (mm)	DIA	HORA propuesto	HORA real	PRECIPITACION (mm)	PRECIPITACION DIARIA (mm)	DIA	HORA propuesto	HORA real	PRECIPITACION (mm)	PRECIPITACION DIARIA (mm)
1	6:30				11	6:30				21	6:30			
	14:00					14:00					14:00			
	18:00					18:00					18:00			
2	6:30				12	6:30				22	6:30			
	14:00					14:00					14:00			
	18:00					18:00					18:00			
3	6:30				13	6:30				23	6:30			
	14:00					14:00					14:00			
	18:00					18:00					18:00			
4	6:30				14	6:30				24	6:30			
	14:00					14:00					14:00			
	18:00					18:00					18:00			
5	6:30				15	6:30				25	6:30			
	14:00					14:00					14:00			
	18:00					18:00					18:00			
6	6:30				16	6:30				26	6:30			
	14:00					14:00					14:00			
	18:00					18:00					18:00			
7	6:30				17	6:30				27	6:30			
	14:00					14:00					14:00			
	18:00					18:00					18:00			
8	6:30				18	6:30				28	6:30			
	14:00					14:00					14:00			
	18:00					18:00					18:00			
9	6:30				19	6:30				29	6:30			
	14:00					14:00					14:00			
	18:00					18:00					18:00			
10	6:30				20	6:30				30	6:30			
	14:00					14:00					14:00			
	18:00					18:00					18:00			
										31	6:30			
											14:00			
											18:00			

In case total precipitation in 24 hours is beyond 20 mm, please inform the fire fighter station of it.
the fire fighter station : xxx-xxx-xxxx

Figure S8-1-17 Rain Gauge Monitoring Record Format

iv) Report

The record should be submitted once a week to Ing. Sandra Vásques of the Soacha Municipality. In the case the accumulate rainfall is more than 20 mm/24h, the person who read the rain gauge should call the firefighter station in Soacha Municipality with following steps.

Excess 20 mm in 24 hours * - Call to Firefighter Station
"Excess 20 mm in 24 hours"
"xx mm in 24 hours from xx:xx hour"

After 20 mm in 24 hours until the rain is over
- Call to Firefighter Station
"Accumulated precipitation is xx mm from xx:xx hour"
(20 mm in 24 hours : normally accumulation of three readings)

1.2.3 Landslide Record

i) Objective Area

All of landslides in Soacha Municipality should be recorded immediately after occurrence of the landslide. Especially, the pilot project areas, Altos de Cazuca and El Divino Nino, are put emphasis on.

ii) Landslides Recorded

Only the landslides which caused damages to persons, houses, facilities and others are recorded.

iii) Record Format

The format is shown in Figure S8-1-18. Figure S8-1-19 shows the type of landslides which is to be filled in the format.

iv) Persons

The format are filled by the engineer immediately after he visited the landslide site, and the following two persons are responsible for the record and the custody.

Dr. Iván Demóstenes Calderón*$^{-1}$: manager of the landslide record
Ing. Sandra Vásquez*$^{-2}$: civil engineer in charge of landslide record

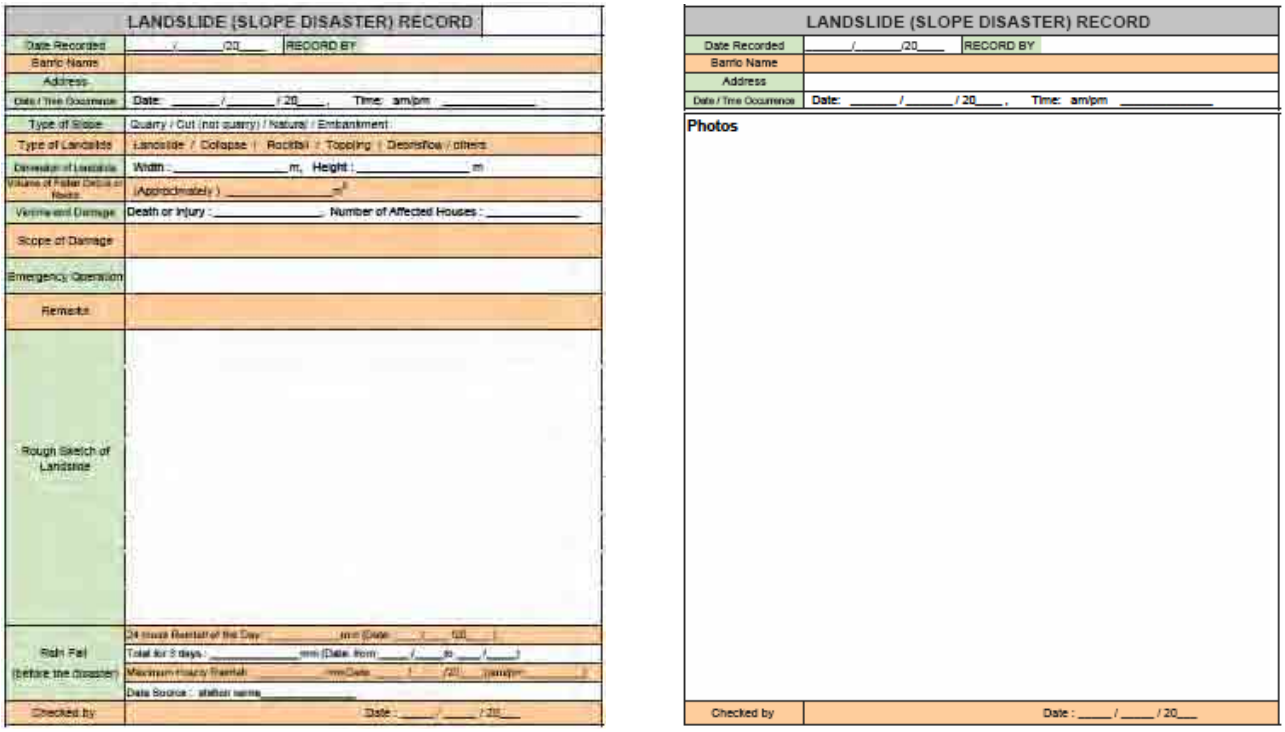
(*$^{-1}$ Technical Director, Justice Support Direction, CLOPAD's Coordinator)
(*$^{-2}$ University Professional, Planning Secretariat, CLOPAD)

v) Report

The report of monitoring contains an analysis of the relation between the rain fall and the landslide disasters.

vi) Filing

Record format which has been recorded should be filed in Ing. Sandra Vásquez's office.



LANDSLIDE (SLOPE DISASTER) RECORD

Date Recorded	/_____/20____ RECORD BY
Barrio Name	
Address	
Date / Time Occurrence	Date: _____/_____/ 20____ , Time: am/pm _____
Type of Slope	Quarry / Cut (not quarry) / Natural / Embankment
Type of Landslide	Landslide / Collapse / Rockfall / Toppling / Desnsflow / others
Dimension of Landslide	Width : _____ m, Height : _____ m
Volume of Fallen Debris or Rocks	(Approximately) _____ m^3
Victims and Damage	Death or Injury : _____ Number of Affected Houses : _____
Scope of Damage	
Emergency Operation	
Remarks	
Rough Sketch of Landslide	
Rain Fall (before the Disaster)	24 Hours Rainfall of the Day _____mm (Date: ____/____/20____)
	Total for 3 days : _____mm (Date: from ____/____ to ____/____)
	Maximum Hourly Rainfall _____mm(Date: ____/____/20____ am/pm)
	Data Source : station name_____
Checked by	Date : ____/____/ 20___

LANDSLIDE (SLOPE DISASTER) RECORD

Date Recorded	/_____/20____ RECORD BY
Barrio Name	
Address	
Date / Time Occurrence	Date: _____/_____/ 20____ , Time: am/pm _____

Photos

Checked by	Date : ____/____/ 20___

Figure S8-1-18 Landslide Record Format, page 1 (left) and page 2 (right)

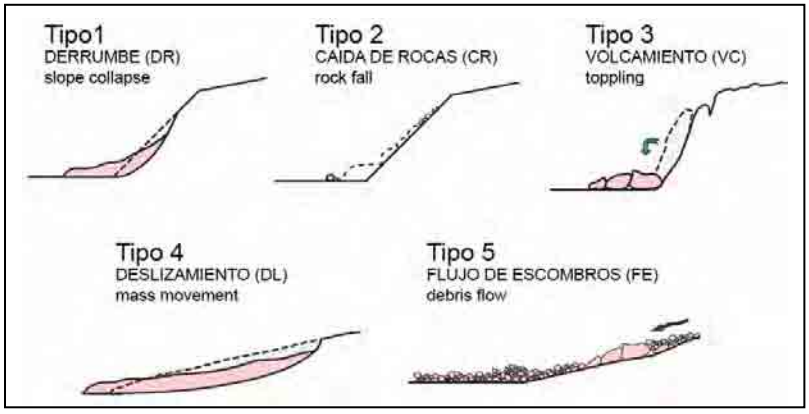


Figure S8-1-19 Type of Landslides (Tipo=Type)

1.2.4 Results

Excursion of Precipitation Monitoring

Reading of rain gauge has been done by school teachers and security guards. In the first stage of the monitoring, some mistake like the unit wrong can be seen in record sheets. Reliable monitoring can be done after workshop which held after one month monitoring.

