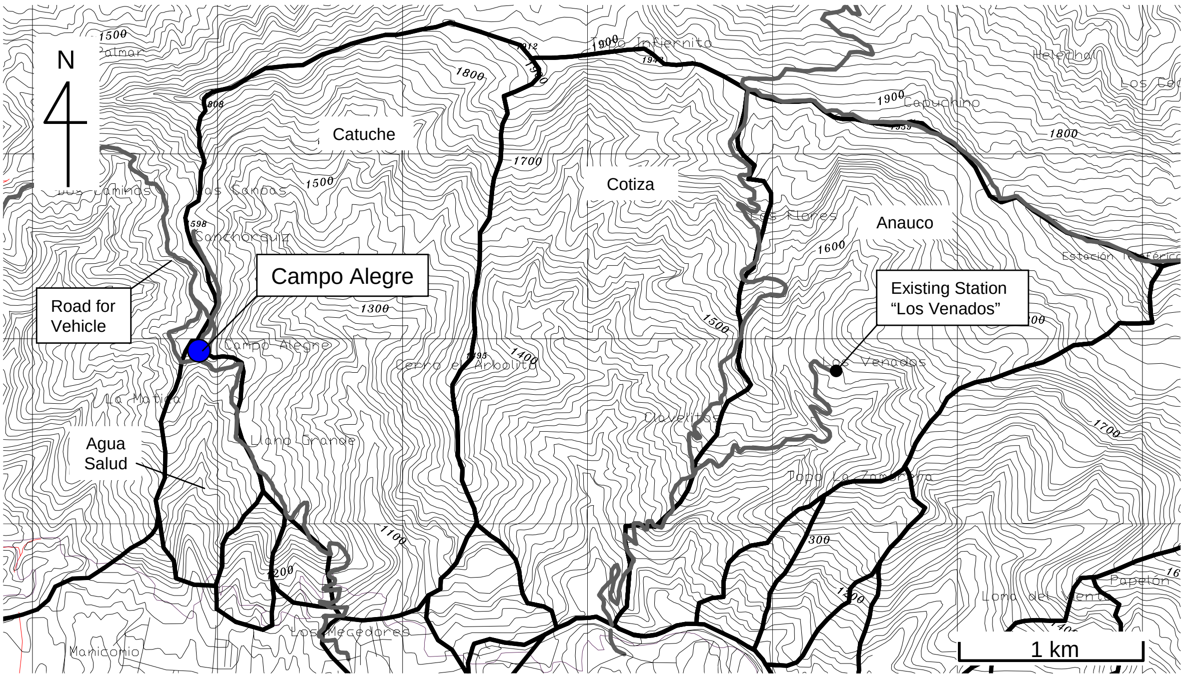


Figure S15-2.1.3 Location Map of Campo Alegre Station

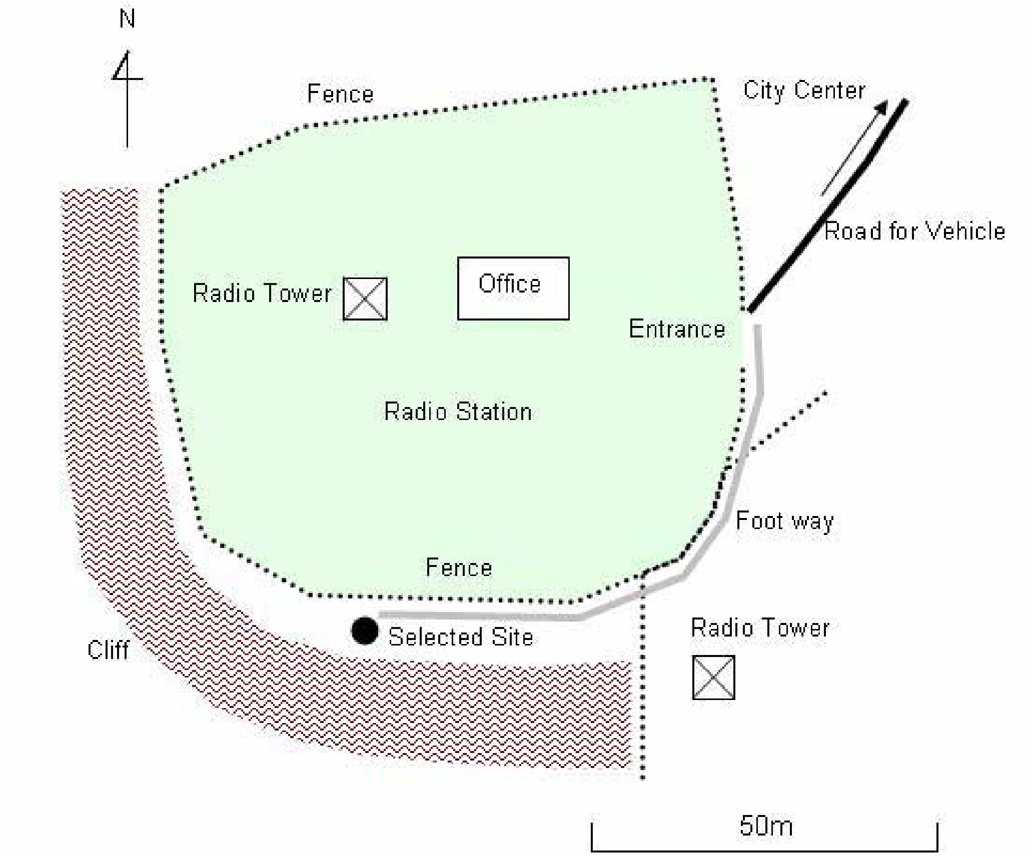


Figure S15-2.1.4 Detailed Location of Campo Alegre Station

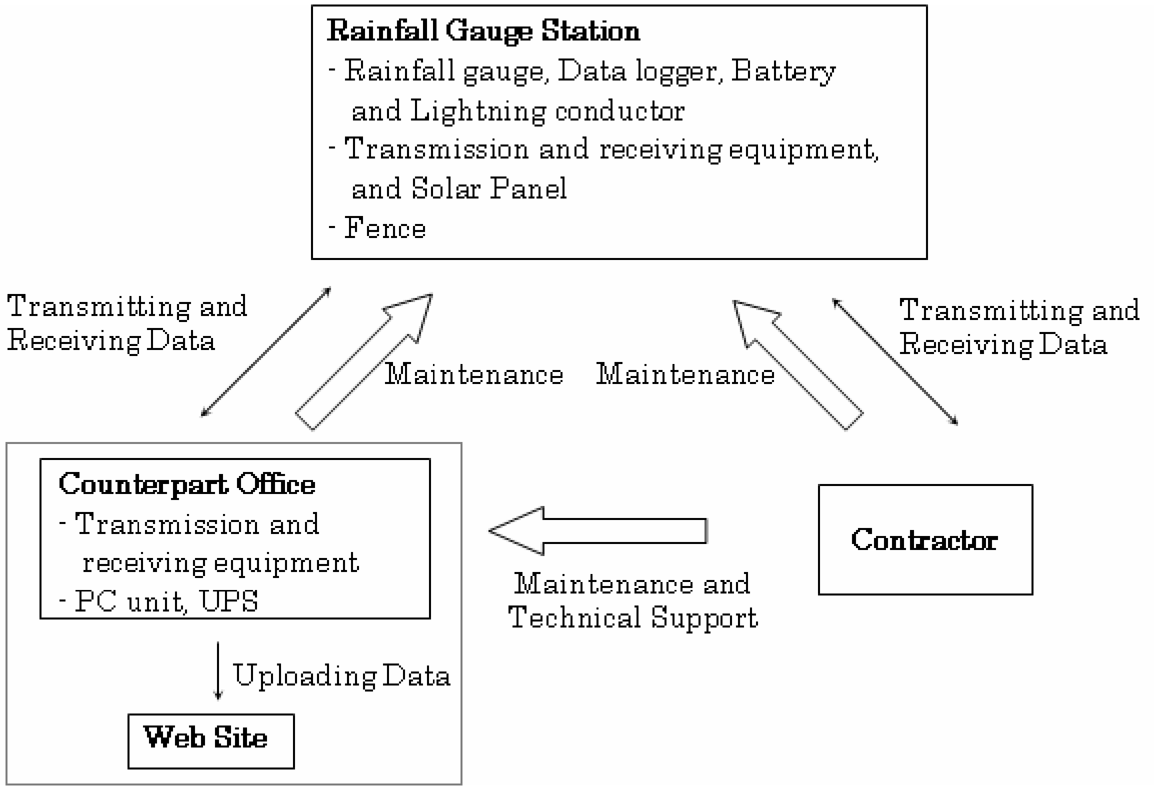


Figure S15-2.2.1 Entire System of the Rainfall Gauge (During the JICA Study Period)

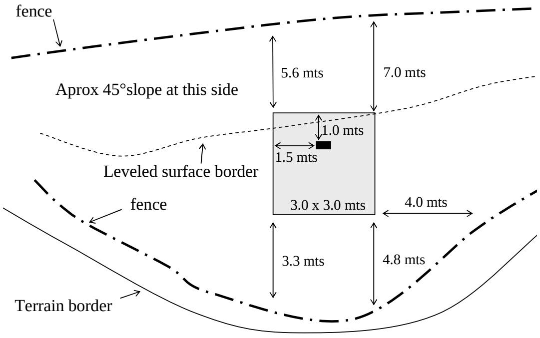
Location of Rainfall Gauge Station

Longitude : 726,870
Latitude : 1,165,920
Elevation : 1,550 msnm

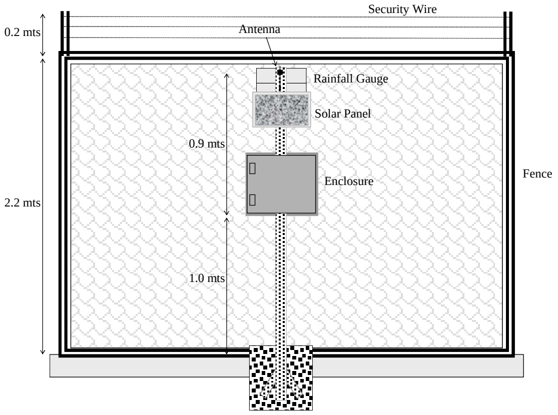
(Coordinates UTM Datum La Canoa;
based on the 1/25,000 Topographic Map)

Full View

Plain



Front



Specification of Rainfall Gauge

Brand: Novalynx System Inc.
Model 260-2501M
Sensor Type: Tipping bucket
Switch: Magnetic sensitive, 3W, 28Vac
Sensitivility: 1 tip per 1 mm
Accuracy: ± 4 % for rainfall rates of 1" to 6" per hour
Orifice: 8" diameter (20.32 cm)
Construction: Anodized Aluminium, Stainless steel fasteners
Dimension: 8.4" D x 15" H (21.34 cm x 38.10 cm)
Weight: 8lb (3.63 kg)

Figure S15-2.2.2 Schematic Drawing of Rainfall Gauge and Station

CHAPTER 3. INSTALLATION OF WATER LEVEL STAFF GAUGE

3. 1 Objectives

The objectives to install the water level staff gauge are shown below.

- To collect the water level data.
- To utilize the observed data for the education program of early warning and evacuation system.
- Technology transfer on installation, operation and maintenance

3. 2 Site Selection

The sites for water level staff gauges were selected according to the points listed below with the help of C/P.

- Visibility by the local people
- Upstream as much as possible
- Easy access for maintenance

The staff gauge or water level indicators were installed at totally twenty (20) locations between the fan apex and the Guaire River, which are listed in Table S15-3.1.1 and the locations are shown in Figure S15-3.1.1.

These locations were determined in function of that the communities located in these catchments are integrated to the proposed M/P, through the reading and recording of the water level with the cooperation with the Civil Protection and Municipalities.

3. 3 Equipment

The staff gauge itself is made of metal and the dimension of 1 piece is 1 m (length)* 10 cm (width)* 3 mm (thickness). The maximum length is 5 meter and the average length is 4 m. The staff gauges are attached in a U-steel bar for protection against the flow to be placed on concrete wall on the site.

The readings of staff gauge are painted in red and white alternately in 10 cm to make the observation easy.

The schematic drawing of a piece of staff gauge is shown in Figure S15-3.1.2.

3. 4 Operation and Maintenance

The water level on a staff gauge is observed by community or public organizations such as the park guard. The frequency of the observation is once or twice a day at the normal time. In the case of flood, the maximum water level and the time series water level during the flood are requested to be observed. The observed data is utilized for the improvement of the hydrological analysis such as the runoff analysis and flood analysis to create the hazard map.

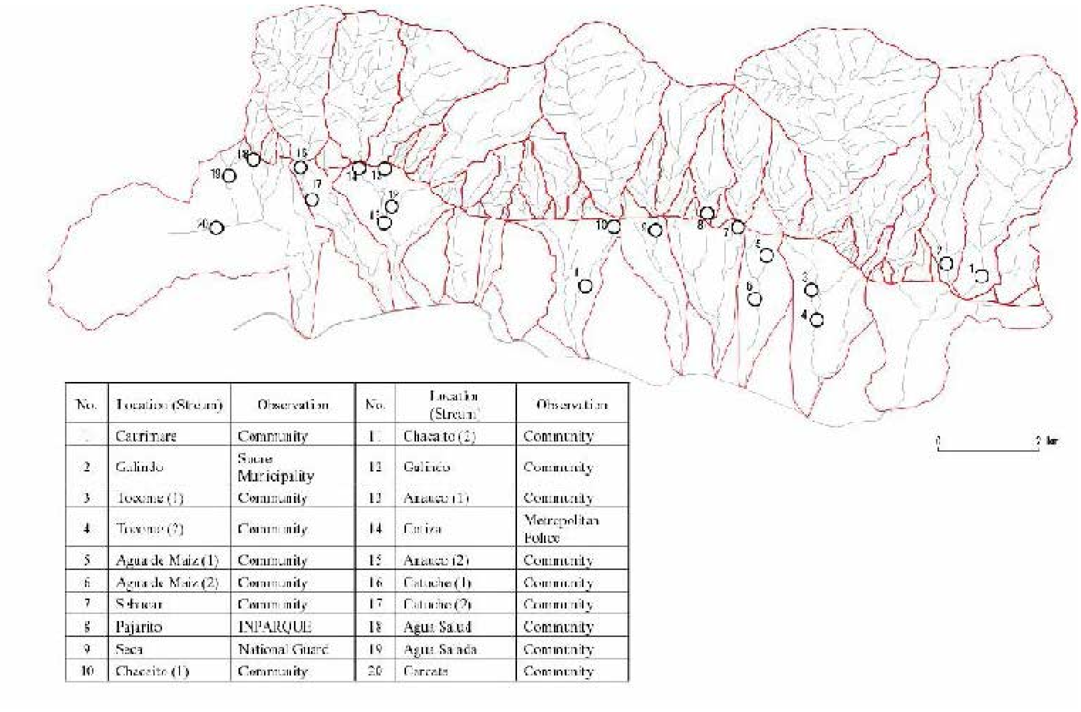
The observed water level data in real time during the flood is utilized for the early warning and evacuation system.

The Study Team visited the 20 sites of the water level staff gauge once a month to confirm whether the staff gauges can be seen clearly without any obstructions or not, during the study period.

Table S15-3.1.1 List of Selected Location for Water Level Staff Gauge

Note: Datum is La Canoa Coordinate system

No.	Location (Stream)	Observation	Latitude	Longitude	Elevation (m)
1	Caurimare	Community	1,162,207	741,721	956
2	Galindo	Park Guard of Galindo Station	1,162,070	741,077	919
3	Tocome (1)	Community	1,161,848	738,309	883
4	Tocome (2)	Community	1,160,777	738,272	850
5	Agua de Maiz (1)	Community	1,162,452	737,336	904
6	Agua de Maiz (2)	Community	1,161,489	737,155	860
7	Sebucan	Community	1,163,156	736,756	974
8	Pajarito	INPARQUE	1,163,362	736,043	1,012
9	Quintero	National Guard	1,162,730	735,011	929
10	Chacaito (1)	Community	1,163,126	734,237	967
11	Chacaito (2)	Community	1,161,903	733,633	894
12	Gamboa	Community	1,163,593	729,762	913
13	Anauco (1)	Community	1,164,225	729,555	928
14	Cotiza	Metropolitan Police	1,164,395	729,048	943
15	Anauco (2)	Community	1,163,329	729,537	894
16	Catuche (1)	Community	1,164,360	727,818	1020
17	Catuche (2)	Community	1,163,714	728,074	969
18	Agua Salud	Community	1,164,178	726,837	1,002
19	Agua Salada	Community	1,164,208	726,383	963
20	Caroata	Community	1,163,113	726,127	933



No.	Location (Stream)	Observation	No.	Location (Stream)	Observation
1	Caurimare	Community	11	Chacaito (2)	Community
2	Galindo	Sucre Municipality	12	Galindo	Community
3	Tocome (1)	Community	13	Anauco (1)	Community
4	Tocome (2)	Community	14	Cotiza	Metropolitan Police
5	Agua de Maiz (1)	Community	15	Anauco (2)	Community
6	Agua de Maiz (2)	Community	16	Catuche (1)	Community
7	Sebucan	Community	17	Catuche (2)	Community
8	Pajarito	INPARQUE	18	Agua Salud	Community
9	Seca	National Guard	19	Agua Salada	Community
10	Chacaito (1)	Community	20	Caroata	Community

Figure S15-3.1.1 Location of Water Level Staff Gauges

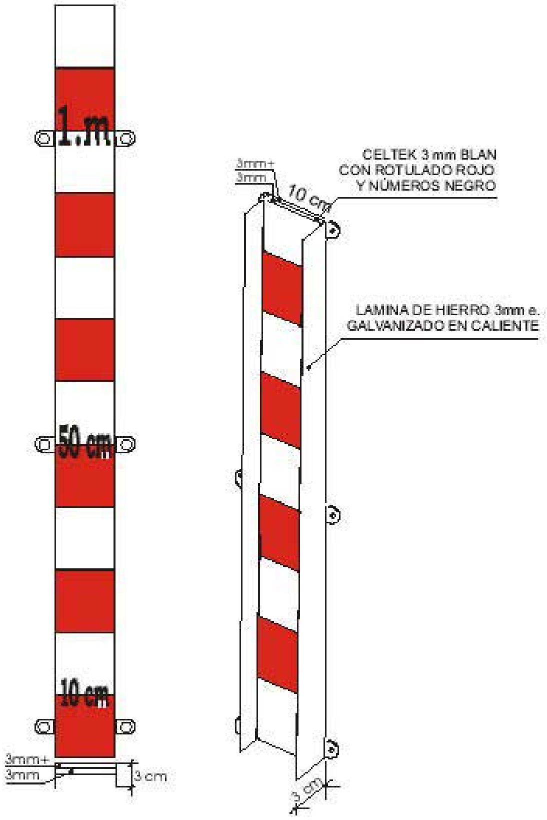


Figure S15-3.1.2 Schematic Drawing of Staff Gauge

CHAPTER 4. TECHNOLOGY TRANSFER

The entire system of the rainfall gauge and the 20 water level staff gauges installed have to be operated and maintained properly by the counterpart after the termination of the Study.

