CHAPTER 6

ASSESSMENT OF DISASTER CRITICAL SPOTS

CHAPTER 6 ASSESSMENT OF DISASTER CRITICAL SPOTS

6.1 Classification of Road Disaster

6.1.1 Assessment of Past Road Disasters

Figure 6.1.1 shows monthly precipitation and Figure 6.1.2 shows annual precipitation in the region.

On the Pacific coast area, there are heavy rains in Chinandega and Leon between May and October. In the mountain area, Somoto, Ocotal and Jinotega, there is also heavy rain in October, but half the level of Chinandega. Therefore rivers with sources in low land near the Pacific Coast, such as Estero Real, have much more water between May and October.

The sources of the Rio Coco and Rio Negro are in mountain area near the boundary of Honduras, and have much higher flows in October. Hurricanes bring heavy rain to the North-Western area of Nicaragua during a short period in October. Table 2.4.1 reveals that the most dangerous natural phenomenon for roads was the heavy rain and floods caused by the Hurricanes, Alleta, Joan, Ceser and Mitch, and the Tropical Storms Gert and Bret in the 1900's. Heavy rains that persist for more than one week cause landslides and major floods and destroy bridges. Hurricane Mitch affected roads , bridges and a range of other facilities, with the summary of damage shown on Table 6.1.1.

Hurricane Mitch (1998) was one of the worst natural disasters in Nicaraguan history. Intense rains from Mitch began on October 22 and continued until October 31, affected 870,000 victims, of which 2,400 people died directly as a result, with 287 serious injuries and 938 people unaccounted for. The material loss was estimated at US$1504 millions (94% due to forced activity, and 6% due to production losses). It also destroyed 3,750 houses and damaged a further 145,700 homes.

The Hurricane damaged 8000km of roads, a staggering 80% of the total network, and 42 bridges destroyed, with 29 bridges semi destroyed. The details are summarized below.

1) NIC.1 (Managua- Tipitapa- San Benito- Sebaco- Esteli- Yalagüina- El Espino)

The crossing through Managua-Tipitapa (km 22) is limited, and due to the overflow of the Xolotlan Lake in this area, a flood occurred 250 m along the road. The Army installed a temporary bridge on the old road of Tipitapa, to safeguard crossing for light and heavy vehicles.

At km 83, where El Venado Bridge is located, erosion occurred on the approach roads, and the Army installed a temporary bridge to allow just light vehicles to pass. After that gabions were installed to permit heavy vehicles. At Sebaco passage for heavy vehicles was soon re-established.

Traffic was also interrupted at the Zanjón Negro Bridge, at around 112 km. Erosion to the approaches affected traffic circulation as far as Esteli.

In La Trinidad-Esteli-Condega section, there was considerable rock collapse.

In Condega-Yalagüina section, traffic was interrupted due to damage to the Condega and Ducualí bridges. Between Yalagüina and El Espino the road was cut completely because of damage to the Inalí bridge.

2) NIC. 3 (Sébaco- Matagalpa- Jinotega)

In the section between Sebaco-Matagalpa, a culvert collapsed at El Guayacán. Waswali Bridge was partially destroyed and erosion occurred to one of the approach roads.

In the Matagalpa-Jinotega section, there are many construction works dealing with damage to slope and the road surface.

3) NIC. 5 (Matagalpa- La Dalia)

In the El Tuma section where is located 21.6km from Matagalpa, it often suffers from the damage of the Rockfalls/ Collapsing.

4) NIC.15 (Yalagüina- Ocotal- Las Manos)

Traffic was interrupted because of the bridge destroyed at the entrance to Ocotal, on the Coco River and damage to the Dipilto bridge. The road was also cut between 205 and 206 km.

5) NIC. 24 (Chinandega- El Guasaule)

Between Chinandega and El Guasaule, damage occurred to the bridges at Hato Grande, Rio Negro, El Gallo, Tecosmapa, and Guasaule

6) NIC. 26 (San Isidro- Telica)

Traffic was interrupted due to the collapse of Jicaral Bridge. Plant required for the restoration of the bridge was isolated in the Dos Montes-El Sauce section and between Santa Clara and Jalapa, and repair works were seriously delayed.