Figure S8-1-20 Work Shop on Precipitation Monitoring (September 24, 2007)

Results of Precipitation Monitoring

Precipitation monitoring has been carried out for five months, still the precipitation data need to be accumulated for more periods to tell something about rainfall. At the moment, the following things were found in the monitoring.

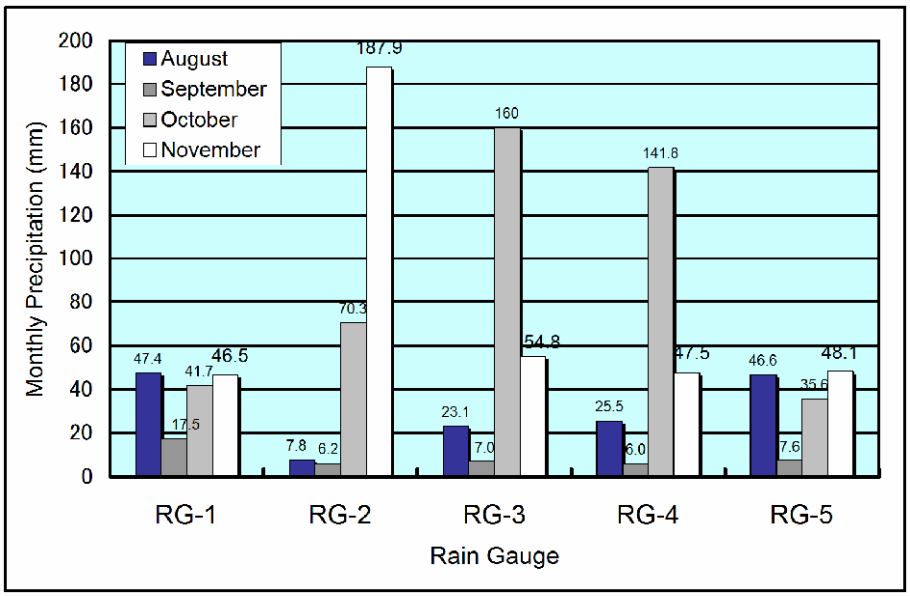


Figure S8-1-21 Monthly Precipitation in September and October

b) Monthly precipitation in August is more than in September. It shows different trends from average normal year as shown in Figure S8-1-22.

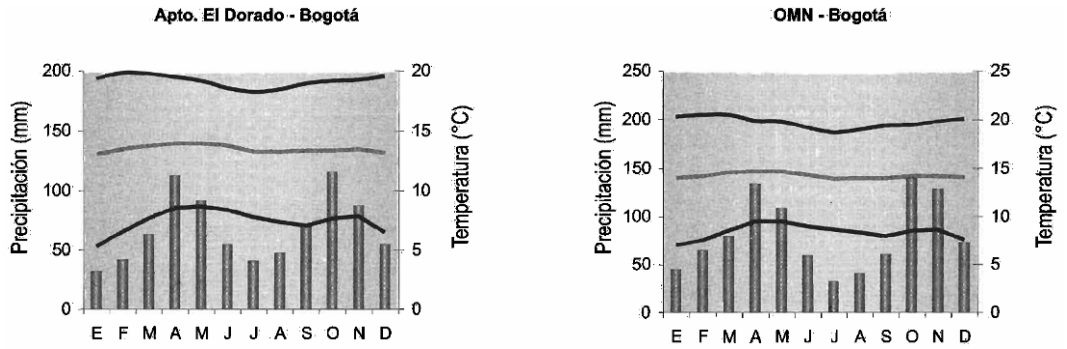


Figure S8-1-22 Average Monthly Precipitation at Stations in Bogota (IDEAM)

c) Monthly precipitation is different in each point in August, and is not different in each point in September.

d) Maximum monthly precipitation was observed with RG-4 by 141.8 mm in October.

e) Maximum daily precipitation was observed with RG-4 by 58.2 mm on 13th October.

f) The lower the altitude is, the more it tends to rain both especially in August.

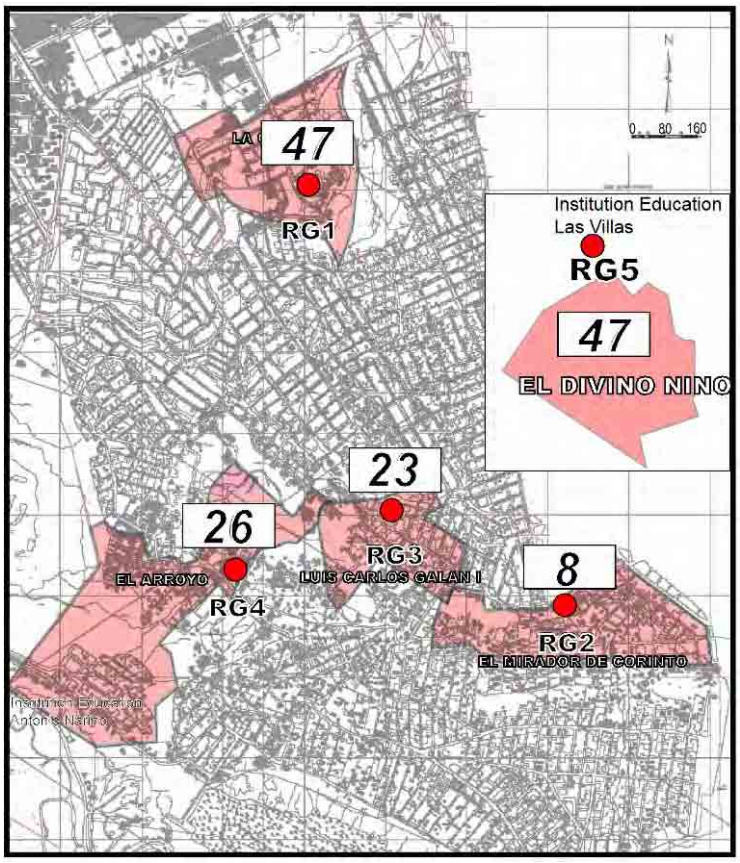


Figure S8-1-23 Monthly Precipitation of September at Each Monitoring Points

Relation between Precipitation and Landslide Disasters

Three landslide disasters occurred in the period from 13th October to 15th October in Los Robbles, Terranova and El Capilla in Altos de Cazuca. Rain continued intermittently from 6th October to 14th October in Altos de Cazuca. Nearest rain gauge points to Los Robbles is RG-4, to Terranova is RG-3 and to La Capilla is RG-1. According to Figure S8-1-24, excess 20 mm of accumulate precipitation may be appropriate for Alert Level 1 and excess 50 mm of accumulate precipitation may be appropriate for Alert Level 2.