In order to ensure the sustainable operation and maintenance by the counterpart, the Study Team supported technically the counterpart in terms of the installation, operation and maintenance of the entire system of the rainfall gauge and the water level staff gauges.

In the course of the technology transfer to the counterpart, the Study Team advised and provided necessary information for the counterpart to prepare the operation and maintenance plan including measure for budget.

S16

FACILITY DESIGN AND COST ESTIMATE

“If knowing is of wise persons, preventing is of smart ones”

Reinaldo Ollarves

STUDY ON
DISASTER PREVENTION BASIC PLAN
IN THE METROPOLITAN DISTRICT OF CARACAS

FINAL REPORT

SUPPORTING REPORT

S16

FACILITY DESIGN AND COST ESTIMATE

TABLE OF CONTENTS

S16

LIST OF TABLES

S16

LIST OF FIGURES

S-16 FACILITY DESIGN AND COST ESTIMATE

CHAPTER 1. GENERAL

The works for the master plan project consist mainly of earth works and concrete works such as the construction of sabo dams, channel works and water channel works.

The construction planning described in this report was prepared on the basis of the design of structures in consideration of results of the studies on the capability of contractors in Venezuela such as technical level, prevailing construction methods, and similar domestic projects and so on.

Construction materials and equipment except specially specified ones will be procured in Venezuela.

Direct cost was estimated on the basis of the construction plan. The indirect cost was estimated taking into account similar domestic projects in Venezuela.

CHAPTER 2. FACILITY DESIGN

2. 1 Basic Concept

In the Supporting Report S12, the potential runoff sediment volume from the southern part of the Avila was estimated. Also the flood water discharge from each mountain stream above its control point was calculated for various return periods.

In the sediment study area, the area below the basic points is already highly urbanized and almost all the mountain streams have been confined and occupied by houses and buildings. Therefore the assumed sediment runoff volume should be controlled in the area upstream of the basic points, which is in the Avila. In order to protect property below the basic points, this is the only way.

Also the urban area in Caracas has been developed historically on the alluvial fans, which was formed by the runoff sediment from the Avila. The natural stream courses on the alluvial fans are not so stable and vulnerable for bank erosion. Those natural stream courses, especially in the upstream section below the control points should be improved by channel works. Besides, the water channels in the urban area have small flow capacity, resulting into the spreading inundation. The water channel with small flow capacity should be improved to minimize the inundation damage.

2. 2 Conceivable Structure Measures

Figure S16-2.2.1 shows the work flow diagram for the selection of structure measures for debris flow from the Avila. In the figure, totally 7 types of sediment control measures are mentioned. The seven (7) types of measures are illustrated in Figure S16-2.2.2. The brief explanation for the work flow diagram is as follows,

Possibility of occurrence of debris flow can be recognized for all the mountain streams in the sediment study area. Sediment control structure was studied for all the mountain streams (47 streams).

Each mountain stream can be divided into two (2) segments at its control point. The segment upstream of the control point has steep stream bed slope steeper than around 3 degree, which belongs to the Avila. The other segment downstream of the control point has comparatively mild stream bed slope milder than around 3 degree, which belongs to the urban area in Caracas.

In the Avila there are three (3) structure measures possible.

- Measure(1) for sediment generation control (Hillside works/groundsill or Protection works for landslide)
- Measure(2) to mitigate debris flow energy (Sabo dams)
- Measure(3) to trap debris flow (Sabo dams)

The measures (1) and (2) require the basin-wide layout of structure. They are not appropriate in the Avila in terms of the scale of structure. The measure (3) aims at trapping of debris flow by a series of Sabo dam at the downstream reach within the Avila. The measure (3) is recommended for the Avila.

In the urban area of Caracas, there are four (4) structure measures possible.

- Measure(4) to trap sediment (Sediment Trap)
- Measure(5) to guide debris flow (Training Channel)
- Measure(6) to stabilize stream course (Channel Works)
- Measure(7) to make flood flow safely (Water Channel Works)

If the runoff sediment can not be controlled completely in the Avila, the measures (4) and (5) are required in the urban area. In Caracas, it is not practical to construct such large scale structures in terms of the availability of open space. In this context, the runoff sediment must be controlled upstream within the Avila.

The measure (6) aims at the stabilization of stream courses on the alluvial fan. The streams that the Cota Mil is crossing at its control point do not need the measure (6) because the Cota Mil could fix the stream course already. The measure (6) should be applied to the fan apex of Catuche, Chacaito, Tocome.

The measure (7) could be applied to all the stream courses in the urban area.

2. 3 Proposed Level

The scenario for the sediment disaster is set to the level comparable to the event in December 1999 in Caracas with respect to the sediment, while set to 100 years return period for the water discharge from the Avila.

The flow capacity of the existing Guaire river has been evaluated 25 to 50 years return period as shown in Figure S16-2.3.1 based on the Caracas Project[1].

In addition to the scenario case, 25 years return period for the sediment and 10 years return period for the water channel shall be proposed as the short term case (action plan).

2. 4 Sabo Dam in the Avila

2. 4. 1. Function of Sabo Dam

Generally Sabo Dam has the following functions.

	FUNCTIONS	APPLICABILITY in the Avila
1	Avoiding of vertical (longitudinal) erosion to give a fixed elevation by dams	No
2	Avoiding of bank erosion to guide the stream flow toward center by dams	No
3	Avoiding of slope failure to raise the stream bed by dams	No
4	Storage and keeping of runoff sediment	Yes
5	Control of sediment runoff to deposit temporally during floods	No

Among the above five (5) functions, the function no.4 can be applicable in the Avila. Because the Avila is in comparatively stable and low frequency in terms of sediment runoff process, only debris

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[1] UCV-IMF, Impacto y Prevencion de Inundaciones y Aludes Torrenciales en El Valle de Caracas, Informe Tecnico No.1, 2003

flow generated by extraordinary heavy rainfall is subject to the function of Sabo Dam. The functions No.1,2,3 and 5 are applicable for the unstable mountain streams with high frequency of small floods.

2. 4. 2. Preliminary Design

(1) General

Preliminary design of Sabo dam was prepared from the viewpoint of availability of construction materials near the dam site, economy, construction efficiency and construction experiences in Venezuela.

The structure type of sabo dam was studied to take into consideration the construction method, access road and maintenance work, etc.

The location and the height of proposed Sabo Dam was decided based on the objective of the dam and the site conditions. Since the stream bed of the Avila as the base of the Dam is composed of sand and gravel materials, the Dam height was set to be shorter than 15 m.

The function of the proposed Sabo Dam for the Avila is to storage and keeping of runoff sediment as discussed in section 2.4.1. Generally the methodology to determine the location and the height of Sabo Dam is different among the objectives. Here the methodology only for the Sabo Dam to storage and keep the runoff sediment was explained below.

It is more advantageous that the more sediment trapping capacity and the surface area of the trap for unit concrete volume of a Dam. Therefore it is desirable to locate a Dam at narrow section with V-valley and wider section upstream as well as mild stream bed slope.

(2) Preliminary Design

For the purpose of the estimation of number of Sabo Dam and work quantity in the Avila, the concrete Sabo Dam, the most general structure type, was designed. The basic structure of Sabo Dam is shown in Figure S16-2.4.1.

The basic design principles in the Study are as follows,

- The dam height is lower than 15 m.

- The effective height of the dam is 2 m shorter than the dam height.

- The downstream side slope of a dam is generally 1: 0.2, while the upstream side slope was decided by the stability calculation.

The dimension of the designed Sabo Dam is summarized in Table S16-2.4.1 (1/2 and 2/2).

2. 4. 3. Layout of Sabo Dam

For the target sediment volume decided in the S12, the necessary Sabo Dam was designed. The trapped sediment volume by each Sabo Dam was calculated as shown in Figure S16-2.4.2. The size and number of Sabo Dam was designed in a manner that the trapped sediment volume is larger than the target sediment volume.

$Q – E–(C+D+B)=0$

Q: Target Sediment Volume

E: Design Allowable Sediment Transport (=0)

C: Design Trapped Volume

D: Design Deposit Volume

B: Design Reduction Volume for Debris flow generation (=0)

Design Allowable Sediment Transport (E) is the sediment volume which can be transported not to cause damage at the basic point downstream. In Caracas, since the basic point downstream is urban area, the E is set zero.

Design Trapped Volume (C) is the sediment volume which can be allowed to deposit at Sabo Dam when a debris flow occurs. In Caracas, this volume was considered. The trapped volume capacity can be recovered naturally after small-middle scale floods after the debris flow. However, in the case of small catchment area and small flood discharge, or in the case that the Dam slit is closed by large boulders, the recovery of the trapped capacity can not be expected. In those cased, the excavation is required immediately after the debris flow.

Design Deposit Volume (D) is the sediment volume, which can be deposited in the sediment trap area when debris flow occurs. In Caracas, such sediment trap area can not be proposed because the basic point downstream is highly urbanized, therefore D is set zero.

Design Reduction Volume for Debris flow generation (B) is the sediment volume, which can be reduced by slope protection works or groundsill in the segment of debris flow generation and transport. In Caracas, since the Sabo Dams are proposed in the lower reach of each catchment, B is set to zero.

The basic Layout of Sabo Dam principles in the Study are as follows

- Sabo Dam shall be proposed in the lower reach where debris flow can be deposited easily, and in the topography where the trapped sediment volume is large.

- In the case that multiple Sabo Dams are necessary because of the height limitation of 15 meter, they are located not to share the sediment deposit area. Design bed slope was set to 50 % of the original bed slope.

- Only the trapped sediment volume was regarded as the sediment capacity of a dam.

Table S16-2.4.1 shows the proposed Sabo Dam features in the Avila and Figure S16-2.4.3 shows the location of each Sabo Dam.

There is an index called "ratio of trapped to runoff sediment" which can indicate the effectiveness of Sabo Dam. The ratio is calculated by the following formula. When all the Sabo Dams are constructed in a catchment, the ratio would be 100 %.

ratio of trapped to runoff sediment (%)＝Summation（Design Trapped Volume）/（Target SedimentVolume）*100

Table S16-2.4.2 shows the proposed ratio of trapped to runoff sediment for each principal mountain stream.

2. 4. 4. Cost Estimate

The project cost for the Sabo Dam works was estimated based on the concrete volume basis. Table S16-2.4.3 is an actual cost for a dam constructed in Vargas in 2000. The cost is expressed by Bs. in 2000. In this case, the concrete volume for the main dam is 2,095 m^3. The partial cost only for the sabo dam works is 600 million Bs. in 2000 including the overhead cost. The project cost per 1 m^3 concrete is 286,400 Bs. in 2000. For the master plan study, 300,000 Bs. per 1 m^3 Sabo Dam concrete will be used as year 2000 price level.

The cost of proposed Sabo dam was shown in Table S16-2.4.1.

2. 5 Channel Works and Water Channel Works

2. 5. 1. Channel Works

Channel Works (refer to Figure S16-2.5.1) was proposed to stabilize the stream course on the alluvial fans for the section downstream of the control point. The stream, whose the control point is not crossed by the Cota Mil or is going through the bridge opening of the Cota Mil, should have the channel works downstream of its control point. Among the 47 mountain streams, the Catuche, Chacaito, Tocome streams need the channel works. The streams west of the Catuche do not need the channel works because their fan apex is forming the clear straight V-valley.

The proposed cross section and detailed dimension are shown in Figure S16-2.5.2 and Table S16-2.5.1, respectively.

2. 5. 2. Water Channel Works

Water Channel Works was proposed to make the flood flow safely from the downstream end of channel work section until the Guaire River. Most of the existing water channels downstream of the control point have insufficient flow capacity against the scenario flood discharge. The Central University of Venezuela has been investigating the flow capacity of the existing channel in Caracas under the Caracas Project funded by the Venezuelan Government[2]. Figure S16-2.5.3 is the flow capacity of the existing channel in the Catuche. For the section whose flow capacity is smaller than the design discharge, the appropriate water channel works should be proposed.

2. 5. 3. Cost Estimate

The project cost for the Channel Works and Water Channel Works was estimated based on the concrete volume basis. The unit price for 1 m^3 concrete (80 kgf / cm^2) is 120,000 Bs. in 2000 according to the Table S16-2.4.3. Considering intangible cost, the unit price is set 240,000 Bs. to estimate the project cost for Channel works and Water Channel Works in Caracas.

The cost of proposed Channel Works was shown in Table S16-2.5.1.

2. 6 Temporary Yard for Construction

Figure S16-2.6.1 illustrates the procedures to determine the location of temporary yard and temporary route between the yard and the construction site. The minimum requirement of temporary yard and access route are described in the bottom of the figure.

Regarding the temporary yard, the availability of appropriate site should be checked, where the access time is less than one (1) hour. If there is not an appropriate site, a new temporary yard should be constructed. Actually in the sediment study area the open space the Cotiza and the Anauco upstream are the only candidate site for the temporary yard.

Also the road for vehicle as temporary route between the yard and the dam site is available in the Cotiza. In the case of Anauco, other way such as cable way must be constructed.

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[2] UCV-IMF,Borrador Informe FONACIT

For other streams, there are no appropriate temporary yards near their dam sites. If new temporary yards and access route are proposed, the construction cost and the environmental impact will be quite higher.

Figure S16-2.6.2 is the proposed temporary works for Sabo dam and channel works.

Table S16-2.6.1 is the work quantity for temporary works.

Table S16-2.6.2 is the proposed construction schedule.

2. 7 Type of Sabo Dam in the Avila

2. 7. 1. Manner of Sediment Runoff and Countermeasures

The manner of sediment transport can be categorized based on the stream bed slope as shown in Table S16-2.4.1. The type of countermeasures such as construction method and structure type can be decided according to the category.

Figure S16-2.7.1 shows the segment of each mountain stream based on the streambed slope. The segment at the Sabo dam site was shown in Table S16-2.7.1.

2. 7. 2. Layout of Sabo Dam

There are two (2) types of Sabo Dam. They are open type and closed type.

Table S16-2.7.2 explains the sabo dam layout based on the feature of debris flow transport. According to this concept, the type of sabo dam was decided as shown in Table S16-2.4.1.

Figure S16-2.7.2 illustrates typical sabo dam layouts for the Avila as a reference.

2. 7. 3. Type of Dam

Open type is the dam which can allow the water and smaller sediment through the slits considering the continuity of flow between upstream and downstream. The open type can trap and storage the first debris flow after the dam starts its operation. In the case of mountain stream in which quite a few small floods occur frequently, the trapped sediment is easily transported downstream to result into that the dam is emptied before the next debris flow. Consequently the function of the dam is kept for long time. This situation is very common in Japan. However in Caracas, such small floods are not so common that when the second debris flow comes, since the dam is already full, the dam can not be functioning. Therefore, in Caracas the maintenance dredging is required in order to keep the function of open type dam.

Closed type is the conventional dam without deep slit. This type is appropriate to the site whose downstream is urban area or whose geological condition is weak for stream bed degradation and bank erosion.

The effectiveness in terms of the controlled sediment volume is quite different between open type and closed type. The open type dam can consider the storage volume and the controlled volume, while the closed type dam can only consider the controlled storage. Therefore open type is more effective in terms of the sediment volume.

Considering the above characteristics, open type sabo dam shall be located from downstream, however, closed type dam shall be located for the stream flowing into the urban area directly without Cota Mil or through bridge.

(1) Open Type Sabo Dam

The open type Sabo dam for the purpose of sediment storage and trapping of debris flow should be located on the stream where debris flow could occur, go downstream and deposit. The open section can be regarded to be blocked after the dam trapped debris flow. If the trapped sediment remains just upstream of the dam the function to storage and trap sediment is lowered, so that the dredging is inevitable.

In terms of the selection of Sabo dam site, the basic principle is same as that of closed type sabo dam. The open type Sabo dam should be avoided to locate just upstream of the property to be protected because the sediment could pass through the open section or the sediment easily flows over the dam due to the remaining sediment upstream.

For the open type dam, the concrete slit type and the steel frame type are conceivable at present. In the case of concrete slit type, sometimes it is difficult to control the sediment during the falling limb of the flood, while it is said that the steel frame type can control even such problems since the frame is dense. Table S16-2.7.3 shows the comparison of structure type of open type Sabo dam. Among the four (4) types in the Table, concrete slit dam and frame type slit dam are more appropriate than the others.

(2) Closed Type Sabo Dam

For the closed type dam, the gravity concrete type, steel frame type and the grouting type are considered as shown in Table S16-2.7.4. As a conclusion, the gravity concrete type is the most appropriate.

2. 8 Design in Selected Mountain Stream

Figure S16-2.8.1 (1/2-2/2) is the typical design of concrete slit sabo dam and steel frame sabo dam, respectively.