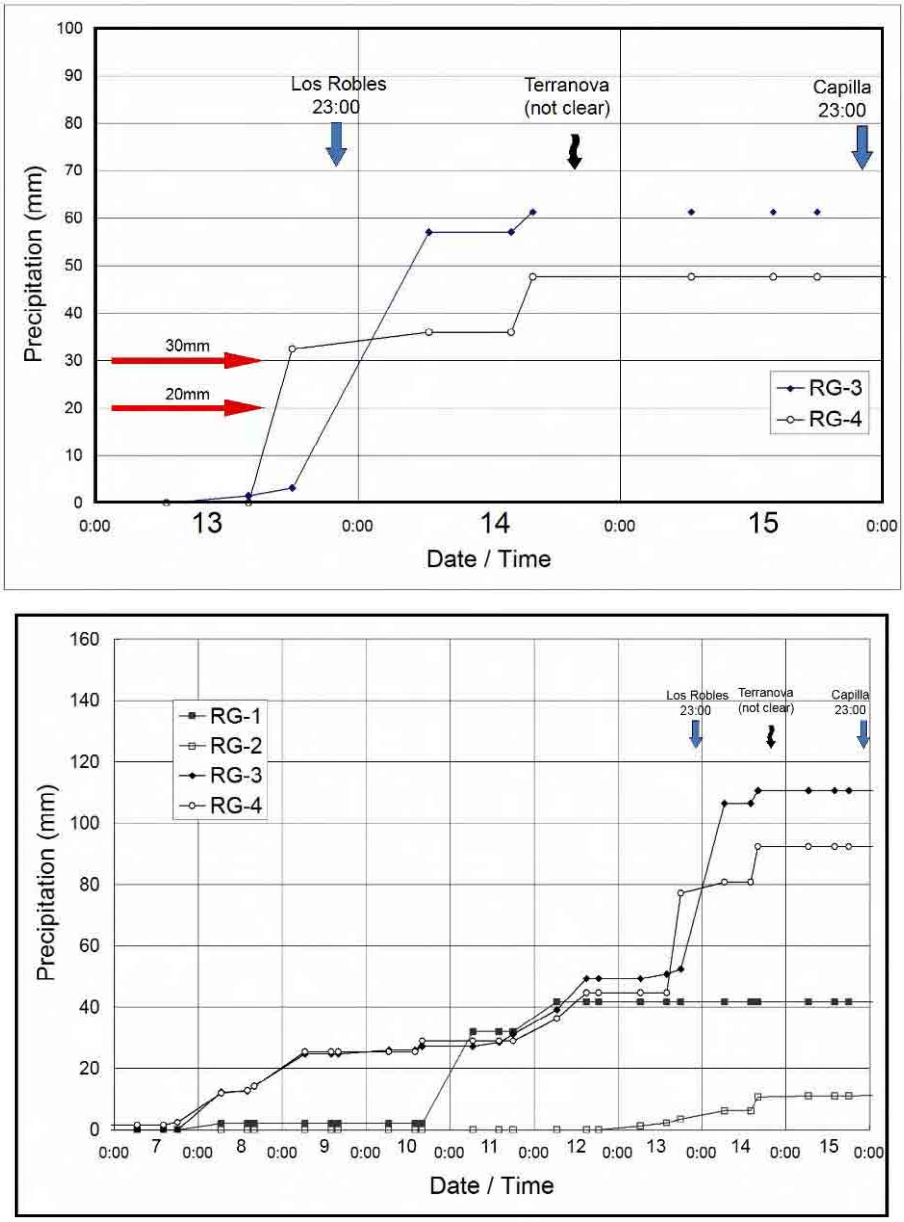
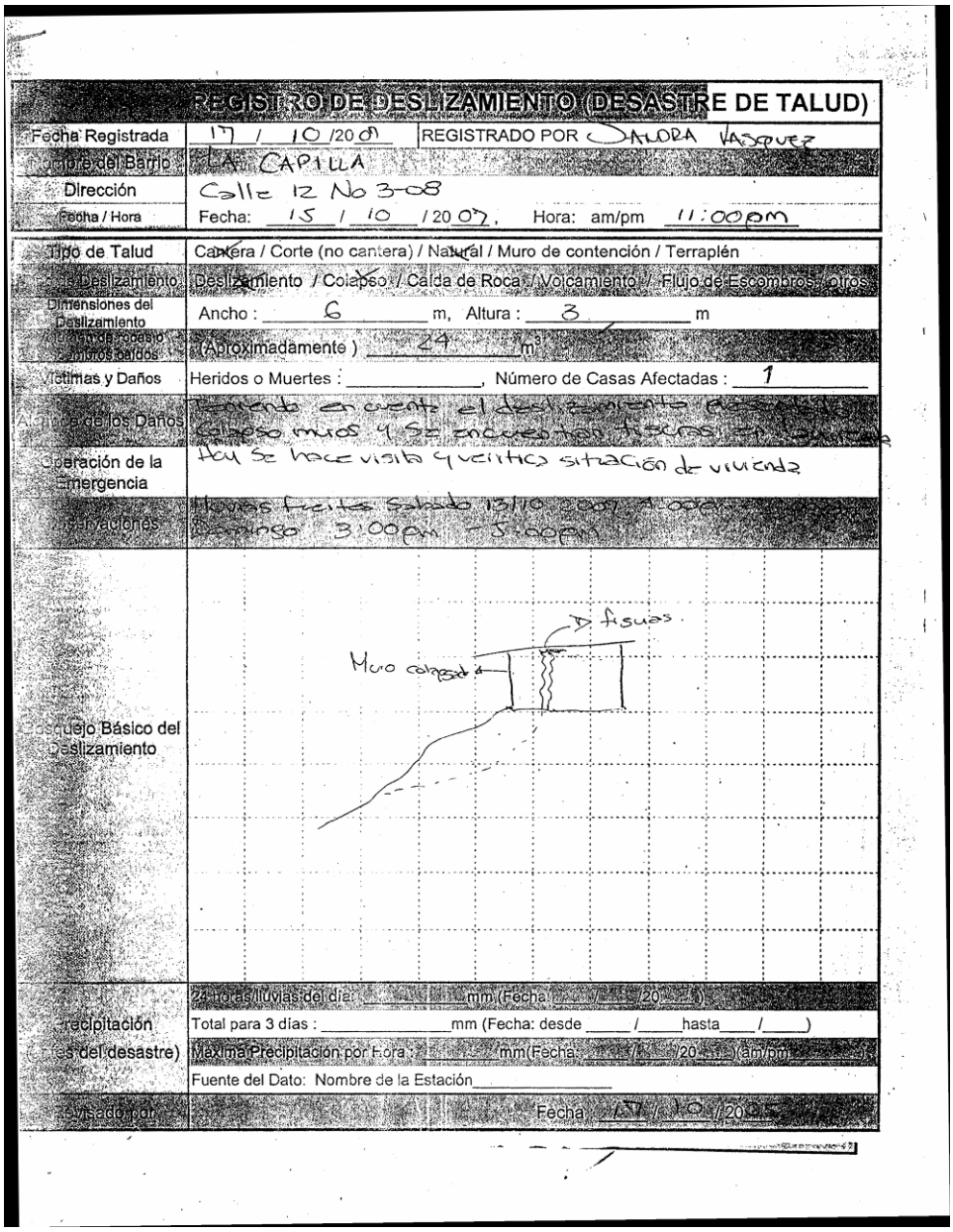


Figure S8-1-24 Precipitation before Landside Disasters in October 2007



REGISTRO DE DESLIZAMIENTO (DESASTRE DE TALUD)

Fecha Registrada	17 / 10 /2007 REGISTRADO POR SANDRA VASQUEZ
Nombre del Barrio	LA CAPILLA
Dirección	Calle 12 No 3-08
Fecha / Hora	Fecha: 15 / 10 / 2007, Hora: am/pm 11:00pm
Tipo de Talud	Cantera / Corte (no cantera) / Natural / Muro de contención / Terraplén
Tipo de Deslizamiento	Deslizamiento / Colapso / Caida de Roca / Volcamiento / Flujo de Escombros / otros
Dimensiones del Deslizamiento	Ancho : 6 m, Altura : 3 m
Volumen de Rocas y/o otros Saldos	(Aproximadamente) 24 m³
Victimas y Daños	Heridos o Muertes : _____, Número de Casas Afectadas : 1
Descripción de los Daños	Reporta en cuanto el deslizamiento Colapso muro y se encuentran fisuras en la vivienda
Operación de la Emergencia	Hoy se hace visita y verifica situación de vivienda
Observaciones	Lluvias fuertes Sabado 13/10 2007 4:00pm Domingo 3:00pm - 5:00pm
Esquejo Básico del Deslizamiento	
Precipitación (días del desastre)	24 horas lluvias del día: _____mm (Fecha: ____/____/20____) Total para 3 días : _____mm (Fecha: desde ____/____hasta____/____) Maxima Precipitación por Hora : _____mm (Fecha: ____/____/20____) (am/pm) Fuente del Dato: Nombre de la Estación_____
Revisado por	Fecha: 17 / 10 /2007

Figure S8-1-25 Landslide Record

CHAPTER 2 FLOOD

2.1 Selection of Equipment Type

2.1.1 Waterlevel Sensor

Self-recording type waterlevel sensors are floating type, pressure probe type and non-contact stage type. In the pilot project area (Chiguaza creek and Soacha river), considering the waterlevel variation, channel size and silting problem, the non-contact stage measurement sensor should be selected.

The advantages of non-contact stage measurement sensor are

- Easy installation to bridge, cantilever
- Cumbersome due to silting, plant growing, garbage can be eliminated.
- Sensor is exposed to public, so it is easy to recognize the change of the sensor such as stolen, damage.

Photo S8-2-2 Non-contact stage measurement sensor
(left: EAAB La Isla Station, Bogota River, right: DPAE San Benito Station, Tunjuelo River)

In general, the types of non-contact stage measurement sensor are ultrasonic type and radar type in the world market. The following table compares the main features of those sensors.

Table S8-2-1 Comparison of non-contact stage measurement sensor

Type of Sensor	Features on Measurement	Measurement range	Resolution	Price
Ultrasonic Stage Sensor	a non-contact sensor that measures the distance to a surface through air.	0.3m-15m	1.3 mm	Aquasonic 7000 (range 0.6-16 feet) US$935
Radar Stage Sensor	a non-contact sensor that sends radar waves (microwaves) perpendicular to the water surface. An intelligent signal processor calculates the exact distance between the sensor and the surface of the water.	1.5m-30m	1.0 mm	Aquadar 7100 US$4,395

http://www.rickly.com/sm/StageSensors.htm

In DPAE, there are four (4) existing waterlevel stations (self-recording) along the Tunjuelo river. All of them are using ultrasonic type sensor.

Station Name	Year/month installed	Sensor type
San Benito	2003 Dec.	ultrasonic type sensor SR50
Independencia	2003 March	ultrasonic type sensor SR50
Kennedy	2003 March	ultrasonic type sensor SR50
Gravilleras	2007 September	ultrasonic type sensor MPLU10

2.1.2 Rainfall Gauge

In the Study, two (2) types of rainfall gauge were considered. One is simple rainfall gauge which does not have time recording function, another is automatic recording rainfall gauge which can record the rainfall amount during certain period connecting to data logger.

Regarding the automatic recording type, at present, the sensor of tipping-bucket type is the most popular in worldwide. Since in Bogota there are a lot of installation cases of the tipping bucket type, so the Study Team selected this type.

Regarding the data logger, the Study Team's policy is the short duration rainfall measurement by people, so that the digital data logger was selected in order that people should monitor the short duration rainfall data.

2.1.3 Staff Gauge

The type of staff gauge which was installed in the Study is IDEAM standard type as shown in Figura S8-2-1. DPAE and EAAB have been installing basically similar one to the IDEAM standard. In the Study there are two (2) type of staff gauge installed. The type 1 was used in the case that the installation on wall, in which strong flow hit is not so expected. The type 2 was applied in the case that the installed staff gauge is exposed to flow or steep slope creek such as the Chiguaza upstream.

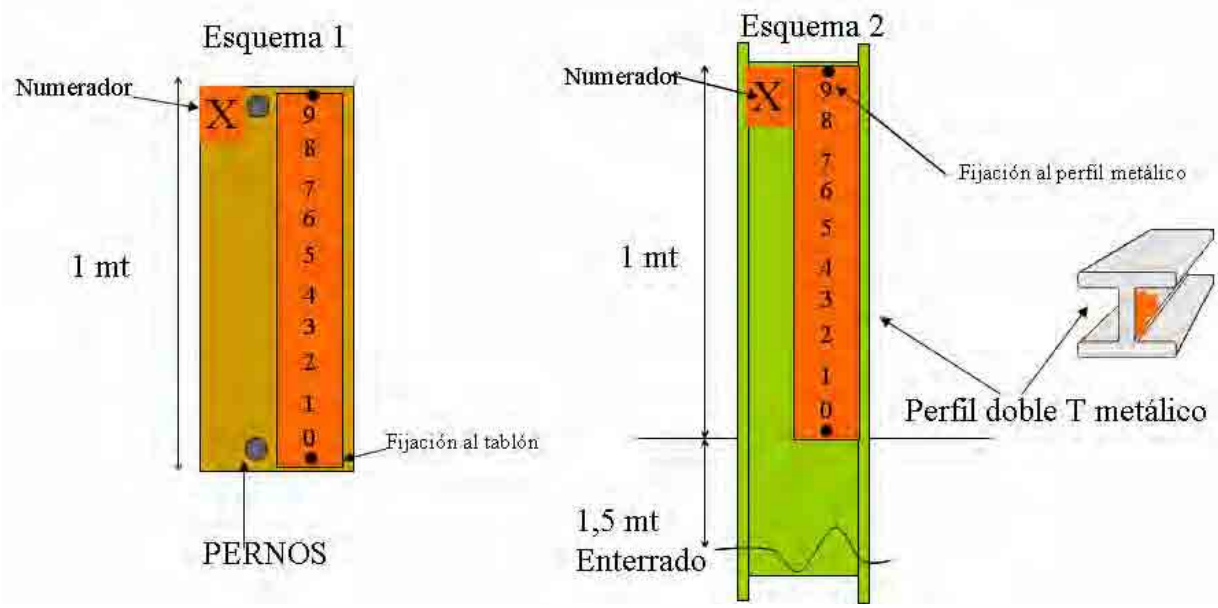


Figure S8-2-1 Standard Staff Gauge in Colombia

2.2 Outline of Pilot Project

The study team installed the meteorological-hydrological measuring equipments in the study areas as a pilot project. The outline of the pilot project is follows.

Table S8-2-2 Pilot project in BOGOTA

Station	Element of Observation	Outline of installation
Moralba	Rain fall	Self-recording type tip-bucket rain gauge Install in the Moralba school
La Gloria	Water Level	Non-recording type staff water level gauge Install in the river and on the river wall
	Water Level	Simplified alarm type water level gauge Install next to the staff type water level gauge on the river wall
Molinos	Water Level	Non-recording type staff water level gauge Install in the river and on the river wall
	Water Level	Recording type ultra sonic water level gauge Install behind (backside of) the footbridge

Table S8-2-3 Pilot project in SOACHA

Station	Type of Observation	Outline of installation
Fire Station	PC system	Desk top PC for data process and Internet connection with router and UPS Lap top PC for data download on site They are installed in the Soacha fire station
	Rainfall	Self-recording type tip-bucket rain gauge Install in the Soacha fire station
San Jorge (ICA gate)	Rainfall	Self-recording type tip-bucket rain gauge Install in the security guard office at the gate
Fusunga	Water Level	Non-recording type staff water level gauge Install in the river
Prison of Soacha	Water Level	Non-recording type staff water level gauge Install by the entrance bridge
	Water Level	Simplified alarm type water level gauge Install next to the staff type water level gauge by the bridge
	Rainfall	Simplified alarm type rain fall gauge Install in the prison office
Ladrillera Santa Fe	Water Level	Non-recording type staff water level gauge Install by the entrance bridge of the brick factory
	Water Level	Recording type ultra sonic water level gauge Install by the entrance bridge of the brick factory with a pillar
Llamo Grande	Water Level	Non-recording type staff water level gauge Install on the wall by the bridge

2.3 Pilot Project in BOGOTA

(1) Target points

As a pilot project the study team chose the three points to install measuring equipments in order to monitor meteorological and hydrological condition in BOGOTA. The bases of selection are follows.

- It is useful to monitor the natural condition for disaster prevention
- By monitoring the natural condition, it is possible to issue some warning notice timely or previously to the local residents
- There is no existing monitoring station for the same element (Avoiding overlap)
- There is appropriate place to install measuring equipments
- It is safe enough against stealing and breaking
- JICA study team can get some volunteer cooperators in the local residents

(2) Installation of hydro-meteorological monitoring equipment

1) Objectives

There are two (2) main objectives for the installation in the Chiguaza creek basin. One is the

enhancement of hydrological data collection to improve our knowledge of flood and provide better warning capabilities, in particular, making use of modern detection instruments. The other is to let people know the importance, limitation and uncertainty of hydrological observation, involving them in the observation activities using the modern equipment and manual equipment.

Regarding the selection of installation location, the view point that the affected areas by the May 1994 should be monitored is significant.

2) Candidate Locations

There are three (3) candidate areas, namely the area around Molinos, the area around the Chiguaza creek and the area around Quindio as shown in Figure S8-2-2.