Table S16-2.4.1 (1/2) Sabo Dam Dimension for 100 Years Return Period

Table S16-2.4.1 (2/2) Sabo Dam Dimension for 25 Years Return Period

Table S16-2.4.2 (1/2)　Summary of Sabo Dam for Principal Stream (100 Years Return Period)

No of Catchment		Catchment name		Area		Sediment Runoff Volume				Qp	No. of Dam	Concrete Volume	Trapped Sediment Volume	Ratio of Trapped to Runoff Volume	Dam_cost	channel works Cost	Total Cost	Construc tion Duration
				(km2)		(m3)		(m3/km2)		(m3/s)		(m3)	(m3)	(%)	×10^3(BS)	×10^3(BS)	×10^3(BS)	(year)
1	48		Caurimare	0.161		9,300		58,000	Vec	8.0	0	0	0	0	0		0	
2	48		Caurimare	0.987	0.321	21,100	11,396	21,000	Ve	24.8	1	2,280	11,880	104	684,000		684,000	1.5
3	48		Caurimare	0.075		3,800		51,000	Vec	3.7	0	0	0	0	0		0	
4	48	Caurimare	Caurimare	6.354		101,400		16,000	Vec	75.0	6	21,260	102,130	101	6,378,000		6,378,000	7.5
5	48	Galindo	Caurimare	3.845		59,000		15,000	Vec	68.0	2	8,460	59,650	101	2,538,000		2,538,000	3.0
6	48		Caurimare	0.087		6,800		78,000	Ve	3.2	1	2,070	7,560	111	621,000		621,000	1.0
7	48		Caurimare	0.360		16,300		45,000	Vec	14.4	1	3,130	16,670	102	939,000		939,000	1.5
8	48	Pasaquire	Caurimare	1.143		34,200		30,000	Ve	34.0	2	5,140	35,220	103	1,542,000		1,542,000	2.0
9	48		Caurimare	0.117		7,000		60,000	Ve	5.1	1	2,050	7,680	110	615,000		615,000	1.0
10	48		Caurimare	0.055		3,300		60,000	Ve	2.4	1	1,700	3,800	115	510,000		510,000	1.0
11	50	Gamburi	Tocome	0.247		15,100		61,000	Vec	10.6	1	3,120	15,680	104	936,000		936,000	1.5
12	50	La Julia	Tocome	2.100		62,900		30,000	Vec	74.0	2	6,580	63,750	101	1,974,000		1,974,000	2.5
13	50		Tocome	0.327	0.142	39,700	17,240	121,000	Ve	13.9	1	1,810	17,330	101	543,000		543,000	1.0
14	50	Tocome	Tocome	9.448		152,200		16,000	Vec	182.0	5	19,480	154,460	101	5,844,000	313,200	6,157,200	6.5
15	50	Tenerias	Tocome	1.403		45,200		32,000	Ve	47.0	2	4,900	46,020	102	1,470,000		1,470,000	2.0
16	52	Agua de maiz	Agua de maiz	0.380	0.142	32,100	12,000	84,000	Ve	12.0	1	4,080	13,020	109	1,224,000		1,224,000	1.5
17	54	Sebucan	Sebucan	1.570		48,700		31,000	Vec	53.0	3	8,990	49,700	102	2,697,000		2,697,000	3.5
18	54		Sebucan	0.167	0.100	18,300	10,960	110,000	Ve	7.1	1	2,570	11,670	106	771,000		771,000	1.0
19	54	Pajarito	Sebucan	1.374		44,700		33,000	Vec	42.0	3	9,330	44,900	100	2,799,000		2,799,000	3.5
20	54		Sebucan	0.112		7,800		70,000	Ve	4.8	1	2,590	8,550	110	777,000		777,000	1.0
21	54		Sebucan	0.270	0.223	24,900	20,570	92,000	Vec	11.5	2	4,620	20,610	100	1,386,000		1,386,000	2.0
22	56	Quintero	Seca	1.973		56,200		28,000	Vec	41.2	2	7,290	57,360	102	2,187,000		2,187,000	2.5
23	56	Seca	Seca	0.775		30,800		40,000	Vec	25.9	1	3,860	32,300	105	1,158,000		1,158,000	1.5
24	56		Seca	0.207	0.840	15,100	6,130	73,000	Ve	8.8	1	1,750	6,920	113	525,000		525,000	1.0
25	58	Chacaito	Chacaito	6.332		112,400		18,000	Vec	117.0	4	9,300	113,470	101	2,790,000	771,600	3,561,600	4.0
26	58		Chacaito	0.158		10,100		64,000	Ve	6.7	0	0	0	0	0		0	
27	58		Chacaito	0.253	0.180	19,100	13,590	75,000	Ve	10.3	2	5,260	13,610	100	1,578,000		1,578,000	2.0
28	58	Chapellin	Chacaito	1.192		50,000		42,000	Ve	40.0	4	10,490	50,160	100	3,147,000		3,147,000	4.0
29	58		Chacaito	0.069		4,100		59,000	Ve	3.3	1	3,120	5,180	126	936,000		936,000	1.5
30	58	Cuno	Chacaito	0.598		57,100		95,000	Ve	24.5	4	13,700	57,500	101	4,110,000		4,110,000	5.0
31	58		Chacaito	0.235	0.136	14,000	8,100	60,000	Ve	10.9	1	2,720	9,000	111	816,000		816,000	1.5
32	62		Mariperez	0.057		3,400		60,000	Ve	2.7	0	0	0	0	0		0	
33	62	Mariperez	Mariperez	0.696		26,600		38,000	Vec	34.0	1	3,790	27,210	102	1,137,000		1,137,000	1.5
34	63		Canoas	0.092	0.034	5,500	2,030	60,000	Ve	4.3	1	1,140	2,250	111	342,000		342,000	1.0
35	63	Canoas	Canoas	0.569		23,200		41,000	Vec	28.0	1	1,900	24,750	107	570,000		570,000	1.0
36	66		Anauco	0.266	0.107	17,100	6,880	64,000	Ve	8.9	1	2,190	7,560	110	657,000		657,000	1.0
37	66	Gamboa	Anauco	3.071		71,800		23,000	Vec	52.8	5	11,350	73,310	102	3,405,000		3,405,000	4.5
38	66		Anauco	0.192		11,400		59,000	Ve	6.4	1	2,570	11,670	102	771,000		771,000	1.0
39	66	Beatas	Anauco	0.427		15,600		37,000	Vec	10.0	1	2,570	16,500	106	771,000		771,000	1.0
40	66		Anauco	0.191		11,400		60,000	Ve	6.4	2	3,940	12,060	106	1,182,000		1,182,000	2.0
41	66	Anauco	Anauco	3.690		106,900		29,000	Ve	50.0	4	9,370	107,570	101	2,811,000		2,811,000	4.0
42	66	Cotiza	Anauco	3.798		144,500		38,000	Vec	56.0	5	15,900	145,720	101	4,770,000		4,770,000	6.0
43	67		Catuche	0.269		11,300		42,000	Vec	10.4	0	0	0	0	0		0	
44	67	Catuche	Catuche	4.499		95,900		21,000	Vec	59.0	3	7,470	96,140	100	2,241,000	1,010,400	3,251,400	3.0
45	69	St.Isabel	Catroata	0.091		5,400		59,000	Ve	3.0	1	2,190	5,400	100	657,000		657,000	1.0
46	69		Catroata	0.082		4,900		60,000	Ve	2.7	1	1,680	5,540	113	504,000		504,000	1.0
47	69	Agua Salud	Catroata	0.478		21,700		45,000	Vec	14.7	2	3,930	21,710	100	1,179,000		1,179,000	2.0
											86	241,640	1,593,170		72,492,000	2,095,200	74,587,200	98

Table S16-2.4.2 (2/2) Summary of Sabo Dam for Principal Stream (25 Years Return Period)

No of Catchment		Catchment name		Area		Sediment Runoff Volume			Qp	No. of Dam	Concrete Volume	Trapped Sediment Volume	Ratio of Trapped to Runoff Volume	Dam_cost	channel works Cost	Total Cost	Construction Duration
				(km2)		(m3)		(m3/km2)	(m3/s)		(m3)	(m3)	(%)	×10³(BS)	×10³(BS)	×10³(BS)	(year)
1	48		Caurimare	0.161		7,751		48,000	6.0	0	0	0		0		0	
2	48		Caurimare	0.987	0.630	21,105	11,399	21,000	17.0	1	2,270	11,880	1726	681,000		681,000	1.5
3	48		Caurimare	0.075		3,193		43,000	2.8	0	0	0		0		0	
4	48	Caurimare	Caurimare	6.354		84,548		13,000	48.0	5	16,650	85,220	755	4,995,000		4,995,000	6.0
5	48	Galindo	Caurimare	3.845		49,147		13,000	50.0	2	7,110	49,550	1300	2,133,000		2,133,000	2.5
6	48		Caurimare	0.087		6,796		78,000	2.2	1	2,060	7,560	2575	618,000		618,000	1.0
7	48		Caurimare	0.36		13,029		36,000	10.1	1	2,990	16,670	2811	897,000		897,000	1.5
8	48	Pasaquire	Caurimare	1.143		28,309		25,000	22.0	2	4,400	28,950	1925	1,320,000		1,320,000	2.0
9	48		Caurimare	0.117		6,970		60,000	3.6	1	1,980	7,680	3051	594,000		594,000	1.0
10	48		Caurimare	0.055		3,276		60,000	1.7	1	1,700	3,800	3055	510,000		510,000	1.0
11	50	Gamburi	Tocome	0.247		11,797		48,000	7.5	1	2,500	11,990	3020	750,000		750,000	1.0
12	50	La Julia	Tocome	2.1		49,070		23,000	49.0	2	5,740	51,030	2333	1,722,000		1,722,000	2.5
13	50		Tocome	0.327	0.142	39,377	17,099	120,000	9.6	1	1,730	17,330	2920	519,000		519,000	1.0
14	50	Tocome	Tocome	9.448		118,627		13,000	105.0	5	16,680	123,980	1111	5,004,000	313,200	5,317,200	6.0
15	50	Tenerias	Tocome	1.403		35,465		25,000	31.0	2	4,040	36,210	2210	1,212,000		1,212,000	2.0
16	52	Agua de maiz	Agua de maiz	0.38	0.142	32,100	11,995	84,000	8.5	1	3,900	13,020	2237	1,170,000		1,170,000	1.5
17	54	Sebucan	Sebucan	1.57		38,088		24,000	32.0	3	6,970	39,910	2038	2,091,000		2,091,000	3.0
18	54		Sebucan	0.167	0.100	18,294	10,954	110,000	4.9	1	2,570	11,670	2922	771,000		771,000	1.0
19	54	Pajarito	Sebucan	1.374		34,996		25,000	27.0	3	7,420	35,840	1965	2,226,000		2,226,000	3.0
20	54		Sebucan	0.112		7,757		69,000	3.3	1	2,590	8,550	2920	777,000		777,000	1.0
21	54		Sebucan	0.27	0.223	19,479	16,088	72,000	7.9	2	3,910	16,740	2907	1,173,000		1,173,000	2.0
22	56	Quintero	Seca	1.973		43,948		22,000	24.1	1	4,390	45,360	1221	1,317,000		1,317,000	2.0
23	56	Seca	Seca	0.775		24,102		31,000	17.1	1	3,110	24,780	2300	933,000		933,000	1.5
24	56		Seca	0.207	0.084	15,093	6,124	73,000	6.1	1	1,740	6,920	2323	522,000		522,000	1.0
25	58	Chacaito	Chacaito	6.352		87,960		14,000	70.0	4	7,710	93,200	1105	2,313,000	771,500	3,084,500	3.5
26	58		Chacaito	0.150		10,056		64,000	4.5	0	0	0	2921	0		0	
27	58		Chacaito	0.253	0.180	19,114	13,601	76,000	7.1	2	5,240	15,610	2787	1,572,000		1,572,000	2.0
28	58	Chapellin	Chacaito	1.152		49,904		42,000	26.0	4	10,400	50,160	2101	3,129,000		3,129,000	4.0
29	58		Chacaito	0.069		4,110		60,000	2.1	1	3,110	5,180	3195	933,000		933,000	1.5
30	58	[illegible]	Chacaito	0.538		55,503		93,000	15.0	4	13,070	37,500	2509	3,921,000		3,921,000	5.0
31	58		Chacaito	0.225	0.106	10,993	8,102	50,000	7.5	1	2,500	9,000	3304	700,000		700,000	1.0
32	62		Mariperez	0.057		3,395		60,000	1.5	0	0	0	3228	0		0	
33	62	Mariperez	Mariperez	0.636		20,715		30,000	23.0	1	3,050	21,240	3305	915,000		915,000	1.5
34	63		Canoas	0.039	0.034	5,480	2,095	60,000	3.0	1	1,100	2,950	3159	330,000		330,000	1.0
35	63	Canoas	Canoas	0.559		10,140		19,000	20.0	1	1,680	20,060	3515	504,000		504,000	1.0
36	66		Anauco	0.206	0.107	17,073	6,070	34,000	6.1	1	2,100	7,500	2005	654,000		654,000	1.0
37	66	Gamboa	Anauco	3.071		73,030		24,000	31.5	5	10,810	75,310	1034	3,243,000		3,243,000	4.5
38	66		Anauco	0.182		11,437		65,000	4.1	1	2,570	7,670	2307	771,000		771,000	1.0
39	66	Boatico	Anauco	0.427		12,493		29,000	7.0	1	2,050	12,690	1639	615,000		615,000	1.0
40	66		Anauco	0.131		11,815		90,000	4.4	2	3,380	12,060	2104	1,140,000		1,140,000	2.0
41	66	Anauco	Anauco	5.50		106,007		20,000	30.0	4	9,200	107,570	710	2,704,000		2,704,000	4.0
42	66	Cotiza	Anauco	3.798		110,771		29,000	39.0	4	11,170	125,220	509	3,351,000		3,351,000	4.5
43	67		Catuche	0.269		9,054		34,000	7.3	0	0	0	2503	0		0	
44	67	Catuche	Catuche	4.439		73,477		16,000	34.0	3	6,120	78,200	756	1,536,000	1,310,400	2,846,400	2.5
45	69	St.Isabel	Caroata	0.091		5,421		60,000	2.1	1	2,190	5,400	2308	657,000		657,000	1.0
46	69		Caroata	0.072		4,005		55,000	1.3	1	1,670	5,540	2305	501,000		501,000	1.0
47	69	Agua Salud	Caroata	0.478		17,862		36,000	10.0	2	3,140	15,110	2004	942,000		942,000	1.5
										63	209,550	1,770,170		52,705,000	2,095,200	54,800,200	96

Table S16-2.4.3　Actual Cost for Sabo Dam Constructed in Vargas in 2000

FONTUR Prpject: Qda. Guanape (Vargas State)

Main Work Item	Description	Unit	Quantity	Unit Price (Bs. in 2000)	Total	Total for only related with Dam Works
Excavation	Removal of Vegetation	m3	1,200	1,775	2,130,492	2,130,492
	Excavation for Common Works 1	m3	66	5,034	332,227	332,227
	Excavation for Common Works 2	m3	2,317	5,034	11,663,176	11,663,176
	Excavation for Dam Works	m3	10	19,291	192,912	192,912
	Excavation for Channel Works 1	m3	50,000	3,185	159,270,000	–
	Excavation for Channel Works 2	m3	100,000	4,666	466,604,000	–
	Temporary Works	m3	15,000	2,590	38,844,750	38,844,750
	Sub TOTAL				**679,037,557**	**53,163,557**
Concrete Works	Concrete (80kg/cm2) for Closed Dam	m3	1,100	120,697	132,766,216	132,766,216
	Concrete (80kg/cm2) for Open type Dam	m3	995	120,697	120,093,077	120,093,077
	RC Concrete (250kg/cm2) for Closed Dam	m3	80	187,111	14,968,917	14,968,917
	RC Concrete (250kg/cm2) for Open type Dam	m3	250	190,322	47,580,485	47,580,485
	RC Concrete (250kg/cm2) for Channel Works	m3	4,130	176,793	730,153,768	–
	RC Concrete (250kg/cm2) for Channel Transition	m3	800	192,232	153,785,632	153,785,632
	Sub TOTAL				**1,199,348,095**	**469,194,327**
TOTAL					**1,878,385,652**	**522,357,884**
Overhead (15% of TOTAL)					281,757,848	78,353,683
Ground Total					**2,160,143,500**	**600,711,566**

Table S16-2.5.1 Channel Works

Table S16 2.5.1 Channel Works

14.Tocome

No	Name	section	Coordinate		Distance		Existing Channel			Proposed Channel				
			X	Y	Cumulative	Interval	Bed Elevation	Bed Slope		Proposed bed elevation	Proposed Drop Height	Original Bed slope	Proposed Bed Slope	
			(m)	(m)	(m)	(m)	(m)	(1/n)	(degree)	(m)	(m)	(1/n)	(1/n)	(degree)
14	tocome	1	738223	1162484	0.00		903.0			903.00		49.14		
14	tocome	2	738202	1162580	98.27	98.27	905.0	49.14	1.17	905.00	0.00		50.00	1.15
14	tocome	3	738197	1162622	140.57	42.30	907.5	16.92	3.38	907.50	1.65	23.64	50.00	1.15
14	tocome	4	738221	1162694	216.46	75.89	910.0	30.36	1.89	910.00	0.98		50.00	1.15
14	tocome	5	738249	1162754	282.67	66.21	915.0	13.24	4.32	912.99	1.67	22.11	50.00	1.15
14	tocome	6	738347	1162874	437.60	154.93	920.0	30.99	1.85	920.00	3.91		50.00	1.15

25.Chacaito

No	Name	section	Coordinate		Distance		Existing Channel			Proposed Channel				
			X	Y	Cumulative	Interval	Bed Elevation	Bed Slope		Proposed bed elevation	Proposed Drop Height	Original Bed slope	Proposed Bed Slope	
			(m)	(m)	(m)	(m)	(m)	(1/n)	(degree)	(m)	(m)	(1/n)	(1/n)	(degree)
25	chacaito	1	733786	1162298	0.00		910.0			910.00		26.41		
25	chacaito	2	733801	1162364	67.68	67.68	912.5	27.07	2.12	912.50	0.00		26.00	2.20
25	chacaito	3	733836	1162418	132.03	64.35	915.0	25.74	2.22	915.00	0.02		26.00	2.20
25	chacaito	4	733883	1162472	203.62	71.59	920.0	14.32	3.99	918.79	1.04	18.89	26.00	2.20
25	chacaito	5	733938	1162526	280.70	77.08	925.0	15.42	3.71	922.87	1.12		26.00	2.20
25	chacaito	6	733962	1162592	350.93	70.23	930.0	14.05	4.07	926.59	1.02		26.00	2.20
25	chacaito	7	733989	1162664	427.83	76.90	932.5	30.76	1.86	930.66	1.11		26.00	2.20
25	chacaito	8	734046	1162724	510.59	82.76	935.0	33.10	1.73	935.04	1.20		26.00	2.20
25	chacaito	9	734098	1162802	604.33	93.74	940.0	18.75	3.05	940.00	1.35		26.00	2.20
25	chacaito	10	734130	1162838	652.50	48.17	945.0	9.63	5.93	943.73	1.88	12.90	26.00	2.20
25	chacaito	11	734169	1162898	724.06	71.56	950.0	14.31	4.00	949.28	2.79		26.00	2.20
25	chacaito	12	734191	1162940	771.47	47.41	955.0	9.48	6.02	952.96	1.86		26.00	2.20
25	chacaito	13	734201	1162994	826.39	54.92	960.0	10.98	5.20	957.21	2.14		26.00	2.20
25	chacaito	14	734212	1163018	852.79	26.40	962.5	10.56	5.41	959.26	1.03		26.00	2.20
25	chacaito	15	734219	1163054	889.46	36.67	965.0	14.67	3.90	962.10	1.43		26.00	2.20
25	chacaito	16	734224	1163090	925.81	36.35	967.5	14.54	3.93	964.92	1.42		26.00	2.20
25	chacaito	17	734240	1163138	976.41	50.60	970.0	20.24	2.83	968.84	1.97		26.00	2.20
25	chacaito	18	734248	1163174	1013.29	36.88	972.5	14.75	3.88	971.70	1.44		26.00	2.20
25	chacaito	19	734254	1163216	1055.72	42.43	975.0	16.97	3.37	975.00	1.67		26.00	2.20
25	chacaito	20	734268	1163264	1105.72	50.00	980.0	10.00	5.71	980.00	3.08	10.00	26.00	2.20