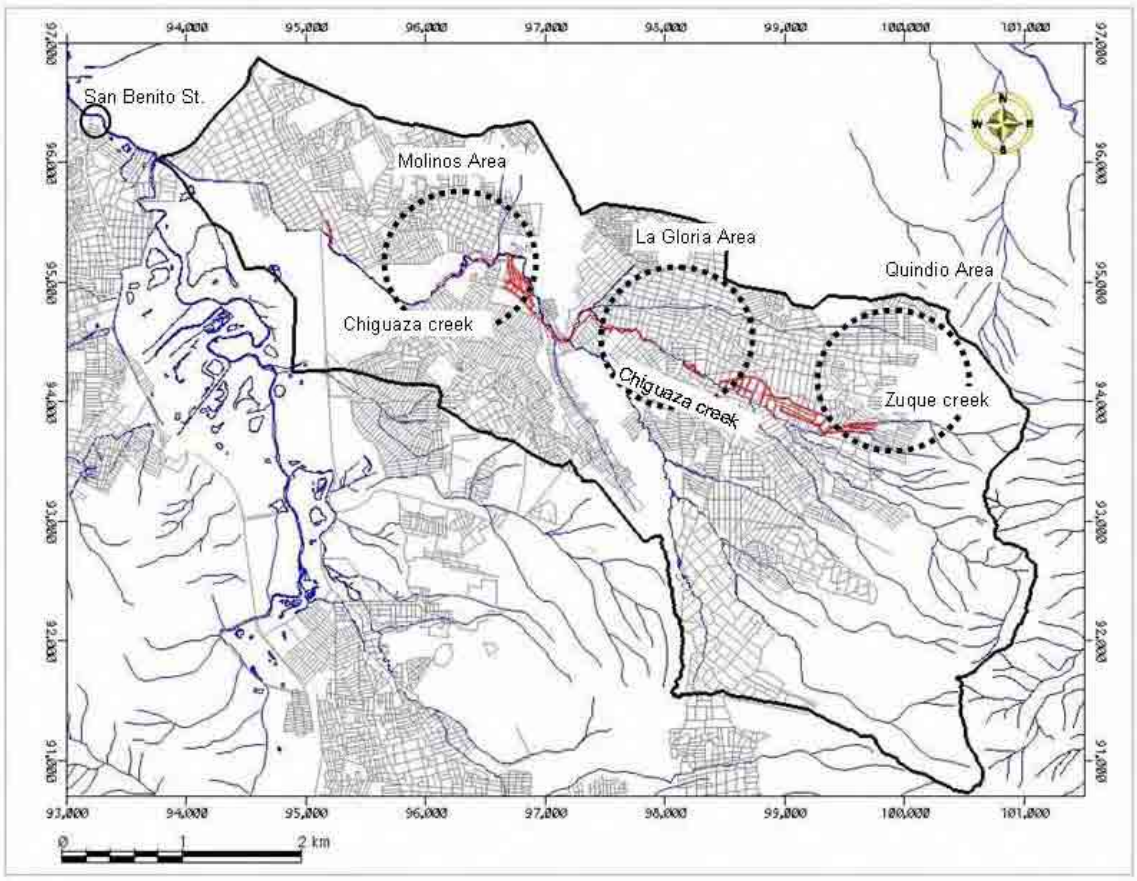


Figure S8-2-2 Location of Candidate Areas

In Molinos, the Study Team selected three (3) locations for the waterlevel station as shown in Figure S8-2-3.

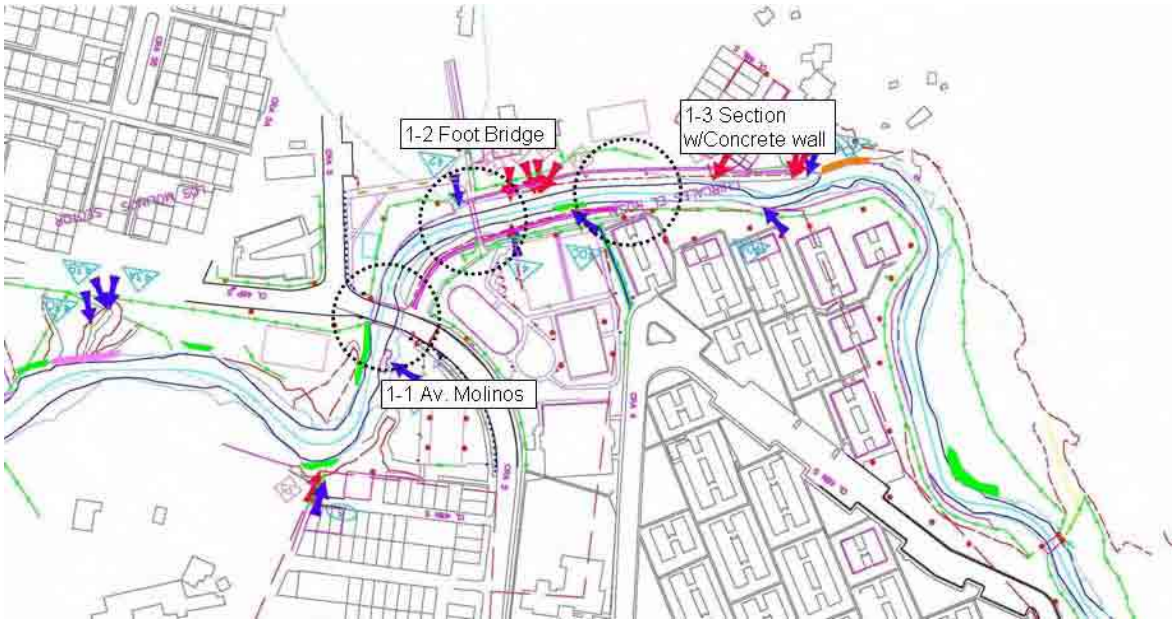


Figure S8-2-3 Candidate Locations for Waterlevel gauge in Molinos Area

The detailed comparison is shown the table below.

Table S8-2-4 Candidate Locations for Waterlevel Gauge Station around Molinos

No.	Name of Candidate Location	Address (Description on the location)	Advantage	Disadvantage
1-1	Ave. Molinos Bridge	The bridge of Ave. Molinos over Chiguaza creek	Since there is 3 barrel box culvert with concrete slab under the bridge, the cross section is comparatively stable. Staff gauge can be installed on the sidewall of the box culvert.	Due to heavy traffic on the bridge, vibration can be anticipated frequently. Since the bridge is located in the bending reach, the flow is always leaned to the right bank. Since there is 3 barrel box culvert the waterlevel of one barrel is not representative, otherwise 3 sensors are necessary.
1-2	Footbridge	Upstream of the Ave. Molinos bridge	It is located in the straight reach. Colombia Viva (school) which is on the right bank could be used to store the logger and power supply.	Staff gauge installation is comparatively difficult because the both side banks of the section are earth slope. (Staff gauge can be installed on the concrete wall)
1-3	Section with Concrete wall	Section next to a house whose address is “CL 48 M SUR KR 3 D”	It is located in the straight reach. Staff gauge can be installed on the sidewall of the section.	There is stepped drop in the reach, so that the waterlevel profile will be disturbed. Since there is no bridge here, the sensor should be supported by cantilever. Hence the sensor will be exposed to the public eye.

The following candidate locations were investigated among the affected areas by May 1994 flood. Figure S8-2-4 to Figure S8-2-7 are showing the candidate locations.

Figure S8-2-4 Candidate Locations for Staff gauge near Chiguaza creek (1)

Figure S8-2-5 Candidate Locations for Staff gauge near Chiguaza creek (2)

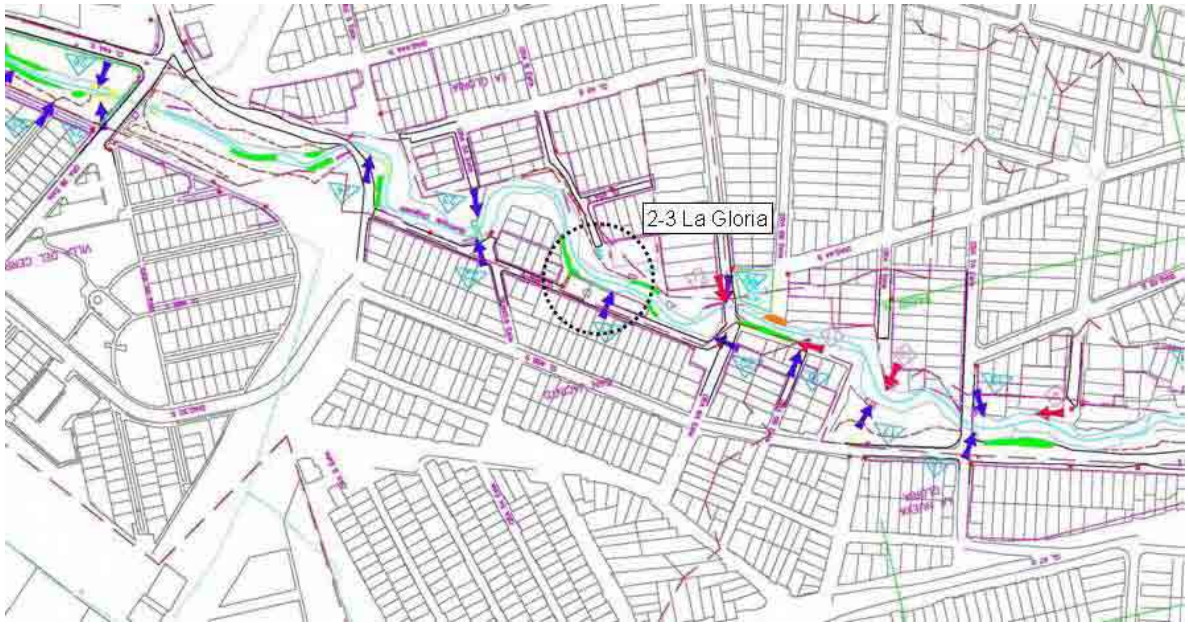


Figure S8-2-6 Candidate Locations for Staff gauge near Chiguaza creek (3)