↑See attached figures

Table S16-2.6.1 Work Quantity for Temporary Works

No of Catchment		Temporary Yard		Cable Crane		Road	Monorail	Construction Period(1/100)									Construction Period(1/25)								
								Period for Temporary Works		Month for Earth Works		Period for Concrete Works			Total		Period for Temporary Works		Month for Earth Works		Period for Concrete Works			Total	
		Availability	Area	nos.	length	length	length	Total length	L<500m:1M L<1000m:2M L<3000m:3M	noc. of dam	3M /1 dam	Concrete Volume	55m^3/(1day+4day)				Total length	L<500m:1M L<1000m:2M L<3000m:3M	noc. of dam	3M /1 dam	Concrete Volume	55m^3/(1day+4day)			
		Area>600m^2	(m^2)	(-)	(m)	(m)	(m)	(m)	(month)	(-)	(month)	(m3)	(day)	(month)	(month)	(year)	(m)	(month)	(-)	(month)	(m3)	(day)	(month)	(month)	(year)
2		○	18,238	1	50	1,198	0	1,248	3	1	3	2,280	207	7	13	1.5	1,248	3	1	3	2,270	206	7	13	1.5
4	Caurimare	○	1,478	0	0	977	491	1,468	3	6	18	21,260	1,933	65	86	7.5	2,084	3	5	15	16,650	1,514	51	69	6.0
5	Galindo	○	2,786	0	0	309	0	309	1	2	6	8,460	769	26	33	3.0	828	2	2	6	7,110	646	22	30	2.5
6		○	share with No.7	1	242	0	0	242	1	1	3	2,070	188	7	11	1.0	206	1	1	3	2,060	187	7	11	1.0
7		○	1,048	1	247	0	0	247	1	1	3	3,130	285	10	14	1.5	309	1	1	3	2,990	272	10	14	1.5
8	Pasaquire	○	1,669	0	0	401	0	401	1	2	6	5,140	467	16	23	2.0	506	2	2	6	4,400	400	14	22	2.0
9		○	1,036	0	0	0	0	0	1	1	3	2,050	186	7	11	1.0	204	1	1	3	1,980	180	6	10	1.0
10		○	579	0	0	0	0	0	1	1	3	1,700	155	6	10	1.0	171	1	1	3	1,700	155	6	10	1.0
11	Gamburi	○	1,114	0	0	0	0	0	1	1	3	3,120	284	10	14	1.5	308	1	1	3	2,500	227	8	12	1.0
12	La Julia	○	1,277	0	0	312	0	312	1	2	6	6,580	598	20	27	2.5	645	2	2	6	5,740	522	18	26	2.5
13		○	859	0	0	0	0	0	1	1	3	1,810	165	6	10	1.0	181	1	1	3	1,730	157	6	10	1.0
14	Tocome	○	2,341	7	1,524	531	656	2,711	3	5	15	19,480	1,771	60	78	6.5	1,909	3	5	15	16,680	1,516	51	69	6.0
15	Tereries	○	share with No.14	0	0	239	0	239	1	2	6	4,900	445	15	22	2.0	482	1	2	6	4,040	367	13	20	2.0
16	Agua de maiz	○	1,134	0	0	0	0	0	1	1	3	4,080	371	13	17	1.5	401	1	1	3	3,900	355	12	16	1.5
17	Sebucan	○	2,115	0	0	0	0	0	1	3	9	8,990	817	28	38	3.5	883	2	3	9	6,970	634	22	33	3.0
18		○	1,195	0	0	0	0	0	1	1	3	2,570	234	8	12	1.0	254	1	1	3	2,570	234	8	12	1.0
19	Pajarito	○	2,802	1	210	244	257	711	2	3	9	9,330	848	29	40	3.5	917	2	3	9	7,420	675	23	34	3.0
20		○	2,276	1	126	0	0	126	1	1	3	2,590	235	8	12	1.0	255	1	1	3	2,590	235	8	12	1.0
21		○	2,101	1	84	99	0	183	1	2	6	4,620	420	14	21	2.0	455	1	2	6	3,910	355	12	19	2.0
22	Quintero	○	2,552	0	0	224	0	224	1	2	6	7,290	663	23	30	2.5	716	2	1	3	4,390	399	14	19	2.0
23	Seca	○	share with No.22	1	181	337	0	518	2	1	3	3,860	351	12	17	1.5	380	1	1	3	3,110	283	10	14	1.5
24		○	826	2	295	0	0	295	1	1	3	1,750	159	6	10	1.0	175	1	1	3	1,740	158	6	10	1.0
25	Chacaito	○	1,045	0	0	1,041	0	1,041	3	4	12	9,300	845	29	44	4.0	918	2	4	12	7,710	701	24	38	3.5
27		○	1,245	1	140	0	0	140	1	2	6	5,260	478	16	23	2.0	517	2	2	6	5,240	476	16	24	2.0
28	Chapellin	○	1,422	1	300	504	0	804	2	4	12	10,490	954	32	46	4.0	1,032	3	4	12	10,430	948	32	47	4.0
29		○	1,281	0	0	0	0	0	1	1	3	3,120	284	10	14	1.5	308	1	1	3	3,110	283	10	14	1.5
30	Cuno	○	2,628	4	698	369	0	1,067	3	4	12	13,700	1,245	42	57	5.0	1,344	3	4	12	13,070	1,188	40	55	5.0
31		○	1,262	1	71	0	0	71	1	1	3	2,720	247	9	13	1.5	269	1	1	3	2,600	236	8	12	1.0
33	Mariperez	○	1,409	0	0	169	0	169	1	1	3	3,790	345	12	16	1.5	373	1	1	3	3,050	277	10	14	1.5
34		○	758	0	0	0	0	0	1	1	3	1,140	104	4	8	1.0	116	1	1	3	1,100	100	4	8	1.0
35	Canoas	○	1,389	0	0	0	163	163	1	1	3	1,900	173	6	10	1.0	189	1	1	3	1,680	153	6	10	1.0
36		○	861	0	0	0	151	151	1	1	3	2,190	199	7	11	1.0	217	1	1	3	2,180	198	7	11	1.0
37	Gamboa	○	2,013	0	0	871	0	871	2	5	15	11,350	1,032	35	52	4.5	1,119	3	5	15	10,810	983	33	51	4.5
38		○	1,077	0	0	0	0	0	1	1	3	2,570	234	8	12	1.0	254	1	1	3	2,570	234	8	12	1.0
39	Beatas	○	1,077	0	0	0	0	0	1	1	3	2,570	234	8	12	1.0	254	1	1	3	2,050	186	7	11	1.0
40		○	1,865	1	119	0	0	119	1	2	6	3,940	358	12	19	2.0	389	1	2	6	3,930	357	12	19	2.0
41	Anauco	○	1,724	2	688	1,483	0	2,171	3	4	12	9,370	852	29	44	4.0	925	2	4	12	9,280	844	29	43	4.0
42	Cotiza	○	6,909	0	0	1,218	0	1,218	3	5	15	15,900	1,445	49	67	6.0	1,561	3	4	12	11,170	1,015	34	49	4.5
44	Catuche	○	1,390	0	0	923	0	923	2	3	9	7,470	679	23	34	3.0	736	2	3	9	6,120	556	19	30	2.5
45	St.Isabel	no	construction using small machine or man power	0	0	243	0	243	1	1	3	2,190	199	7	11	1.0	217	1	1	3	2,190	199	7	11	1.0
46		no		1	136	0	0	136	1	1	3	1,680	153	6	10	1.0	169	1	1	3	1,670	152	6	10	1.0
47	Agua Salud	no		0	0	313	0	313	1	2	6	3,930	357	12	19	2.0	388	1	2	6	3,140	285	10	17	1.5
sum			77,721	27	5,111	12,005	1,718	18,834		86		241,640				97.5	24,812		83		209,550				89.5

Table S16-2.6.2 Proposed Implementation Schedule

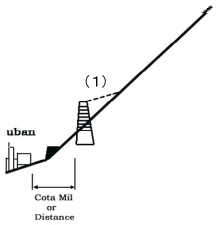
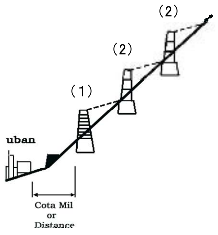
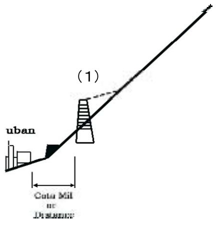
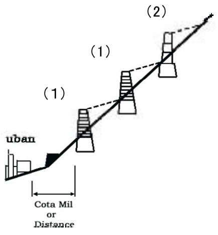
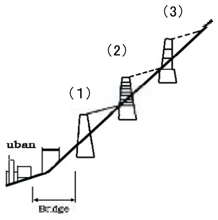
Name of Catchment		Sabo Dam Works				Channel Works				Annual Construction Cost																sum
		Nos.	Concrete Volume	Construction Cost	Construction Period	Length	Concrete Volume	Construction Cost	Construction Period	BS/year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	sum
		(-)	(m3)	(×10³BS)	(year)	(m)	(m3)	(×10³BS)	(year)	(×10³BS)	(×10³BS)	(×10³BS)	(×10³BS)	(×10³BS)	(×10³BS)	(×10³BS)	(×10³BS)	(×10³BS)	(×10³BS)	(×10³BS)	(×10³BS)	(×10³BS)	(×10³BS)	(×10³BS)	(×10³BS)	(×10³BS)
17	Tócome	6	18,480	5,544,000	6.5					852,923	852,923	852,923	852,923	852,923	852,923	852,923	426,462									5,544,000
						450	[illegible]	3,102	8.0	392								392	392	392	392	392	392	392	392	3,102
25	Chacaito	4	9,300	2,790,000	4.0					697,500	697,500	697,500	697,500	697,500												2,790,000
						[illegible]	[illegible]	[illegible]	11.0	701					701	701	701	701	701	701	701	701	701	701	701	[illegible]
44	Catuche	3	7,470	2,241,000	3.0					747,000	747,000	747,000	747,000													2,241,000
						1,600	[illegible]	1,010,400	12.0	84,200				84,200	84,200	84,200	84,200	84,200	84,200	84,200	84,200	84,200	84,200	84,200	84,200	1,010,400
7	[illegible]	6	21,260	6,378,000	7.5					850,400	850,400	850,400	850,400	850,400	850,400	850,400	850,400	425,200								6,378,000
42	Cotiza	5	15,900	4,770,000	6.0					795,000	795,000	795,000	795,000	795,000	795,000	795,000										4,770,000
30	[illegible]	4	13,700	4,110,000	5.0					822,000	822,000	822,000	822,000	822,000	822,000											4,110,000
37	[illegible]	6	11,350	3,405,000	4.5					756,667			756,667	756,667	756,667	756,667	378,333									3,405,000
20	Chapellin	4	10,490	3,147,000	4.0					786,750					786,750	786,750	786,750	786,750								3,147,000
41	Anauco	4	9,370	2,811,000	4.0					702,750						702,750	702,750	702,750	702,750							2,811,000
17	[illegible]	5	8,890	2,667,000	3.5					762,000							762,000	762,000	762,000	381,000						2,667,000
19	Pajarito	3	9,320	2,796,000	3.5					798,714							798,714	798,714	798,714	399,357						2,796,000
5	Galindo	2	8,460	2,538,000	3.0					846,000								846,000	846,000	846,000						2,538,000
11	La Julia	2	6,380	1,914,000	2.5					765,600								765,600	765,600	382,800						1,914,000
22	Quintero	5	7,290	2,187,000	2.5					874,800									874,800	874,800	437,400					2,187,000
8	Pasacuire	2	5,140	1,542,000	2.0					771,000										771,000	771,000					1,542,000
16	[illegible]	2	4,900	1,470,000	2.0					735,000										735,000	735,000					1,470,000
21		2	4,620	1,386,000	2.0					693,000										693,000	693,000					1,386,000
27		2	5,260	1,578,000	2.0					789,000											789,000	789,000				1,578,000
10		2	3,940	1,182,000	2.0					591,000											591,000	591,000				1,182,000
47	Agua Salud	2	3,930	1,179,000	2.0					589,500											589,500	589,500				1,179,000
2		1	2,280	684,000	1.5					456,000											456,000	228,000				684,000
[illegible]		1	2,830	849,000	1.5					566,000												566,000	283,000			849,000
11	[illegible]	1	2,120	636,000	1.5					424,000												424,000	212,000			636,000
13	[illegible]	1	4,080	1,224,000	1.5					816,000												816,000	408,000			1,224,000
23	[illegible]	1	3,860	1,158,000	1.5					772,000												772,000	386,000			1,158,000
29		1	2,920	876,000	1.5					584,000													584,000	292,000		876,000
31		1	2,720	816,000	1.5					544,000													544,000	272,000		816,000
33	[illegible]	1	3,740	1,122,000	1.5					748,000													748,000	374,000		1,122,000
6		1	2,070	621,000	1.0					621,000													621,000			621,000
9		1	2,050	615,000	1.0					615,000													615,000			615,000
10		1	1,700	510,000	1.0					510,000													510,000			510,000
10		1	1,800	540,000	1.0					540,000														540,000		540,000
18		1	2,570	771,000	1.0					771,000														771,000		771,000
[illegible]		1	[illegible]	[illegible]	1.0					[illegible]														[illegible]		[illegible]
24		1	1,750	525,000	1.0					525,000														525,000		525,000
34		1	1,140	342,000	1.0					342,000														342,000		342,000
[illegible]	[illegible]	1	1,900	570,000	1.0					570,000														570,000		570,000
36		1	2,190	657,000	1.0					657,000															657,000	657,000
39		1	2,570	771,000	1.0					771,000															771,000	771,000
34	[illegible]	1	[illegible]	[illegible]	1.0					[illegible]															[illegible]	[illegible]
45	St Isabel	1	2,190	657,000	1.0					657,000															657,000	657,000
43		1	1,680	504,000	1.0					504,000															504,000	504,000
sum		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
										Nos. of stream	5	5	7	7	[illegible]	[illegible]	9	10	9	11	11	11	10	12	0	

Note: BS is the Bolivar Currency in 2005

Table S16-2.7.1 Feature of Transported Sediment

Main Segment	Manner of Sediment Transport	Detailed Segment	Slope	Phenomena	Effectiveness of sabo dam for debris flow transport		Applicable Sabo Dam Type
Debris Flow Segment	Mass Transport	Generation	steeper than 20 degree	Initial Generation of debris Flow Steep slope failure Erosion of streambed deposit	C	(1)Trap of debris flow(reduction of sediment runoff)	A: Open Type (wide slit Type) B:Open Type (narrow slit Type)
		Generation–Transport	15~20	Development of debris flow Erosion of streambed deposit Production and breach of natural dam Concentration of boulders at the debris flow front Surge wave of debris flow	C	(1)Trap of debris flow(reduction of sediment runoff) (2)Trap of boulders and drift woods at the debris flow front	A: Open Type (wide slit Type) B:Open Type (narrow slit Type)
		Transport–Deposit	10~15	Transport of boulders Production and breach of natural dam	B	(1)Trap of debris flow(reduction of sediment runoff) (2)Trap of boulders and drift woods at the debris flow front (3)Reduction of peak discharge of debris flow (4)Retarding of concentration time to alluvial fan (5)Trap of debris flow	A: Open Type (wide slit Type) B:Open Type (narrow slit Type)
		Deposit	3~10	Development of Allivial fans	A	(1)Trap of debris flow(reduction of sediment runoff) (2)Trap of boulders and drift woods at the debris flow front (3)Reduction of peak discharge of debris flow (4)Retarding of concentration time to alluvial fan (5)Trap of debris flow (6)Transition of debris flow to bedload transport	A:Open Type (narrow opening Type) A:Close Type (close to target property)
Bedload Transport Segment	Individual Transport	–	milder than 3 degree	Deposit and clog in channel resulting to overflow	–	(7)Control of bedload (8)Trap of floating wood (9)Elimination of debris flow	B:Close Type B:Drift wood trapping B:Channel Works