Figure S8-2-7 Candidate Locations for Staff gauge near Chiguaza creek (4)

Table S8-2-5 Candidate Locations for Waterlevel Staff Gauge along Chiguaza creek

No.	Name of Candidate Location	Address (Description on the location)	Advantage	Disadvantage
2-1	Los Puentes	The bridge between TV 1 BIS CL 47 SUR and TV 1 BIS CL 43B SUR (Barrio Peninsula)	Staff gauge can be installed on the sidewall of the section.	It is located on too lower reach of the Chiguaza.
2-2	La Nueva Gloria	The bridge on "CRA 3B Este"	None	The creek is deep and the small box culvert is under the bridge. It is not appropriate for the installation of staff gauge.
2-3	La Gloria	The concrete wall near basketball court " Calle 46 A BIS 6-25E" (Barrio Jacinto)	A resident living in the address has clear memory on May 1994 flood, who can point out the flood mark on the wall of her house. It is appropriate to ask the people read the staff gauge.	none
2-4	Altamira	The bridge on "TV 11B 46-98S"	Staff gauge can be installed on the sidewall of the section.	The affected area is only located 100 m downstream from the bridge. People living near the bridge were not damaged on May 1994.

Near Quindio, the Study Team selected three (3) locations for the rainfall station as shown in Figure S8-2-8.

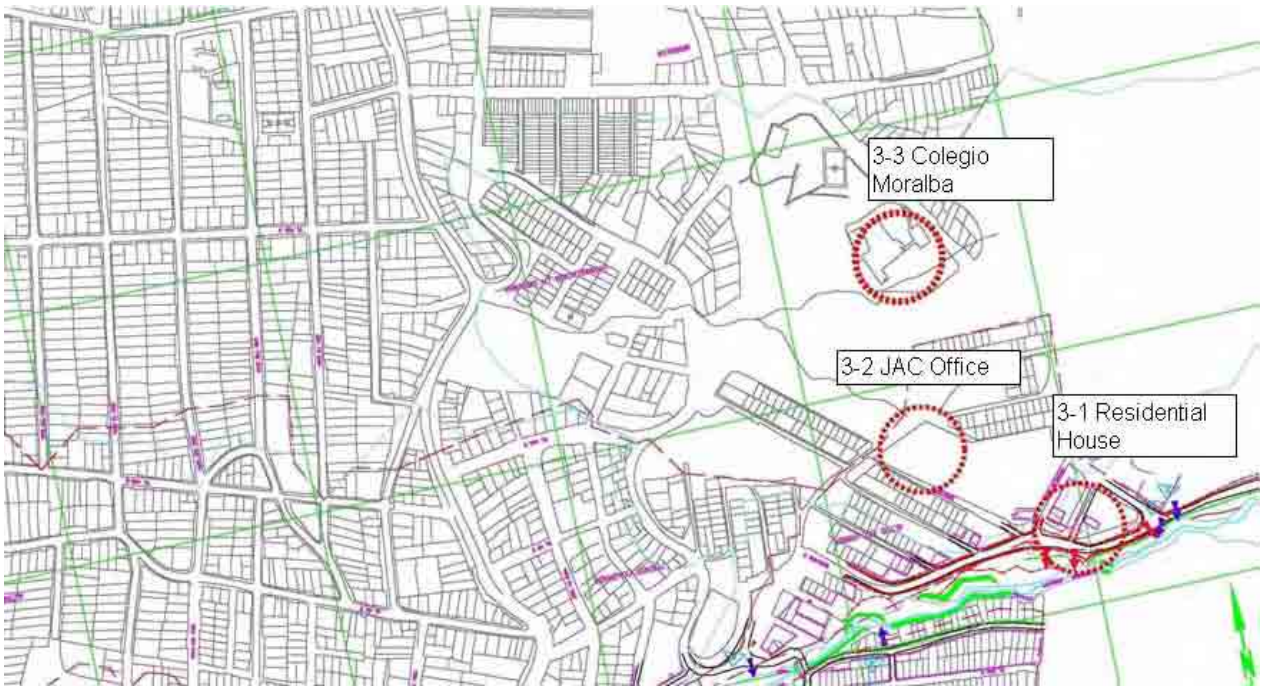


Figure S8-2-8 Candidate Locations for Rainfall gauge near Quindio

The detailed comparison is shown the table below.

Table S8-2-6 Candidate Locations for Rainfall Gauge near “Quindio”

No.	Name of Candidate Location	Address (Description on the location)	Advantage	Disadvantage
3-1	Residential House	TV 17 A-S 47-44 “Altos del Virrey”	The owner of the house has clear memory on May 1994 debris flow along the Zuque creek. It is expected that the owner has understanding for cooperation on rainfall observation.	It is a residential house.
3-2	JAC Office	Diagonal 46 Sur 17 E 00	High security can be expected.	Most of the time nobody stays in the JAC office, so in emergency an observer has to open the office for entering.
3-3	Colegio Moralba S.O.	TV 16 43 Sur	High security can be expected because the school entrance is 24 hours protection. The premise of the school is inundation-prone area due to the runoff from the slope. The installed rainfall station would be good educational material for the student. The principal Mr. Jorge Pinilla is favorable for the installation in the premise.	If an observer is hired out side of the school, he or she has to enter the school each time.

(2) Installation equipments

In Bogota area, JICA study team installed meteorological hydrological measuring equipments in order to monitor meteorological and hydrological condition. The specification of equipments is follows.

Table S8-2-7 Specification of equipments in BOGOTA

Station	Element of Observation	Type	Specification
Moralba	Rain fall	Tip-bucket	Rain gauge : Texas Electronics TR-525 Rainfall Sensor Resolution : 0.1 mm Metric Accuracy : 1.0% up to 50 mm/hour Collector diameter : 245 mm Logger : MOTOROLA MOSCAD-L Remote Terminal Unit Solar panel : SUNTECH STP080S-12/Bb Battery : VISION 6FM55 DC12V 55Ah Regulator : Sun Saver 10
La Gloria	Water Level	Staff gauge	Water level gauge : APCYTEL staff gauge Resolution : 1 cm Metric Gauge rod : steel Self standing and stuck on the river wall
	Water Level	Electrode	Water level gauge : APCYTEL simplified water level gauge Resolution : 20 cm Metric 15 sensors Alarm : Preset the level optionally Gauge device : PVC tubes and telephone cable Stuck on the river wall
Los Molinos	Water Level	Staff gauge	Water level gauge : APCYTEL staff gauge Resolution : 1 cm Metric Gauge rod : steel Self standing and stuck on the river wall
	Water Level	Ultra sonic	Water level gauge : Sonder Ultrasonic Level Meter Measuring range : 0.5m – 12m Resolution : 0.35% of measured range Beam angle : 8deg. at -3dB Logger : MOTOROLA MOSCAD-L Remote Terminal Unit Solar panel : SUNTECH STP080S-12/Bb Battery : VISION 6FM55 DC12V 55Ah Regulator : Sun Saver 10

(3) Installation appearance

1) Moralba

In Moralba, a rain fall gauge was installed. The installation place is the Moralba school. The rain fall gauge is installed on the school house, the data logger and the power supply units are installed in the security guard station of the school.

Photo S8-2-2 Rainfall gauge and Solar Panel in Moralba

Photo S8-2-3 Data logger and Power supply in Moralba

2) La Gloria

In La Gloria, a staff type water level gauge was installed. The installation place is the mid stream of Chiguaza-river. The staff type water level gauge is installed in the river and on the river wall. Regarding an electrode type simplified water level gauge, it is needed to lay on an electric cable among electric/ telephone poles, it will be installed beside the staff type gauge in wait for the permission to use electric poles.

Photo S8-2-4 Water level gauge at La Gloria

3) Los Molinos

In Los Molinos, a staff type water level gauge was installed. The installation place is the down stream of Chiguaza-river. The staff type water level gauge is installed in the river and on the river wall. Regarding an ultrasonic type water level gauge, the sensor unit will be installed under the foot bridge, the data logger and power supply unit will be installed in the school house.

Photo S8-2-5 Staff Gauge (Left) and School's security guard house for Data Logger

Photo S8-2-6 Footbridge for Ultrasonic Sensor installation

(4) Cooperation from local residents

1) Moralba

In Moralba, a rain fall gauge was installed on October 2nd. At first, JICA study team met the principal of the school, asked his cooperation and got a permission to install a rain fall gauge on the school house, and a data logger in the security guard station. On the same day, JICA study team asked the security guards to get their cooperation to check the rain fall data and inform the observing data to DPAE, and explained the way how to check the rain fall data.