Table S16-2.7.2 Comparison of Sabo Dam Layout

<table>
<tr><td>Segment</td><td colspan="2">A. Generation — Generation･Transport — Transport･Deposition</td><td colspan="3">B. Generation — Generation･Transport — Transport･Deposition — Deposition(partially bedload)</td></tr>
<tr><td>Streambed Slope</td><td colspan="2">steeper than 10 degree</td><td colspan="3">steeper than 3 degree or 2 degree</td></tr>
<tr><td>Function</td><td>Single</td><td>Combination</td><td>Single</td><td>Combination</td><td>Combination</td></tr>
<tr><td>Principal Steam No.</td><td>2,6,7,9,10,13,16,18,20,24,29,31
33,34,36,38,39,45,46</td><td>17,21,27,30,40,47</td><td>11,23,35</td><td>5,8,12,(14),15,19,22,28,37,41,42,44</td><td>4,25</td></tr>
<tr><td>General Layout</td>
<td> </td>
<td> </td>
<td> </td>
<td> </td>
<td> </td></tr>
<tr><td>Dam Type</td><td>OpenType(narrow slit)
or
OpenType(wide slit) in the case of far from urban area</td><td>downstream : OpenType(narrow slit)
upstream : OpenType(wide slit)</td><td>OpenType(narrow slit)</td><td>downstream : OpenType(narrow slit)
upstream : OpenType(narrow slit)
or
OpenType(wide slit)</td><td>downstream : CloseType
upstream : OpenType(narrow slit)
or
OpenType(wide slit)</td></tr>
<tr><td>Structure Type</td>
<td><table>
<tr><th>Type</th><th>No</th><th>Applicability</th><th colspan="3">Structure</th></tr>
<tr><td rowspan="5">Open</td><td>1</td><td>○</td><td>1</td><td rowspan="3">Large</td><td>Concrete Slit</td></tr>
<tr><td>1</td><td>※</td><td>2</td><td>Frame/CF/I-type</td></tr>
<tr><td>1</td><td>※</td><td>3</td><td>L-type</td></tr>
<tr><td>1</td><td>※</td><td>4</td><td rowspan="2">Small</td><td>B-type</td></tr>
<tr><td>1</td><td>※</td><td>5</td><td>A-type</td></tr>
<tr><td rowspan="3">Close</td><td></td><td></td><td>1</td><td colspan="2">Concrete</td></tr>
<tr><td></td><td></td><td>2</td><td colspan="2">Doublewall</td></tr>
<tr><td></td><td></td><td>3</td><td colspan="2">Steel Frame</td></tr>
<tr><td></td><td colspan="5">※in the case of far from urban area</td></tr>
</table></td>
<td><table>
<tr><th>Type</th><th>No</th><th>Applicability</th><th colspan="3">Structure</th></tr>
<tr><td rowspan="5">Open</td><td>1</td><td>○</td><td>1</td><td rowspan="3">Large</td><td>Concrete Slit</td></tr>
<tr><td>2</td><td>○</td><td>2</td><td>Frame/CF/I-type</td></tr>
<tr><td></td><td></td><td>3</td><td>L-type</td></tr>
<tr><td>2</td><td>○</td><td>4</td><td rowspan="2">Small</td><td>B-type</td></tr>
<tr><td></td><td></td><td>5</td><td>A-type</td></tr>
<tr><td rowspan="3">Close</td><td></td><td></td><td>1</td><td colspan="2">Concrete</td></tr>
<tr><td></td><td></td><td>2</td><td colspan="2">Doublewall</td></tr>
<tr><td></td><td></td><td>3</td><td colspan="2">Steel Frame</td></tr>
</table></td>
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<tr><th>Type</th><th>No</th><th>Applicability</th><th colspan="3">Structure</th></tr>
<tr><td rowspan="5">Open</td><td>1</td><td>○</td><td>1</td><td rowspan="3">Large</td><td>Concrete Slit</td></tr>
<tr><td>1</td><td>○</td><td>2</td><td>~~Frame/CF~~/I-type</td></tr>
<tr><td></td><td></td><td>3</td><td>L-type</td></tr>
<tr><td></td><td></td><td>4</td><td rowspan="2">Small</td><td>B-type</td></tr>
<tr><td></td><td></td><td>5</td><td>A-type</td></tr>
<tr><td rowspan="3">Close</td><td></td><td></td><td>1</td><td colspan="2">Concrete</td></tr>
<tr><td></td><td></td><td>2</td><td colspan="2">Doublewall</td></tr>
<tr><td></td><td></td><td>3</td><td colspan="2">Steel Frame</td></tr>
</table></td>
<td><table>
<tr><th>Type</th><th>No</th><th>Applicability</th><th colspan="3">Structure</th></tr>
<tr><td>Open</td><td>1</td><td>○</td><td>1</td><td rowspan="4">Large</td><td>Concrete Slit</td></tr>
<tr><td></td><td>1</td><td>○</td><td>2</td><td>~~Frame/CF~~/I-type</td></tr>
<tr><td></td><td>2</td><td>○</td><td>2</td><td>Frame/CF/I-type</td></tr>
<tr><td></td><td>2</td><td>○</td><td>3</td><td>L-type</td></tr>
<tr><td></td><td>2</td><td>○</td><td>4</td><td rowspan="2">Small</td><td>B-type</td></tr>
<tr><td></td><td>2</td><td>○</td><td>5</td><td>A-type</td></tr>
<tr><td rowspan="3">Close</td><td></td><td></td><td>1</td><td colspan="2">Concrete</td></tr>
<tr><td></td><td></td><td>2</td><td colspan="2">Doublewall</td></tr>
<tr><td></td><td></td><td>3</td><td colspan="2">Steel Frame</td></tr>
</table></td>
<td><table>
<tr><th>Type</th><th>No</th><th>Applicability</th><th colspan="3">Structure</th></tr>
<tr><td rowspan="5">Open</td><td>2･3</td><td>○</td><td>1</td><td rowspan="3">Large</td><td>Concrete Slit</td></tr>
<tr><td>2･3</td><td>○</td><td>2</td><td>Frame/CF/I-type</td></tr>
<tr><td>2</td><td></td><td>3</td><td>L-type</td></tr>
<tr><td>2･3</td><td></td><td>4</td><td rowspan="2">Small</td><td>B-type</td></tr>
<tr><td>2</td><td></td><td>5</td><td>A-type</td></tr>
<tr><td rowspan="3">Close</td><td>1</td><td>○</td><td>1</td><td colspan="2">Concrete</td></tr>
<tr><td>1</td><td>○</td><td>2</td><td colspan="2">Doublewall</td></tr>
<tr><td>1</td><td>○</td><td>3</td><td colspan="2">Steel Frame</td></tr>
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</table>

Table S16-2.7.3 Comparison of Open Type Dam

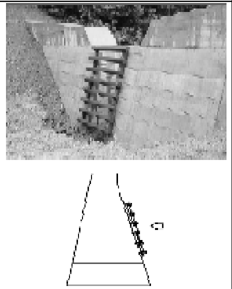
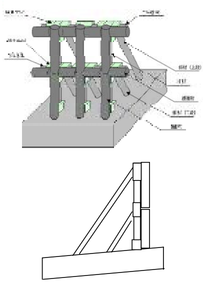
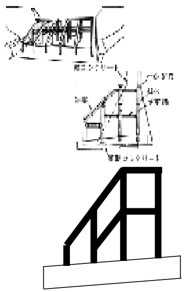
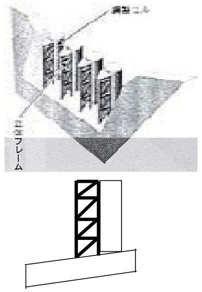
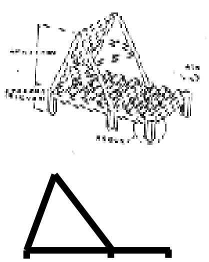
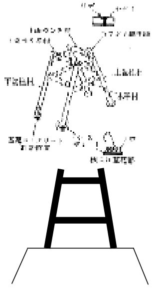
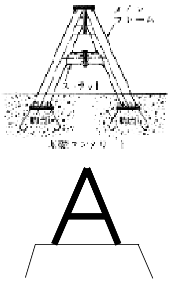
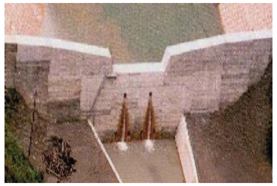
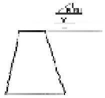
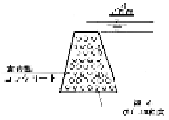
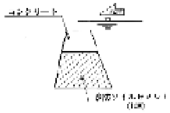
Type	Gravity Concrete Slit Dam	Steel Open Type					
Scale	small-large	large				small	
No	(1)		(2)		(3)	(4)	(5)
slit opening	narrow	narrow-medium	medium-wide	medium-wide	narrow-medium	medium	medium-narrow
Name	**Gravity Concrete Slit Dam**	**I-type Slit Dam**	**Frame-type Slit Dam**	**CF-type Slit Dam**	**Slit Dam Type L**	**Slit Dam Type B**	**Slit Dam Type A**
General Layout							
Structure Type	Gravity Concrete	Solid Steel Pipe for shock absorber	Grid Steel Frame	Combination of Steel cells and Solid Steel Frame	Steel Pipe	Steel Pipe Frame	Steel Pipe Frame filled with concrete
General	This is a new type of the conventional concrete gravity type dam (closed). They have been constructed for Sabo and River Project in Japan and they are reliable and popular. They are rigid, so that strong for deflection. Also the structure can be flexible to the site conditions.	The steel frame as shock absorber is installed upstream and the truss members are installed downstream in order to resist the debris flow energy. The selection of structure type and steel pipe can be flexible to respond to various design conditions and site conditions. The steel frame as shock absorber does not have any joint, so that the hit of boulder is absorbed by the deflection of the beam, not resulting into the break of the beam.	The grid steel frame type is composed of the steel pipe (diameter 600 mm), which is the rigid-jointed structure. The horizonral beams are installed to avoid the trapped debris from passing by the following flow. Also a lot of colums are connected to the foundation, so that the energy of the debris flow is dispersed to those colums.	The CF (Cell Frame) type slit dam is composed of the steel cells upstream and the solid steel frame downstream. The steel cells absorbes the energy of debris flow and resist it with the steel frame.	Steel L-type slit dam was developed for the site where rigid concrete foundation is not available. The upper structure can trap debris flow. The lower structure (foundation) is composed of piles resisting for debris flow hit and drainboard supporting sediment weight. It should be located in debris flow section in order to trap the debris flow. Steel pipes can absorb the debris flow energy by its deformation.	Steel B-type slit dam is a kind of solid frame type, stable structure even when debris flow hits the structure with different direction from the flow direction. Inside the steel pipe, concrete is not filled. It should be located in debris flow section in order to trap the debris flow. Steel pipes can absorb the debris flow energy by its deformation.	Steel A-type slit dam is a frame type of "A" shape with concrete foundation, stable structure even when debris flow hits the structure with different direction from the flow direction. Inside the steel pipe, concrete is filled. It should be located in bedload flow section. It is sometimes used as drift wood trap at sub dam.
Height	No limit	No limit(～14.5m)	Steel Frame H=8.0m～14.5m	No limit(～14.5m)	No limit(～14.5m)	Steel Frame H=3.0m～6.0m	Steel Frame H=3.0m～5.0m
	The stream continuity shall be kept to set the top of the foundation concrete being same as the existing stream bed.	The stream continuity shall be kept to set the top of the foundation concrete being same as the existing stream bed.	The stream continuity shall be kept to set the top of the foundation concrete being same as the existing stream bed.	The stream continuity shall be kept to set the top of the foundation concrete being same as the existing stream bed.	The stream continuity can be kept because the concrete foundation is not necessary.	The stream continuity can not be kept because of the concrete foundation.	The stream continuity can not be kept because of the concrete foundation.
Resistance to Debris Hit	Medium	Large	Large	Large	Small	medium	Small
Environmental Consideration	Decorated form can be used.	The steel frame part does not shut down the background. The wing part can be glazed.	The steel frame part does not shut down the background. The wing part can be glazed.	The steel frame part does not shut down the background. The wing part can be glazed.	The steel frame part does not hide the background.	The steel frame part does not hide the background. The wing part and waterway can be glazed.	The steel frame part does not hide the background. The wing part and waterway can be glazed.
Material	Concrete	Carbon steel pipe	Carbon steel pipe	Rolled steel bar	Carbon steel pipe	Carbon steel pipe	Carbon steel pipe
Foundation	Direct Foundation	Concrete foundation	Concrete foundation	Concrete foundation	Direct foundation	Concrete foundation	Concrete foundation

Table S16-2.7.4 Comparison of Closed Type Dam

Name	Gravity Concrete Type			Steel Frame Type	Grouting Type
General Layout					
	 Mass concrete structure	 Rubble concrete structure	 Soil cement structure		
General Structure	Concrete is filled in between upstream and downstream formings.	Concrete volumeiis reduced by the use of rubble stone.	Soil on site and cement milk is mixtured on site.	Filling material such as cobbles is put inside the steel frame fabricated by factory-made steel beams.	The wall material using grouting is placed downstream and the steel sheet pile is installed upstream for debris flow. The wall material is connected by tierod to tie the filling materials.
Material	Concrete, Forming	High viscous Concrete, Forming Rubble stone(φ0.3m) : on site It is necessary to collect rubble stone and transport on site.	Concrete, Forming Soil on site	Factory-made steel bars	Steel sheet pile, grauting, other steel bars
Applicability for Site Condition	The dam itself is heavy, so the weak ground is not appropriate. Cracks can happen when the dam is placed on the weak ground. The shape of the dam is flexible.			Since the filling material is cobble stone, the dam itself is not heavy. It can be placed on the comparatively weak ground. The joint of each member is hinge-type. The dam can follow the non-uniform subsidence.	Since the filling material is cobble stone, the dam itself is not heavy. It can be placed on the comparatively weak ground. The resistance for lateral deflection is low. The longitudinal deflection is flexible because of the joint by tie rod.
Resistance to Debris Flow	The dam has enough streangth for debris flow. This type of dam is appropriate for the debris flow trapping. ◎			The deflection and break of the steel material are caused by debris flow hit. The upstream side of the dam should have the shock absorber. ×	The steel sheet pile upstream is strong enough for debris flow. It is appropriate as the debris flow trapping. ○
Construction	The access road is necessary for the transpotation of construction machine and materials. The quality control for the concrete is important. △			The dam can be fabricated by bolt locking. In general, any special skill is not needed for the fabrication. Since the quality control for concrete is not necessary, the construction period can be reduced. ○	The main construction work is to install the steel sheet pile. In general, any special skill is not needed for the fabrication. It is not affected by weather conditins. Quality control for filling material is necessary. Since the quality control for concrete is not necessary, the construction period can be reduced. ○
Economic Aspect	In the case of large dam, the greate amount of excavated material has to be disposed. If the disposal site is near the dam site, the construction cost is comparatively cheap. △			This type is economical in the case of small dam. If the stream bed material can be used as the filling material, it can be advantageous. ○	The cost for the wall material is a lot of portion in the entire construction cost, so that the large scale dam is advantageous. Also the excavated materila can be used for the filling material for the dam and the disposal site is not necessary. △
Evaluation	The most appropriate type as long as the disposal site is near the dam site.			Not appropriate for the debris flow trapping.	It is appropriate for the large scale dam when the excavated material ca be used for the filling material of the dam.

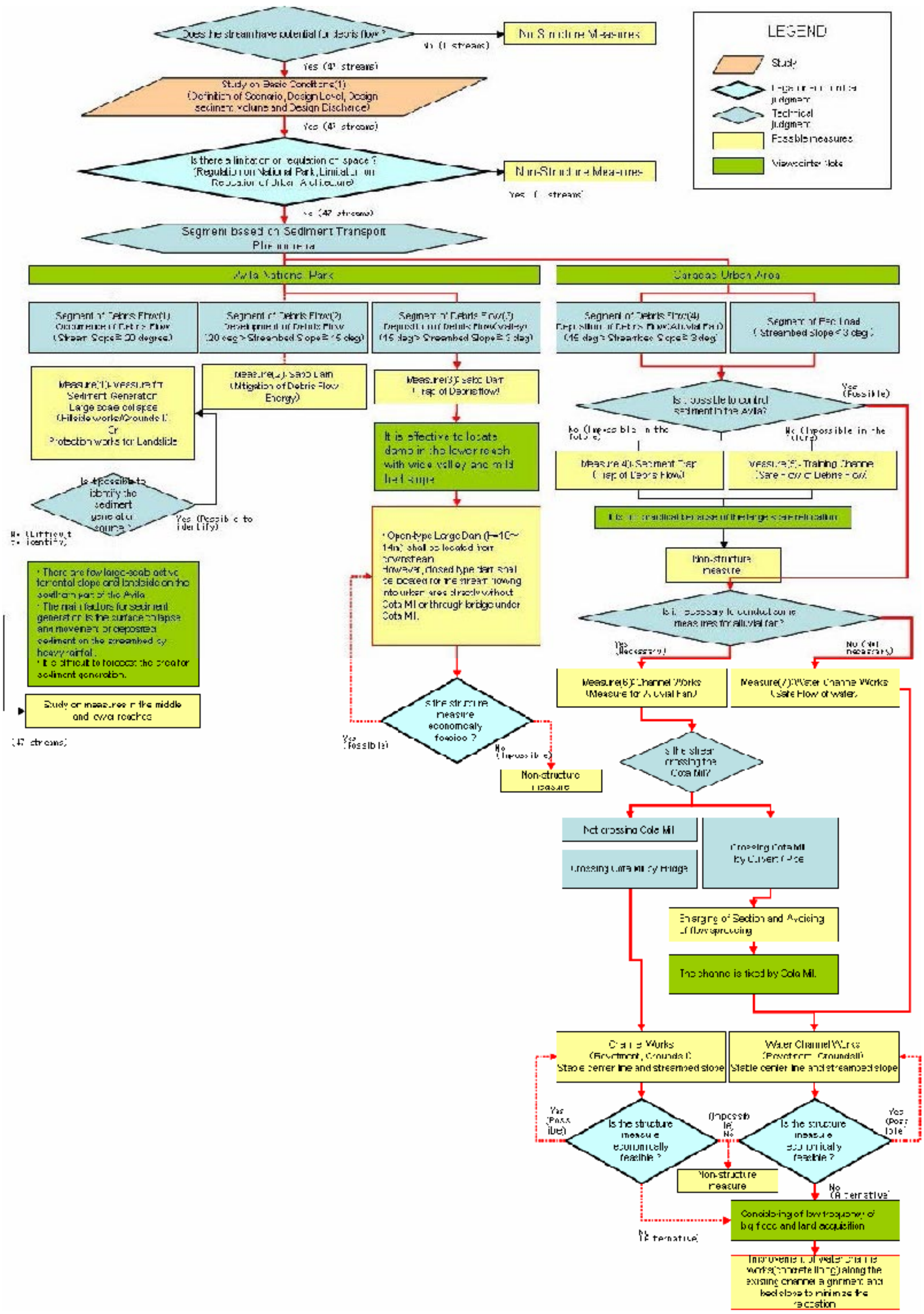


Figure S16-2.2.1 Work Flow Diagram for Structure Measures

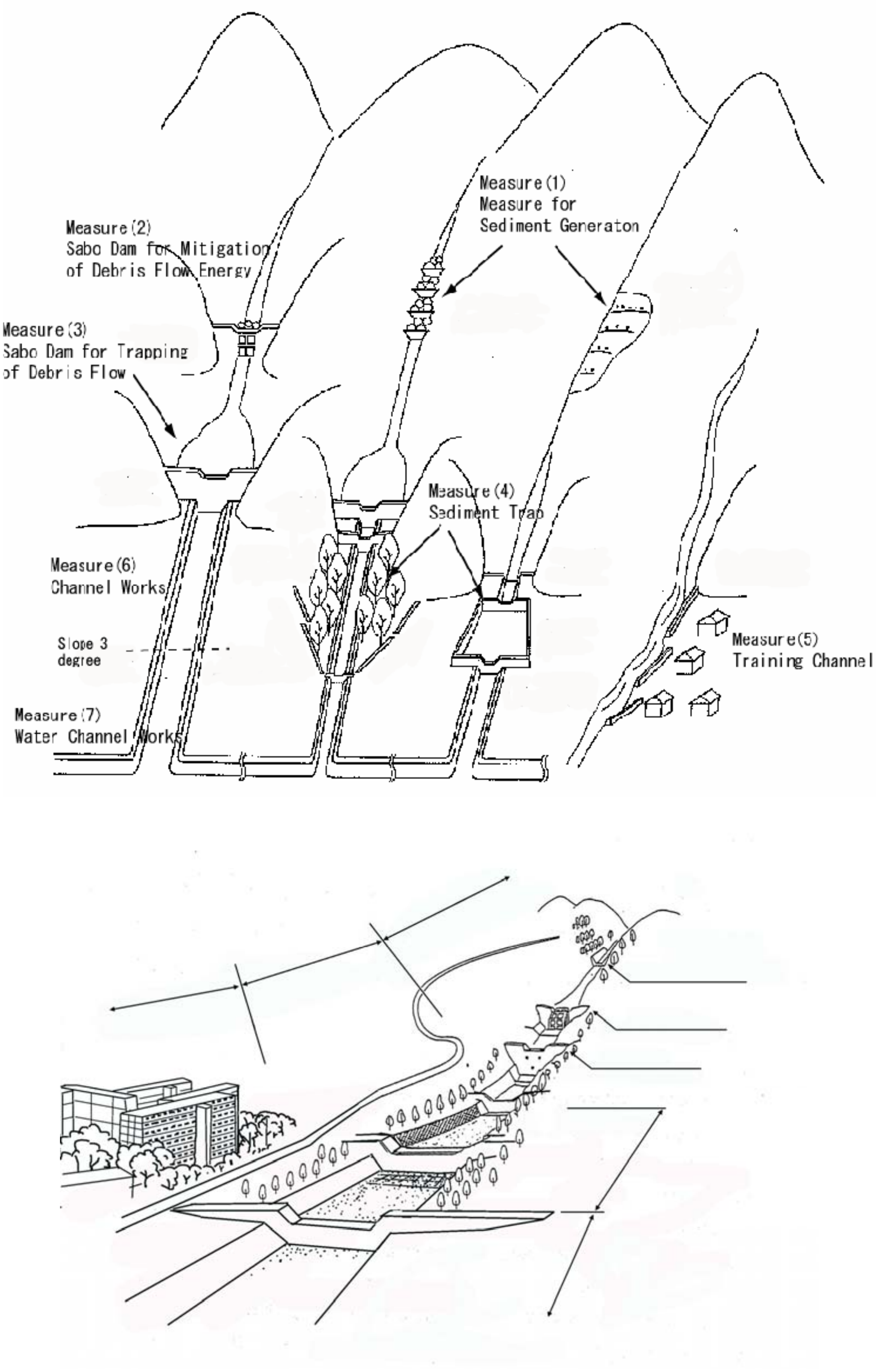


Figure S16-2.2.2 Schematic Image of Sediment Control Structures

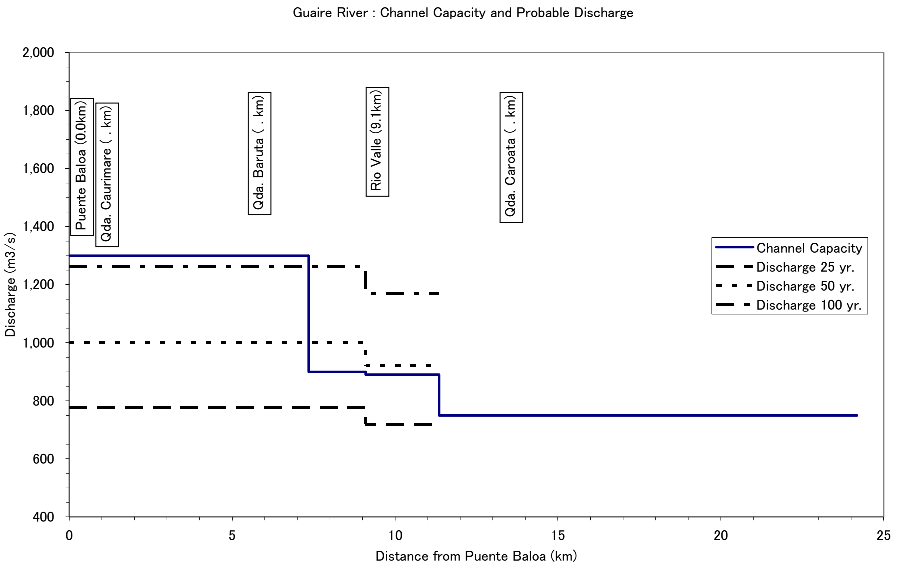


Figure S16-2.3.1 Channel Capacity and Probable Discharge in the Guaire River

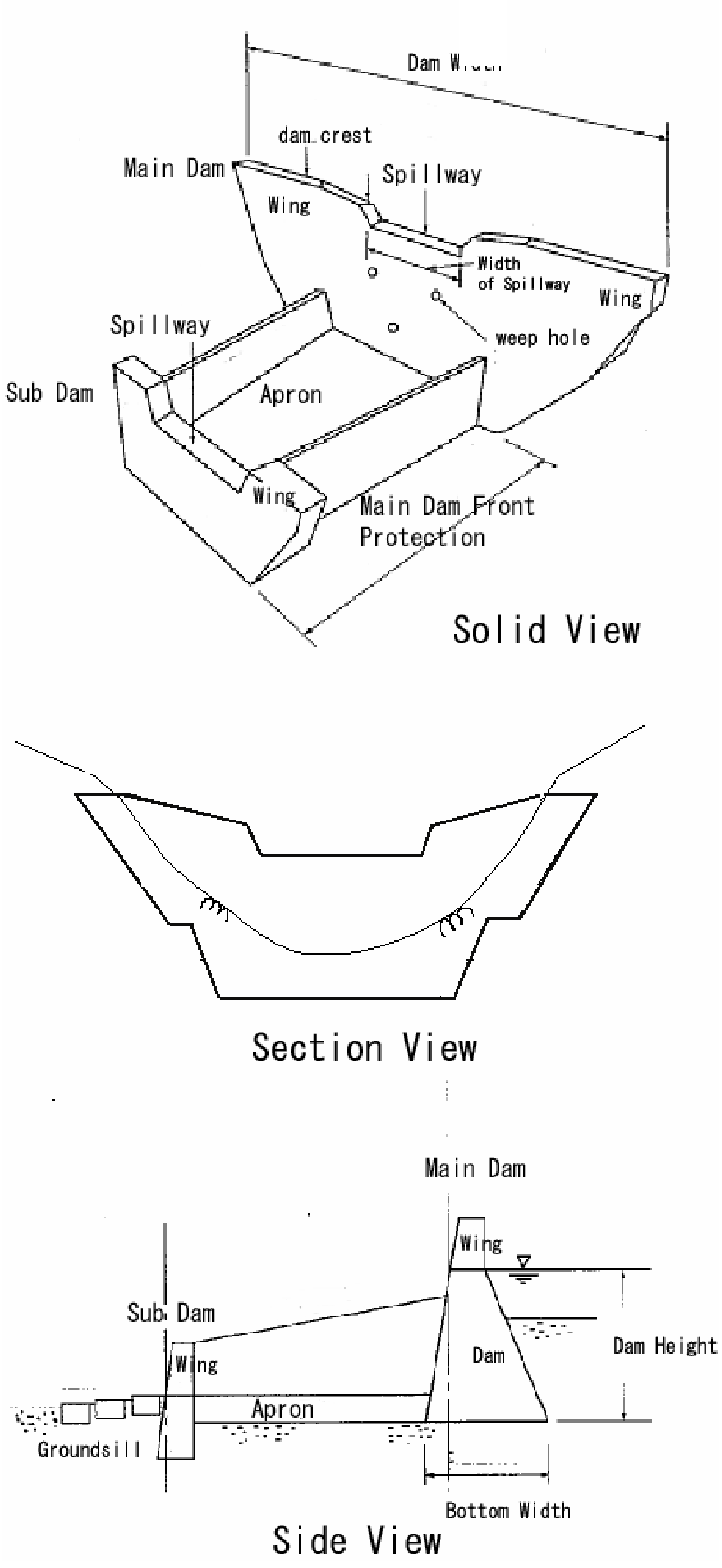
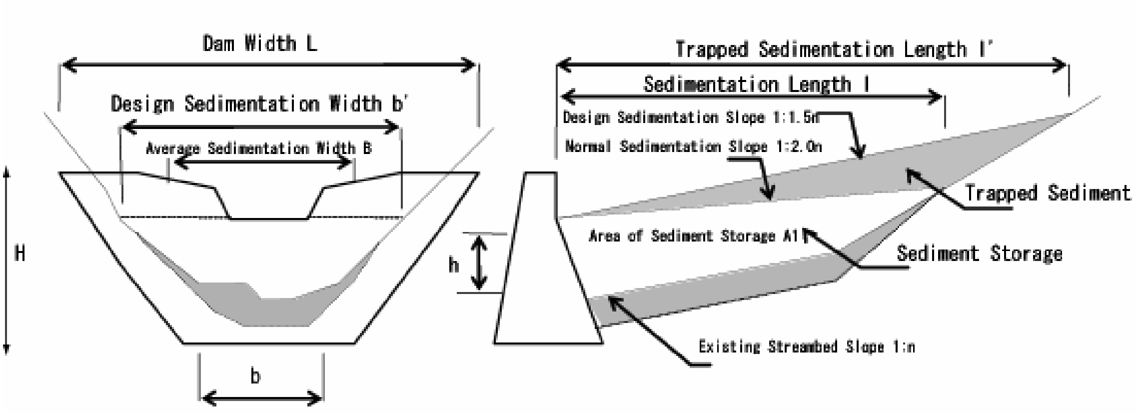


Figure S16-2.4.1 Explanation of Dimension of Sabo Dam



B: Average Sedimentation Width (m)　B=(b+b')/2

b : Average Width of Existing Streambed（m）

b' : Design Sedimentation Width（m）

h : Effective Height of Sabo Dam(m）

Normal Sedimentation Slope : 1/2 of the existing streambed slope “n”

Design Sedimentation Slope: 2/3 of the existing streambed slope “n”（up to i=1/6）

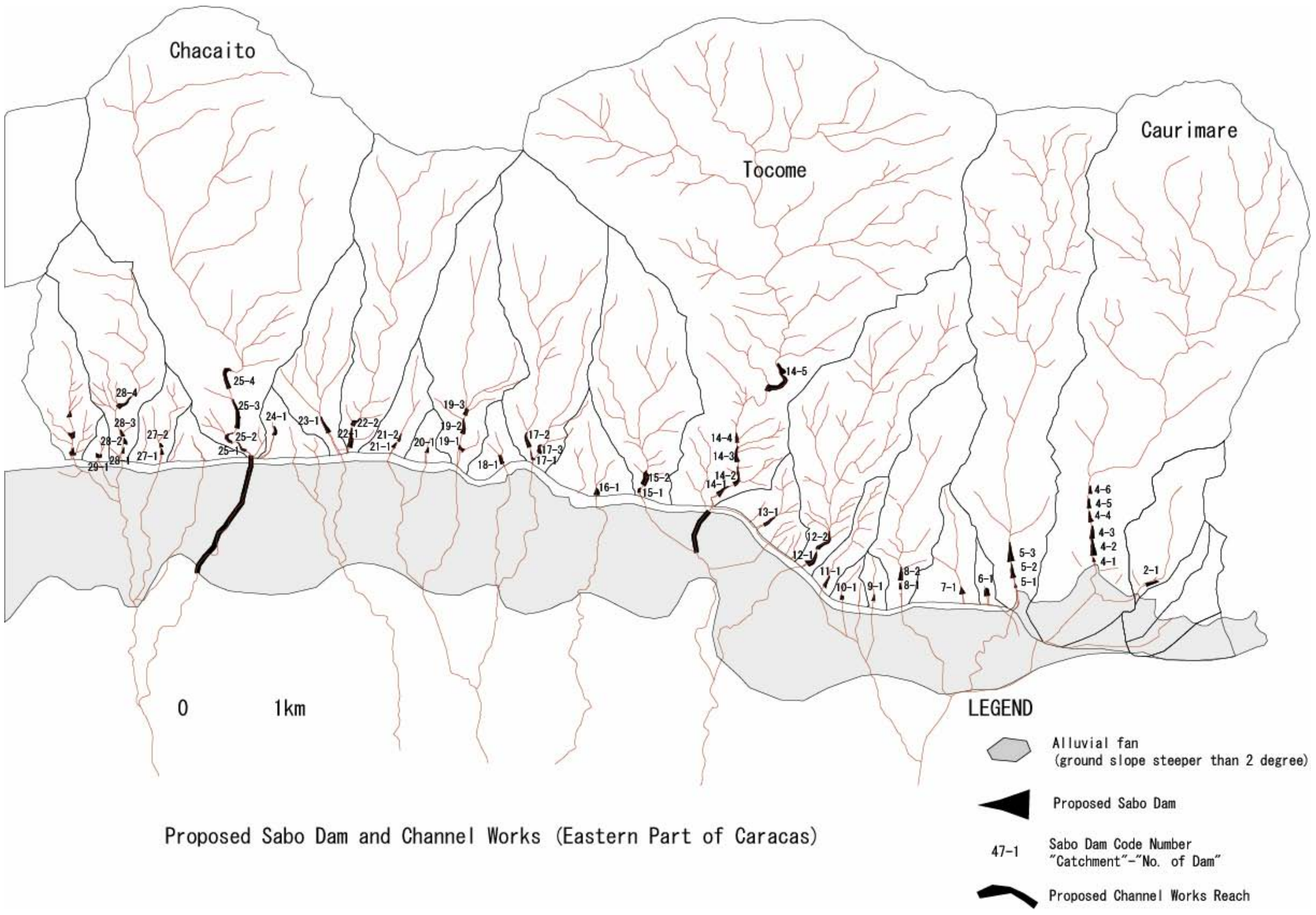
	Normal Sedimentation Slope : 1/2 of the existing streambed slope “n”	Design Sedimentation Slope: 2/3 of the existing streambed slope “n”
Sedimentation Length	$l = \frac{2n \times n}{2n - n} \times h = 2nh$	$l' = \frac{1.5n \times n}{1.5n - n} \times h = 3nh$
Area of Sediment Storage	$A1 = \frac{1}{2} \times h \times l = nh^2$	$A1' = \frac{1}{2} \times h \times l = 1.5nh^2$
Sediment Storage	$Vs = A1 \times B = nBh^2$	$Vs' = A1' \times B = 1.5nBh^2$

［Trapped Sediment Volume］

The trapped sediment volume is calculated assuming that open type sabo dam is constructed and the maintenance excavation is conducted, as follows, to add the storage volume

$$Vs' = 1.5n \times B \times h^2$$

Figure S16-2.4.2　Concept of Trapped Sediment Volume of Sabo Dam



Proposed Sabo Dam and Channel Works (Eastern Part of Caracas)