2) La Gloria

In La Gloria, a staff type water level gauge was installed while ago and the observation by the local residents was already started. When JICA study team visited La Gloria with DPAE officials, the cooperators showed us the recording forms and passed them to the DPAE official. They started observation three times a day and recorded in the designated form. The cooperators invited us into their house, and consented willingly to install an alarm unit of the simplified water level gauge in their house. And they promised us their continued cooperation.

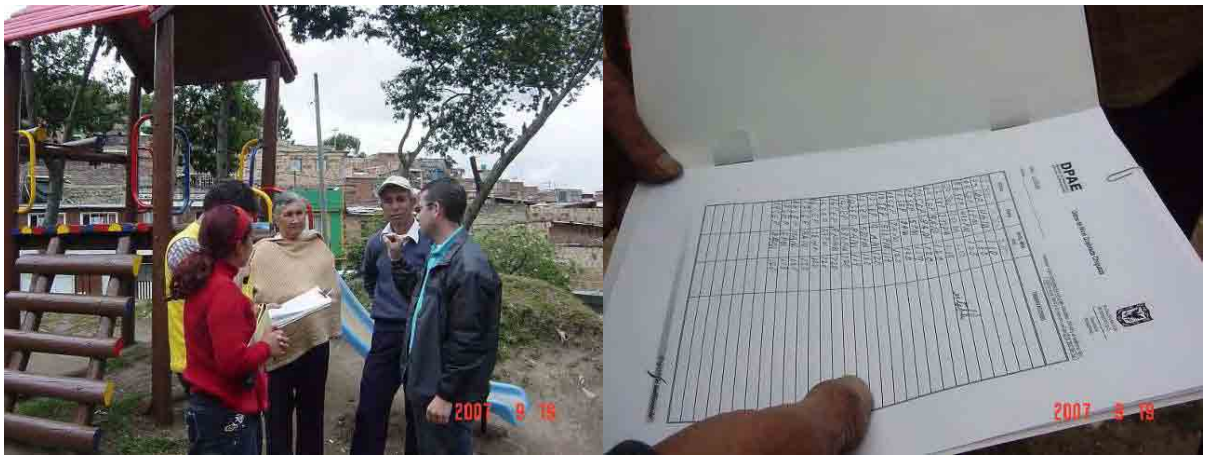


Photo S8-2-7 Community's observer and Recording form by DPAE

Photo S8-2-8 House for Simple Alarm Device

3) Los Molinos

In La Gloria, a staff type water level gauge was installed while ago and the observation by the local residents was already started. When JICA study team visited Los Molinos with DPAE personnel, the cooperators showed us the recording forms and passed them to the DPAE personnel. They started observation three times a day and recorded in the designated form.

At the Los Molinos-school, JICA study team met the principal of the school, asked his cooperation and got a permission to install a data logger unit of an ultrasonic type water level gauge in the school house. The principal consented to our offer willingly.

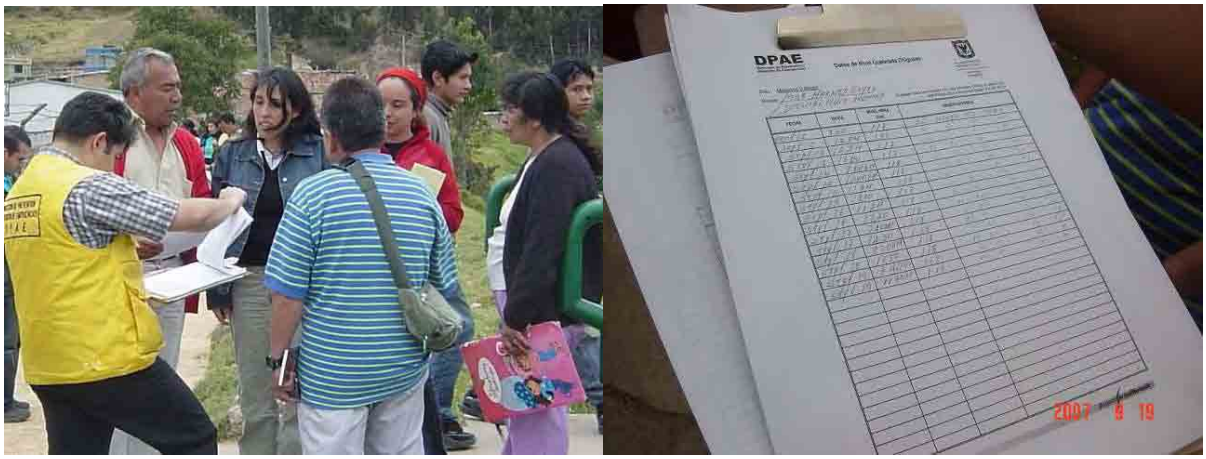


Photo S8-2-9 Community's Observer and Recording form by DPAE

Photo S8-2-10 School for Data Logger Installation

2.4 Pilot Project in SOACHA

(1) Target points

As a pilot project JICA study team chose the three points to install measuring equipments in order to monitor meteorological and hydrological condition. The bases of selection are follows.

- By monitoring the natural condition, it is possible to issue some warning notice timely or in advance to the residential sections
- There is no existing monitoring station for the same element (Avoiding overlap)
- There is appropriate place to install measuring equipments
- It is safe enough against stealing and breaking
- JICA study team can get some volunteer cooperators in the local residents

At the result of the site survey along the Soacha river and consideration with the counter part, the five points were selected. As the data gathering station, the Soacha Firefighter station was selected. Figure S8-2-9 shows the allocation of monitoring stations in Soacha

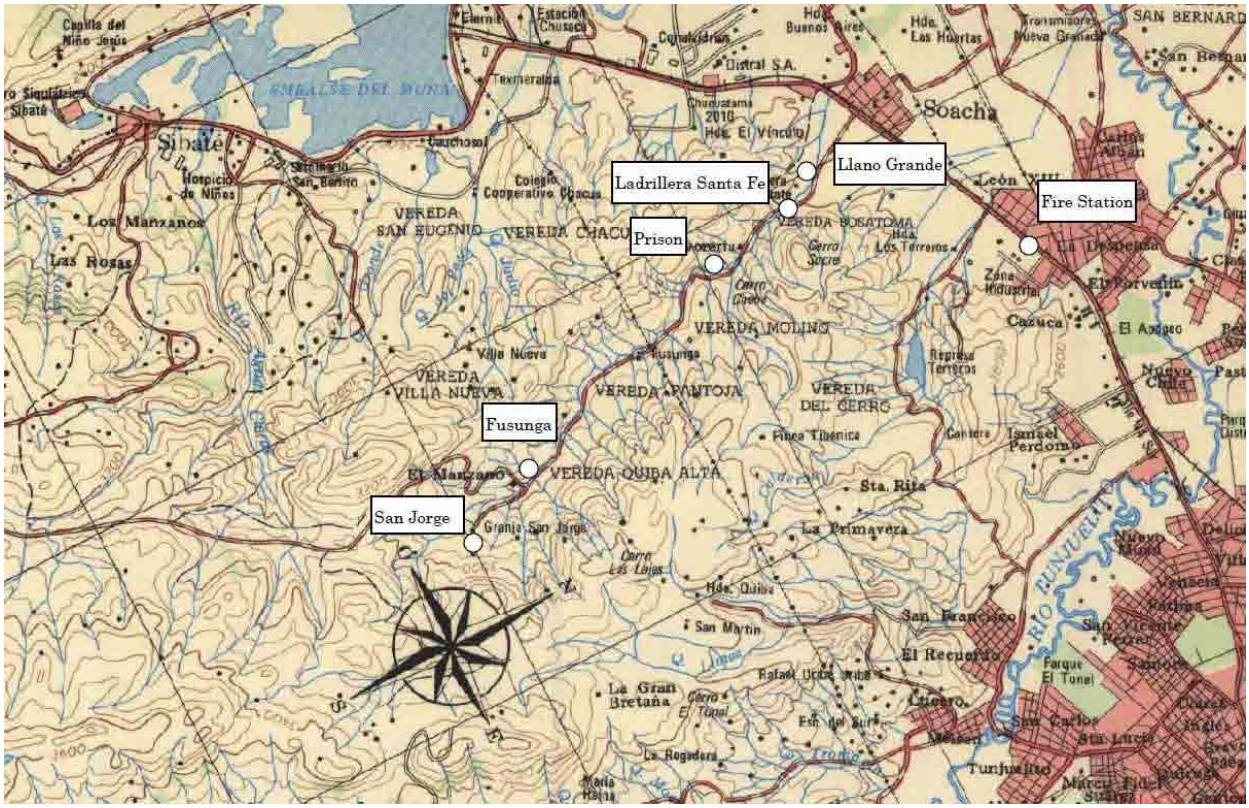


Figure S8-2-9 Location map in Soacha

(2) Installation equipments

In Soacha area, the study team installed meteorological-hydrological measuring equipments in order to monitor meteorological and hydrological condition. The specification of equipments is follows.