Figure S16-2.4.3 (1/2) Location of Sabo Dam

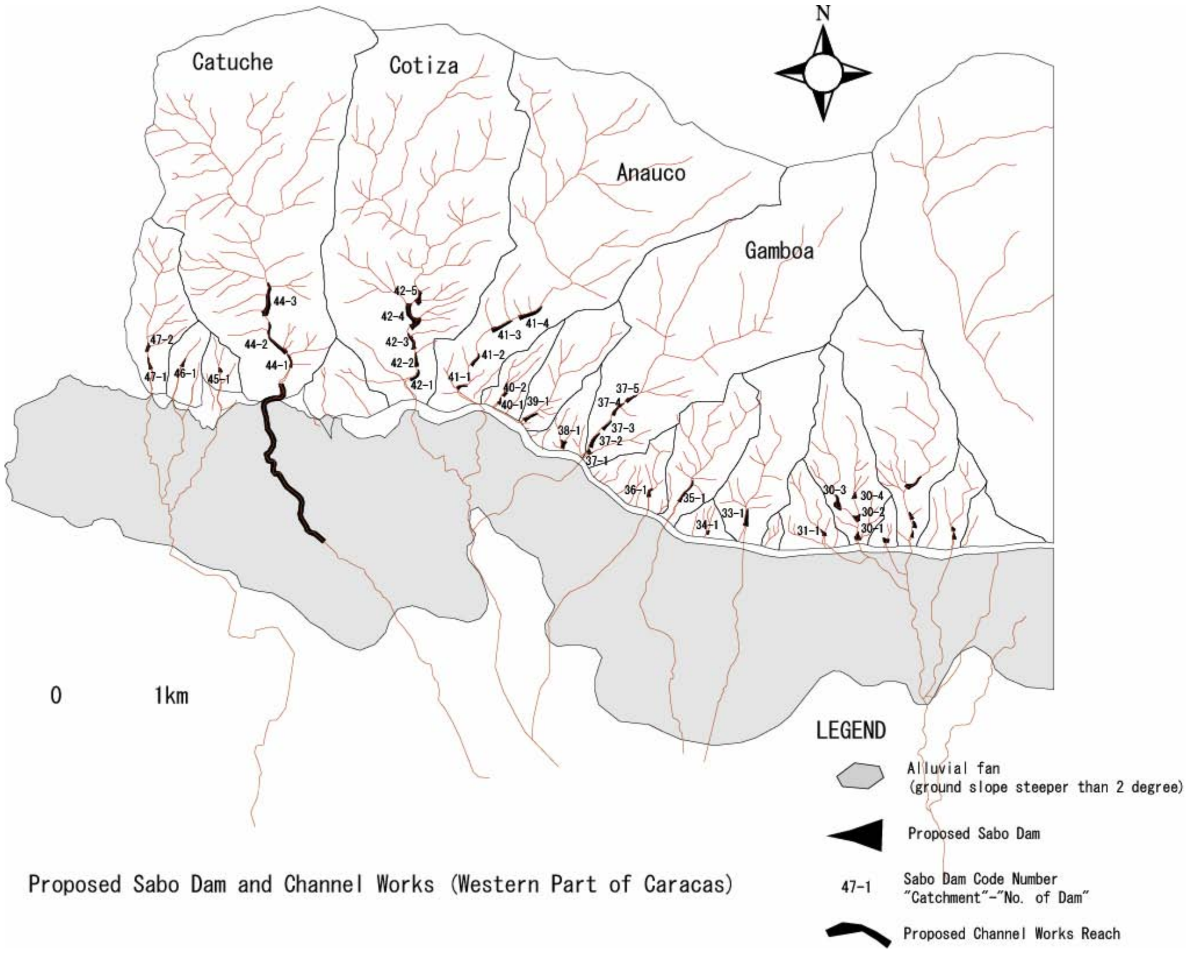


Figure S16-2.4.3 (2/2) Location of Sabo Dam

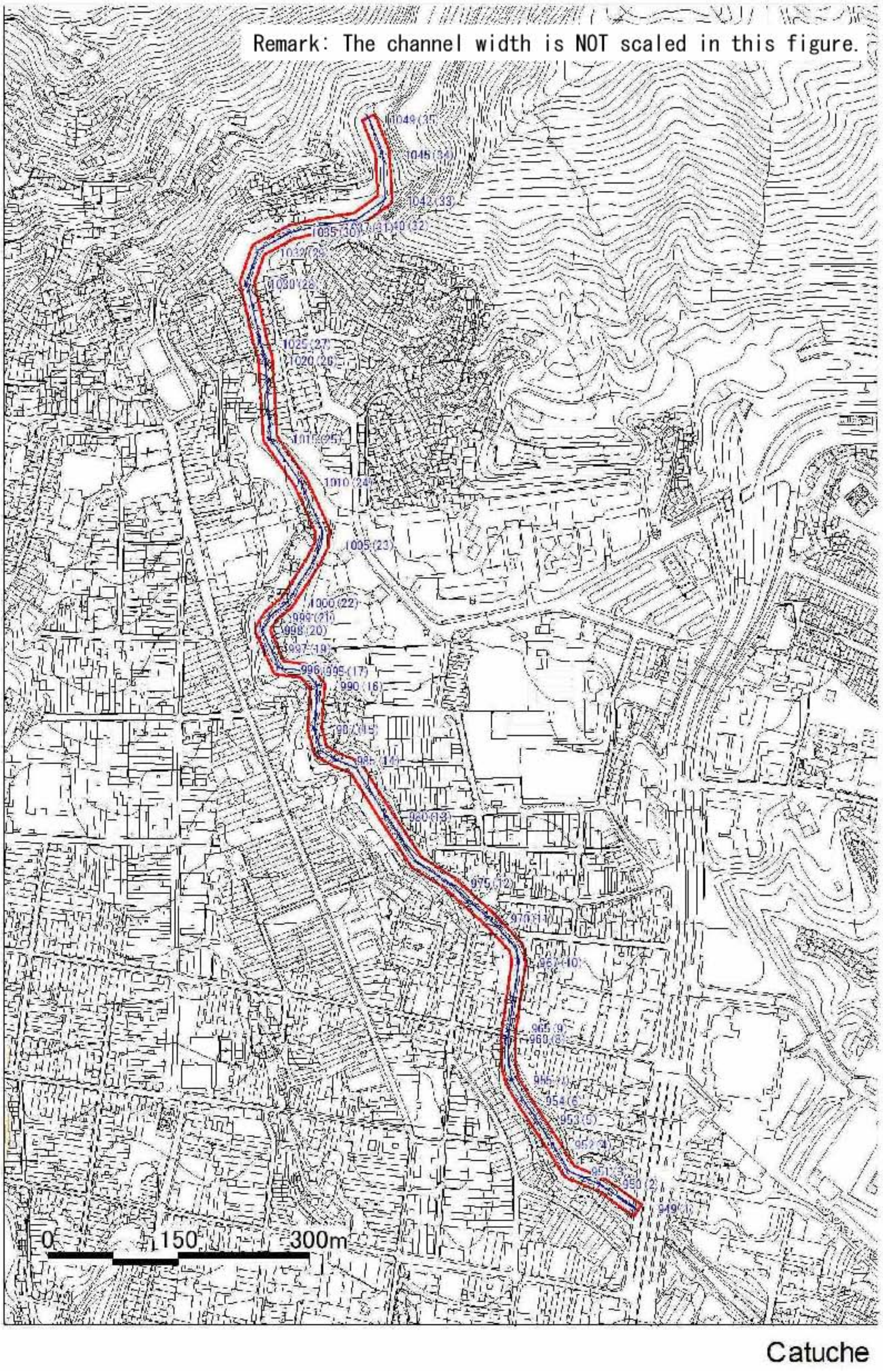


Figure S16-2.5.1 (1/3) Location of Channel Works (Catuche)

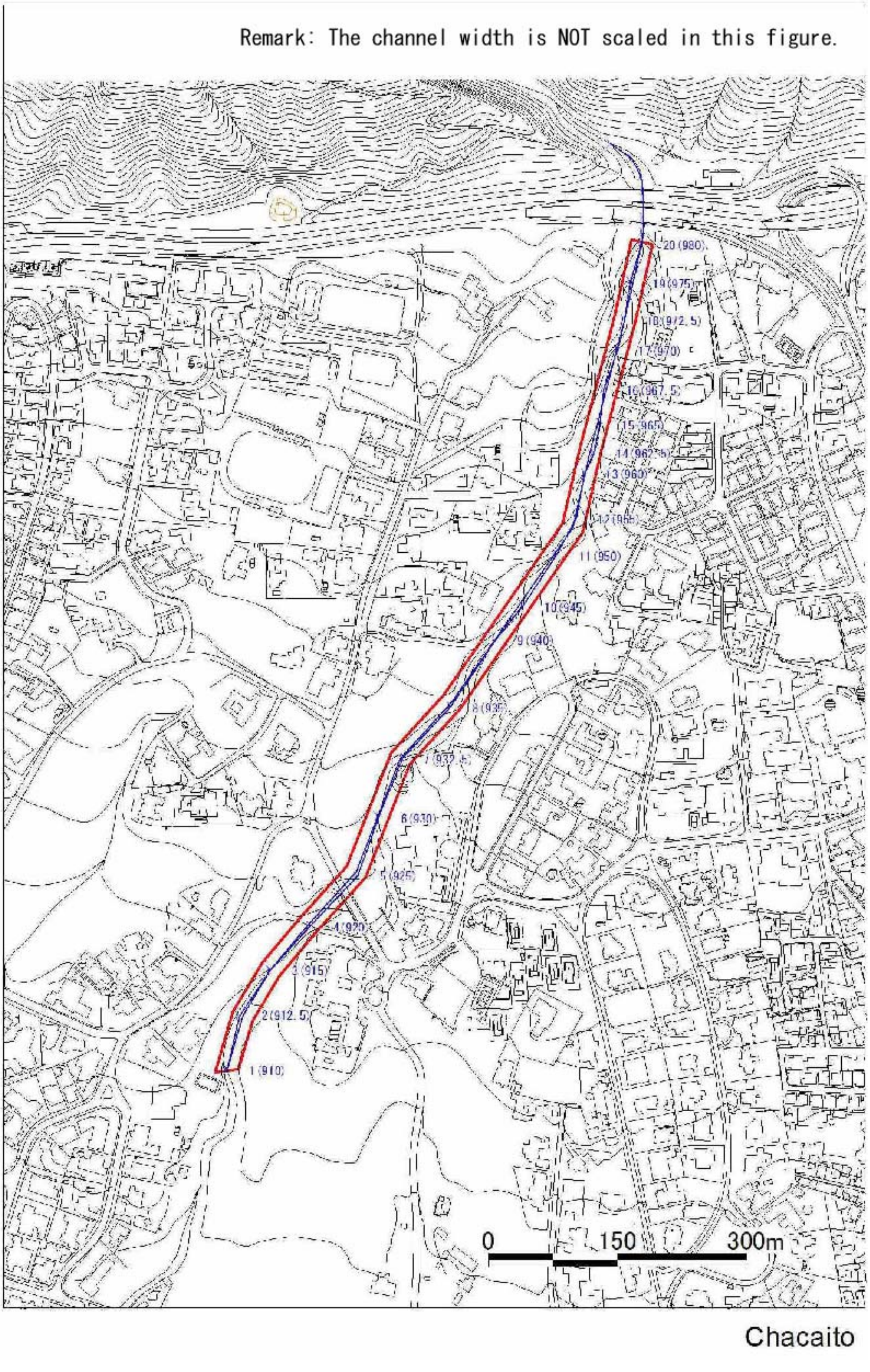


Figure S16-2.5.1 (2/3) Location of Channel Works (Chacaito)

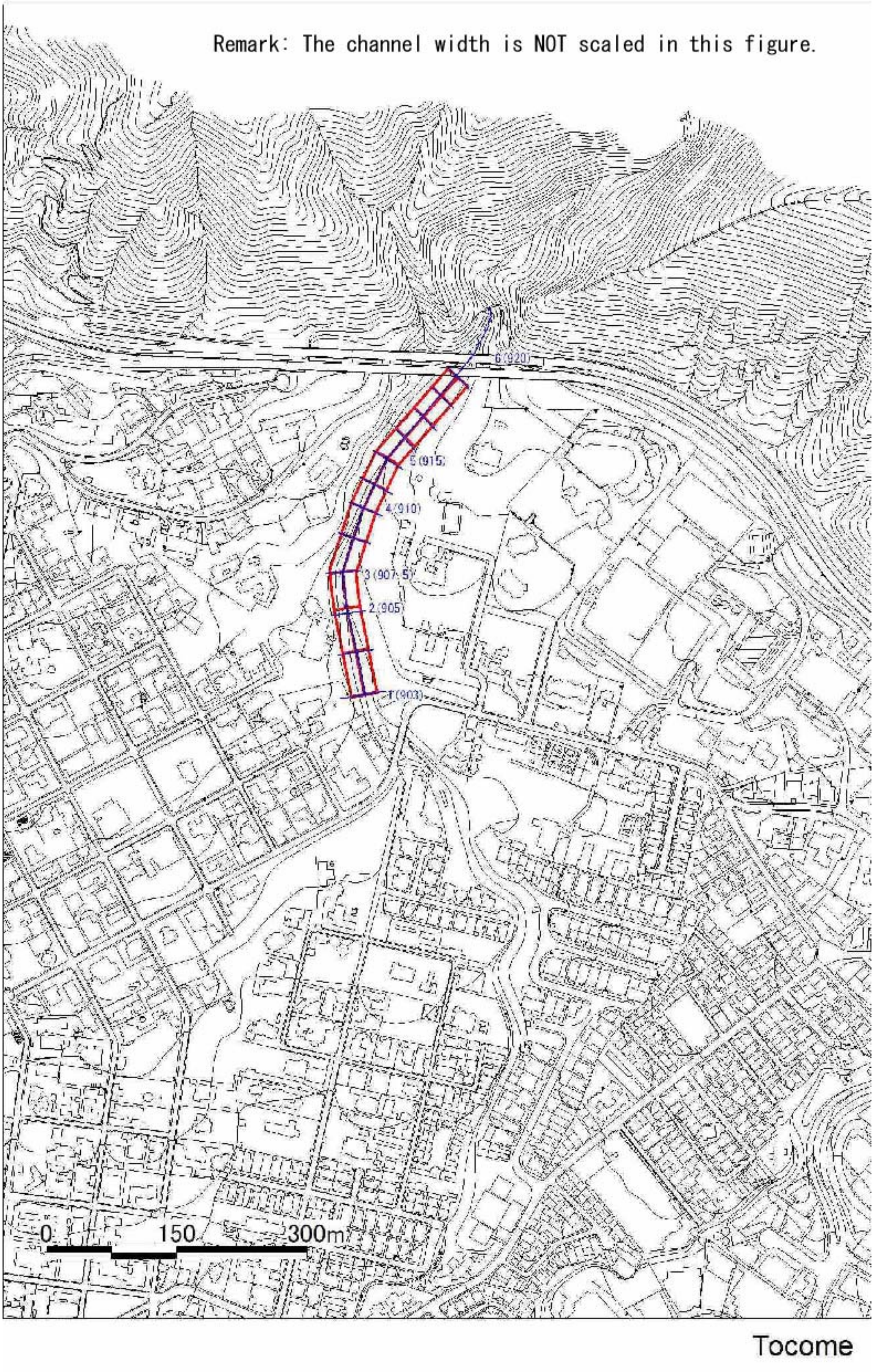


Figure S16-2.5.1 (3/3)   Location of Channel Works (Tocome)

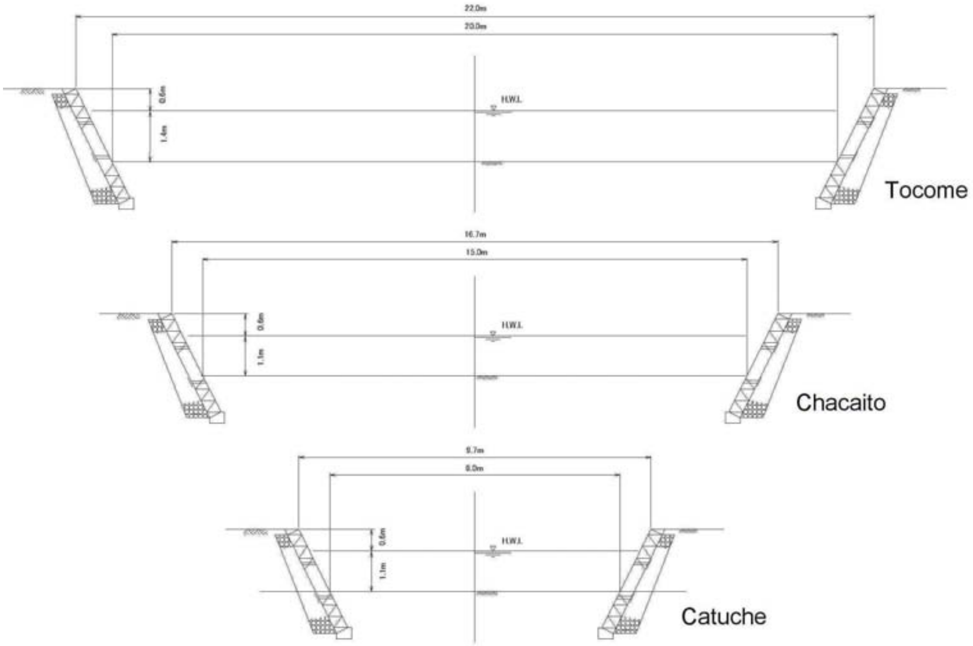


Figure S16-2.5.2　Cross section of Channel Works

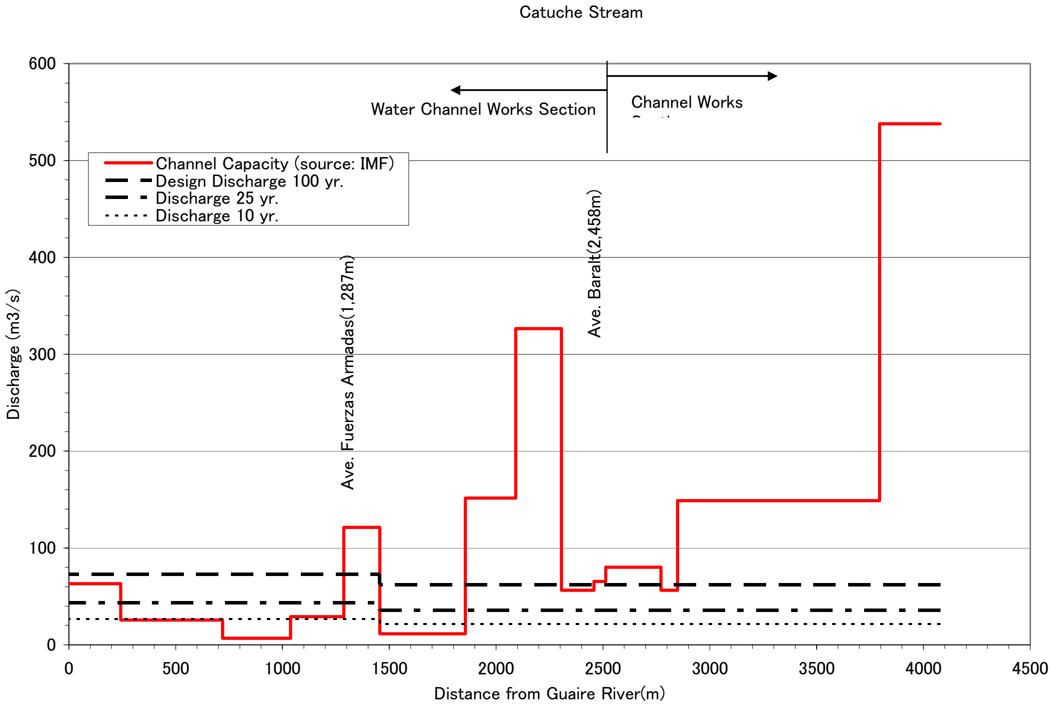


Figure S16-2.5.3　Channel Flow Capacity in the Catuche Stream (Source: IMF)

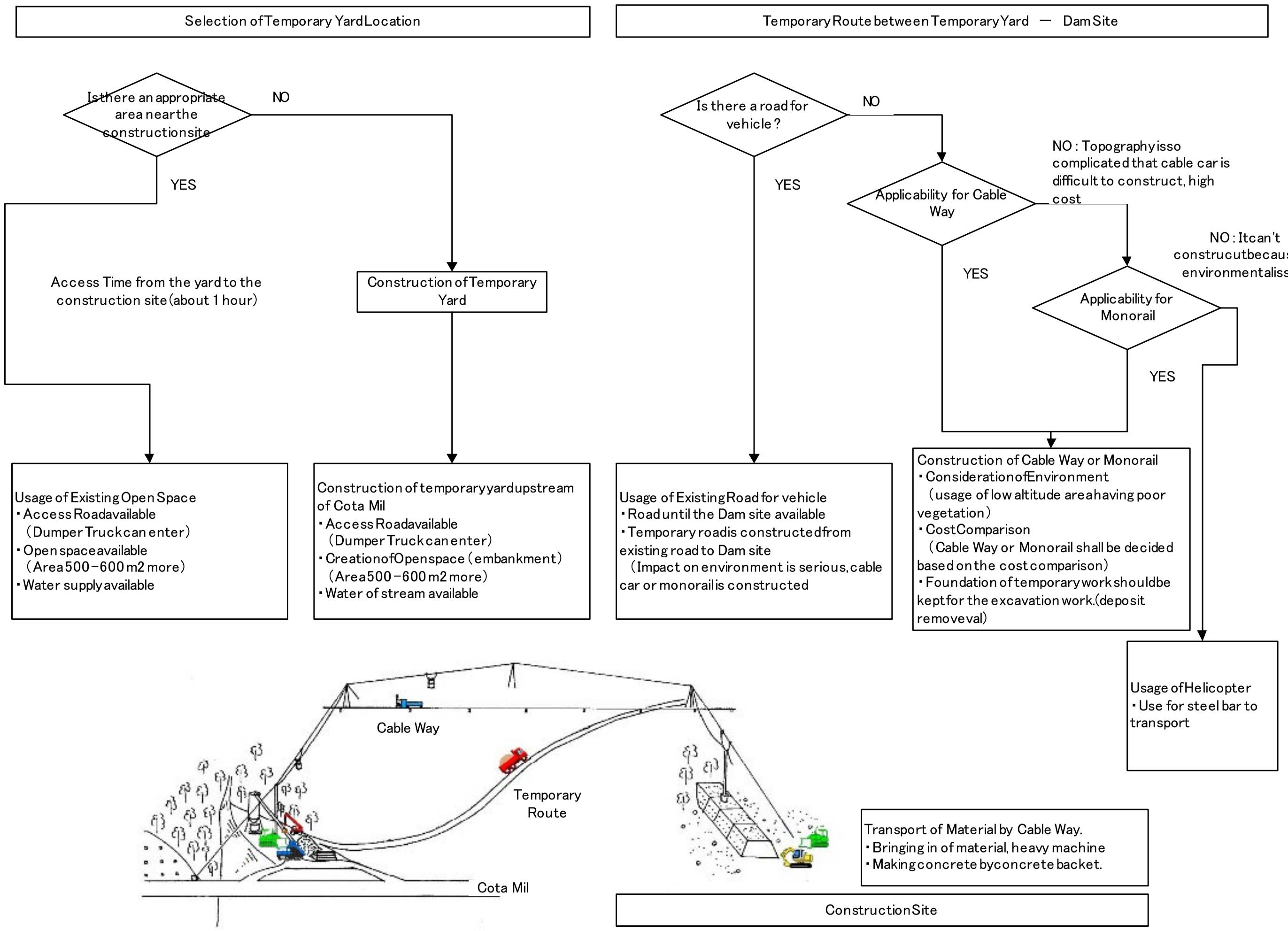


Figure S16-2.6.1 Procedures to Select Temporary Yard and Temporary Route

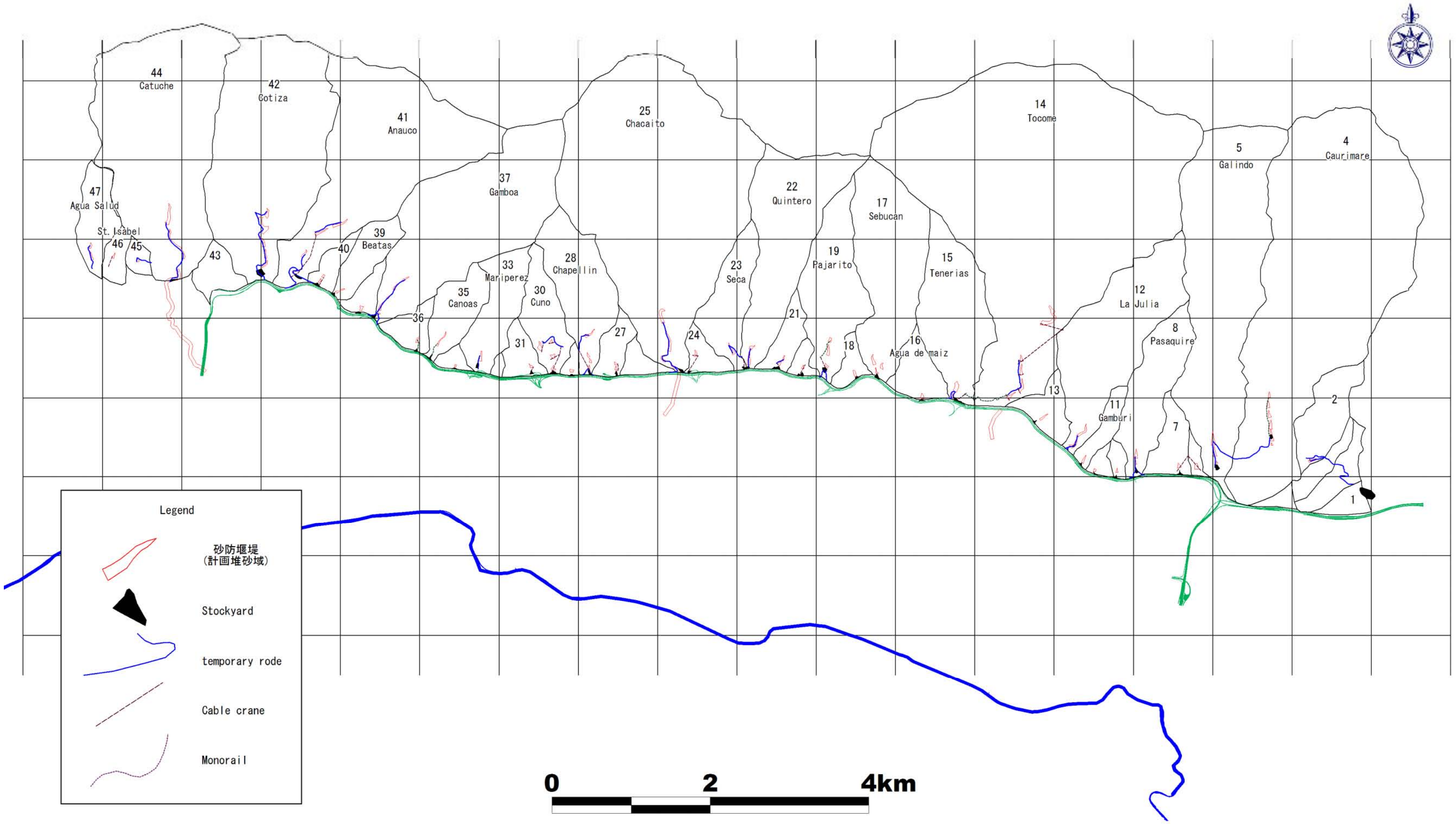


Figure S16-2.6.2 Proposed Temporary Works

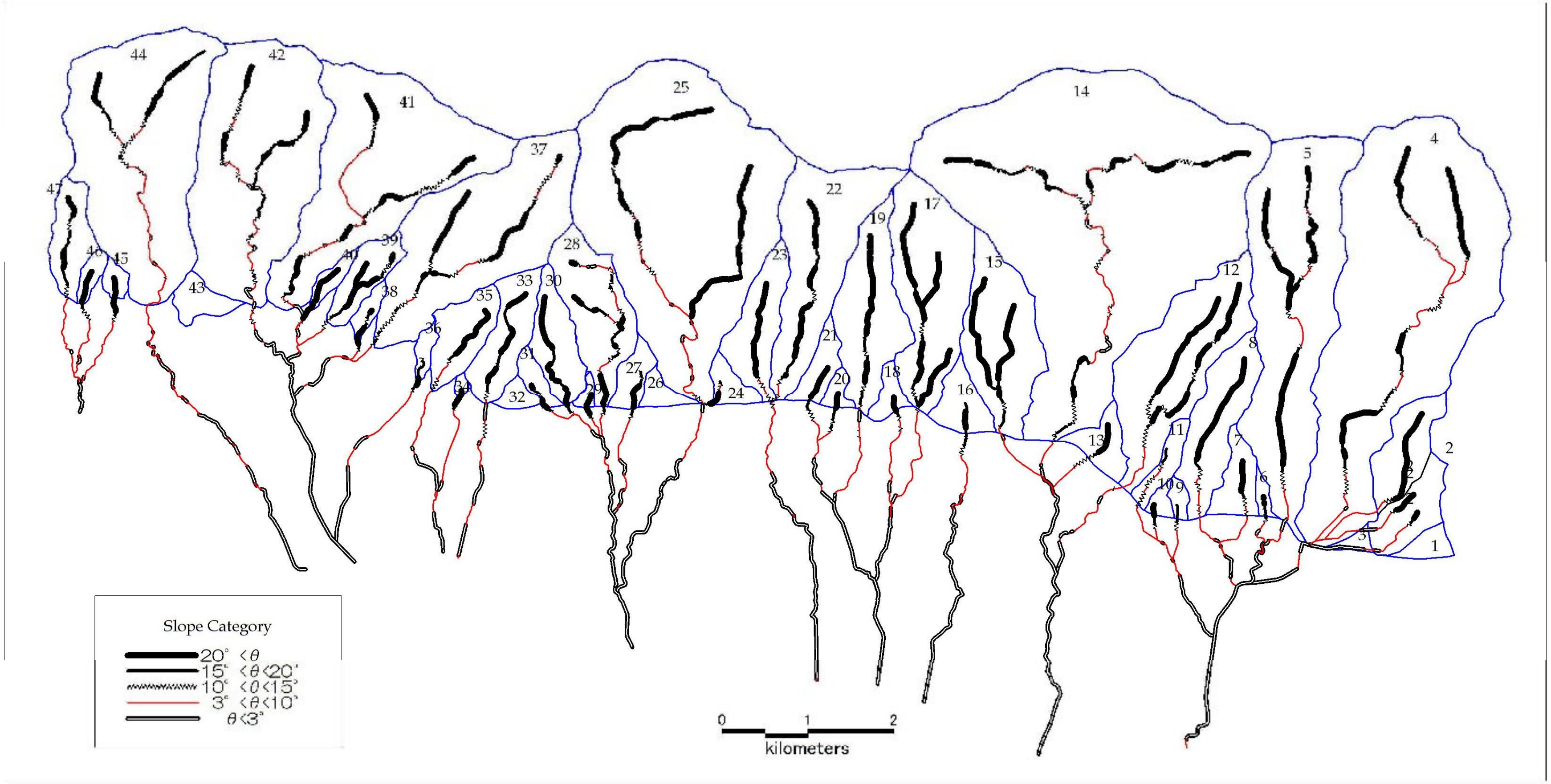


Figure S16-2.7.1 Segment Categorized by Stream Bed Slope

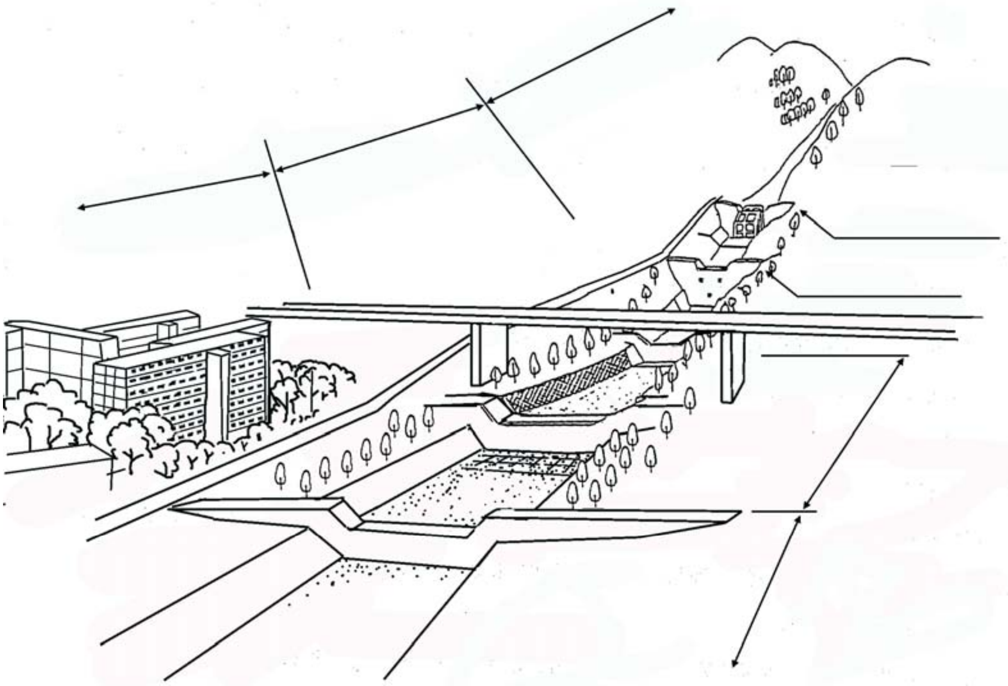
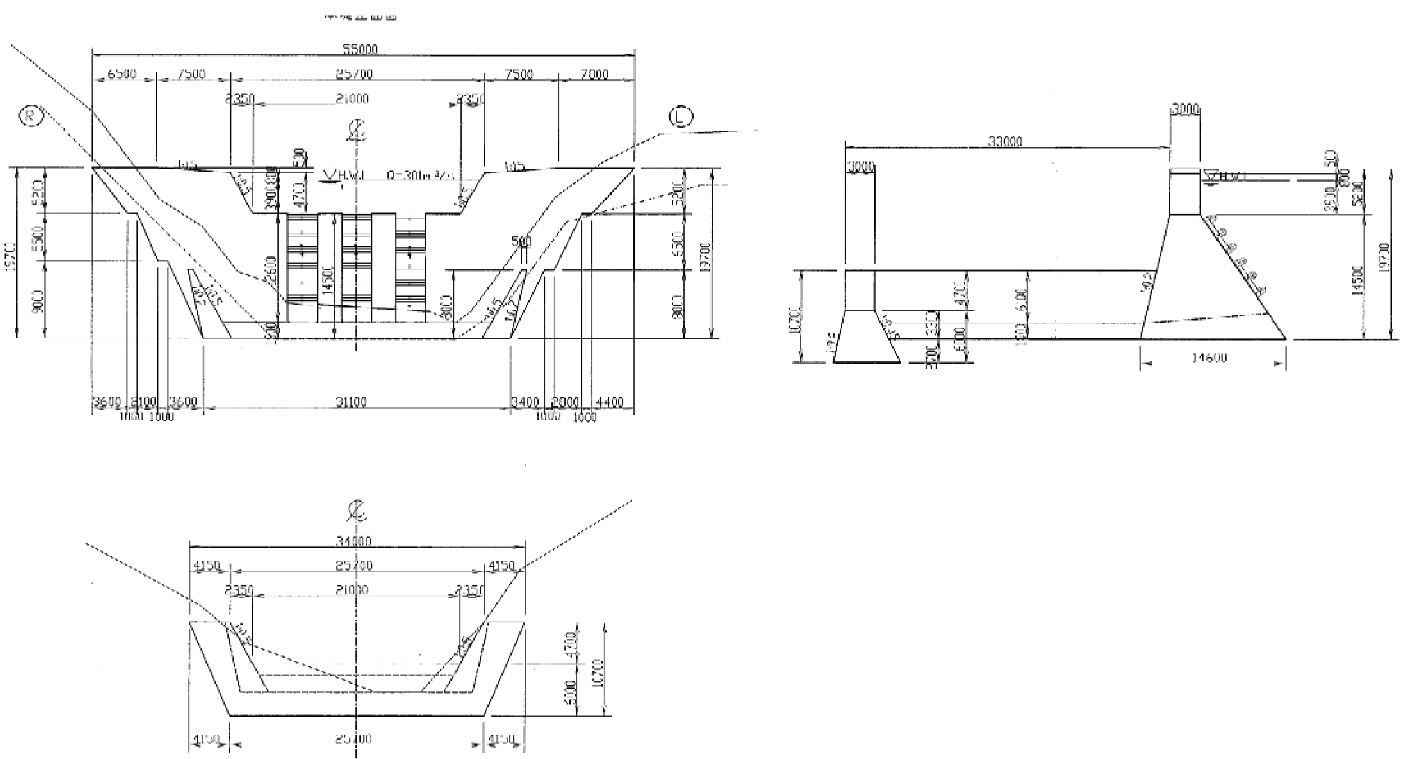
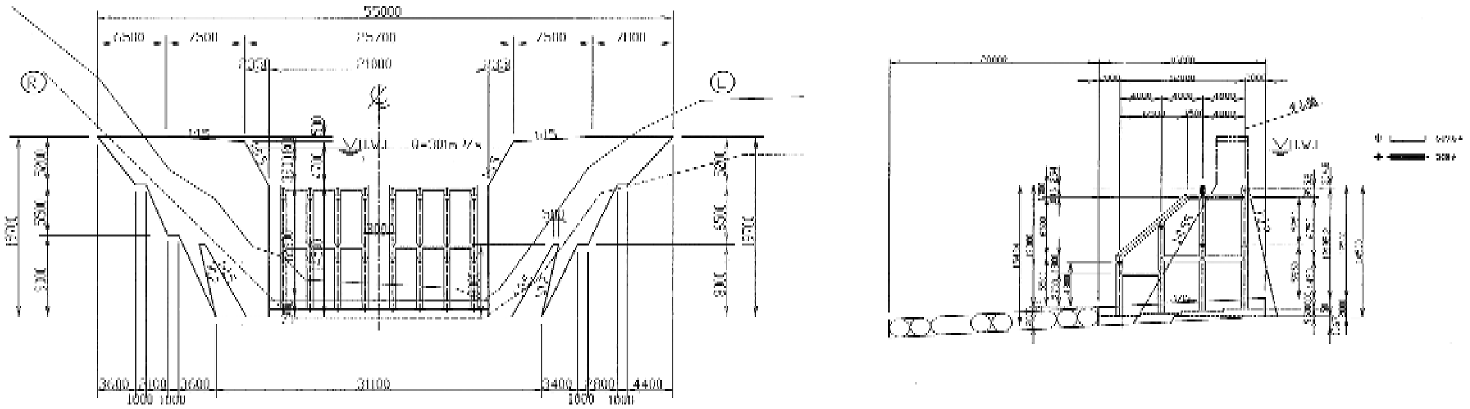


Figure S16-2.7.2   Illustration of Typical Sabo Dam Layout



Work Quantity			
Concrete	Main Dam	5,200 m^3	8,260 m^3
	Sub Dam	950 m^3	
	Apron	1,300 m^3	
	Side Wall	810 m^3	
Steel	Main Dam	14 t	

Figure S16-2.8.1 (1/2) General Structure of Concrete Slit Sabo Dam



Work Quantity			
Concrete	Main Dam	3,300 m^3	4,530 m^3
	Sub Dam	m^3	
	Apron	420 m^3	
	Side Wall	810 m^3	
Steel	Main Dam	212	t

Figure S16-2.8.1 (2/2) General Structure of Steel Frame Sabo Dam