Table S8-2-8 Specification of equipments in SOACHA

Station	Element of Observation	Type	Specification
Fire Station		PC system	Desk top PC : HP Compaq dx2300 Microtorre Lap top PC : HP Compaq nx6320 notebook PC Router : D-Link Air Plus G UPS : POWERWARE 9120
	Rain fall	Tip-bucket	Rain gauge : Texas Electronics TR-525 Rainfall Sensor Resolution : 0.1 mm Metric Accuracy : 1.0% up to 50 mm/hour Collector diameter : 245 mm Logger : MOTOROLA MOSCAD-L Remote Terminal Unit Solar panel : SUNTECH STP080S-12/Bb Battery : VISION 6FM55 DC12V 55Ah Regulator : Sun Saver 10
San Jorge (ICA gate)	Rain fall	Tip-bucket	Rain gauge : Texas Electronics TR-525 Rainfall Sensor Resolution : 0.1 mm Metric Accuracy : 1.0% up to 50 mm/hour Collector diameter : 245 mm Logger : MOTOROLA MOSCAD-L Remote Terminal Unit Solar panel : SUNTECH STP080S-12/Bb Battery : VISION 6FM55 DC12V 55Ah Regulator : Sun Saver 10
Fusunga	Water Level	Staff gauge	Water level gauge : APCYTEL staff gauge Resolution : 1 cm Metric Gauge rod : steel Self standing
Prison of Soacha	Rain fall	Conventional	Rain gauge : TAKUWA Rain fall gauge with water storage bottle and measure cup Collector diameter : 150 mm Resolution : 1 mm Metric Alarm : Preset the level optionally Stuck on the roof
	Water Level	Staff gauge	Water level gauge : APCYTEL staff gauge Resolution : 1 cm Metric Gauge rod : steel Self standing and stuck on the river wall
	Water Level	Electrode	Water level gauge : APCYTEL simplified water level gauge Resolution : 20 cm Metric 10 sensors Alarm : Preset the level optionally Gauge device : PVC tubes and telephone cable Stuck on the board fixed on the bridge
Ladrillera Santa Fe	Water Level	Staff gauge	Water level gauge : APCYTEL staff gauge Resolution : 1 cm Metric Gauge rod : steel Self standing and stuck on the river wall
	Water Level	Ultra sonic	Water level gauge : Sonder Ultrasonic Level Meter Measuring range : 0.5m – 12m Resolution : 0.35% of measured range Beam angle : 8deg. at -3dB Logger : MOTOROLA MOSCAD-L Remote Terminal Unit Solar panel : SUNTECH STP080S-12/Bb Battery : VISION 6FM55 DC12V 55Ah Regulator : Sun Saver 10
Llamo Grande	Water Level	Staff gauge	Water level gauge : APCYTEL staff gauge Resolution : 1 cm Metric Gauge rod : steel Stuck on the river wall

(3) Installation appearance

1) Fire station

In the Soacha fire station, PC system and a rain fall gauge were installed. At this moment a desk top PC is stand alone, but in the near future it will be connected to the inter net. The PC system is used for the following purposes.

- Compiling and organizing of the meteorological-hydrological observing data
- Monitoring of the meteorological-hydrological observing data of DPAE, EAAB
- Downloading of the meteorological-hydrological observing data in Soacha stations (laptop PC)

The rain fall gauge is installed on the roof, the data logger and power supply units are installed in the office room.

Photo S8-2-11 PCs, router and UPS in Firefighter Station

Photo S8-2-12 Rainfall Gauge and Data logger

2) San Jorge

In San Jorge, a rain fall gauge was installed. At first JICA study team planned to install in the IDEAM meteorological field, but the rain fall gauge was installed in the security guard station at the gate of ICA temporarily by various factors.

Photo S8-2-13 Rainfall gauge on the roof and Data logger and power unit

3) Fusunga

In Fusunga, a staff type water level gauge was installed in and by the river. According to the Fusunga lady, the water level increased at 2.3m in the gauge scale on the occasion of the flood in May 2006.

Photo S8-2-14 Water level gauge at Fusunga

4) Prison of Soacha

In the prison of Soacha, a staff type water level gauge and an electrode type water level gauge were installed in the river. In the near future a conventional type rain fall gauge, which is installed in the Soacha fire station now, will be moved here.

Photo S8-2-15 Staff gauge and Electrode type gauge

Photo S8-2-16 Comparison of the scale and Alarm box of Electrode type gauge

Table S8-2- 1 Comparison of the scale at Prison Station

Switch number on Alarm unit box	Water depth on Staff gauge (m)
10	3.15
9	2.95
8	2.75
|	|
2	1.55
1	1.35

5) Ladrillera Santa Fe

In Ladrillera Santa Fe, a staff type water level gauge was installed in the river. In the near future an ultrasonic type water level gauge will be installed. According to the cooperator in the brick factory, the water level reached at the middle of the handrail of the bridge on the occasion of the flood in May 2006. It means the water level was 3.8m in the gauge scale.

Photo S8-2-17 Water level gauge at Ladrillera Santa Fe

Photo S8-2-18 Water level of the flood in May 2006

6) Llano Grande

In Llano Grande, a staff type water level gauge was installed in the river. According to the cooperator in the section, the bridge was covered with the river water on the occasion of the flood in May 2006. It means the water level was 3.5m in the gauge scale.

Photo S8-2-19 Water level gauge at Llano Grande

(4) Cooperation from local residents

1) San Jorge

In San Jorge, a rain fall gauge was installed on September 20th. JICA study team made the training to the security guards to check the rain fall data, record the data on the designated form and inform the observing data to the fire station by the radio transceiver.

Photo S8-2-20 Training to the security guard and Recording form for San Jorge

2) Fusunga

In Fusunga, a staff type water level gauge was already installed. But the observation by the local residents was not started yet. JICA study team visited Fusunga and made the training to the cooperators. So the observation and communication was started three times a day.

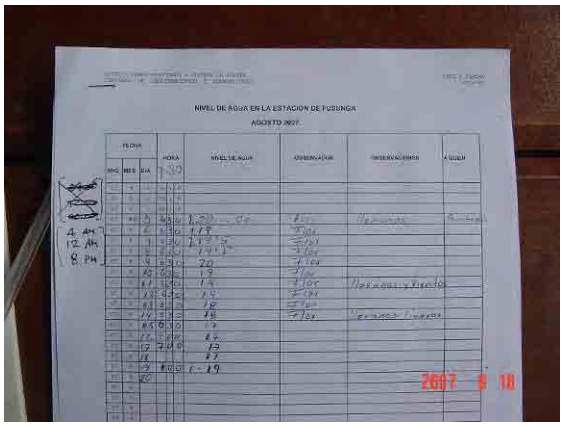


Photo S8-2-21 Recording form of Fusunga

3) Prison of Soacha

In the prison of Soacha, a staff type water level gauge was already installed. But the observation by the security guards was not started yet. JICA study team visited the prison and made the training to the cooperators. So the observation and communication was started three times a day. Regarding the electrode water level gauge, it informs the observer with buzzer if the water level reaches the warning level. At this moment, the warning level is set at the switch number 4. It means 1.95m in the staff gauge scale.

Photo S8-2-22 Recording form for Prison

Photo S8-2-23 Setting level of electrode type water level gauge

4) Ladrillera Santa Fe

In Ladrillera Santa Fe, a staff type water level gauge was already installed by the bridge of the brick factory. But the observation was not started yet. The study team visited the security guard station of the brick factory and made the training to the cooperators. So the observation and communication was started three times a day.

Photo S8-2-24 Recording form for Ladrillera Santa Fe

5) Llano Grande

In Llano Grande, a staff type water level gauge was already installed by the bridge. The study team visited the local residents and made the training to the cooperators.

(5) Role of Soacha fire station

In this project, Disaster Management, the fire station plays a very important role. The firefighters go into action when a disaster happens, the way it was used to be. But after implementation of this project, the observation data, rainfall data and water level data, are communicated to the fire station three times a day. And when dangerous situation happened, the observation and communication would be changed every hour. If the situation became worse and worse, the fire station would be able to prepare to issue the warning and to go into action in advance.

Hereby the study team expects that the disaster prevention ability will be improved by the cooperation of local residents and the information gathering capacity of the fire station.

Photo S8-2-25 Receiving data and Compiling data at Firefighter Station