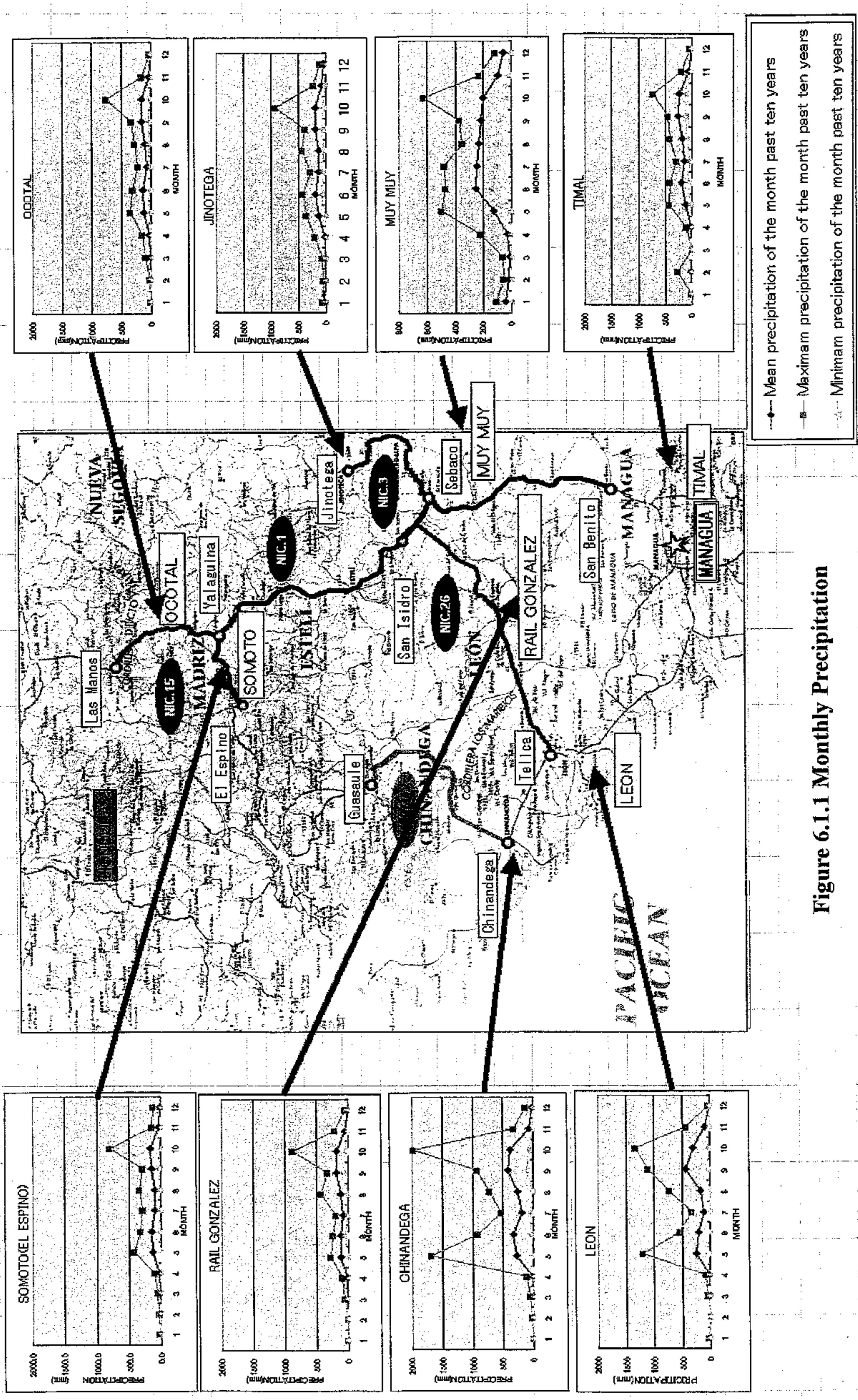


Figure 6.1.1 Monthly Precipitation

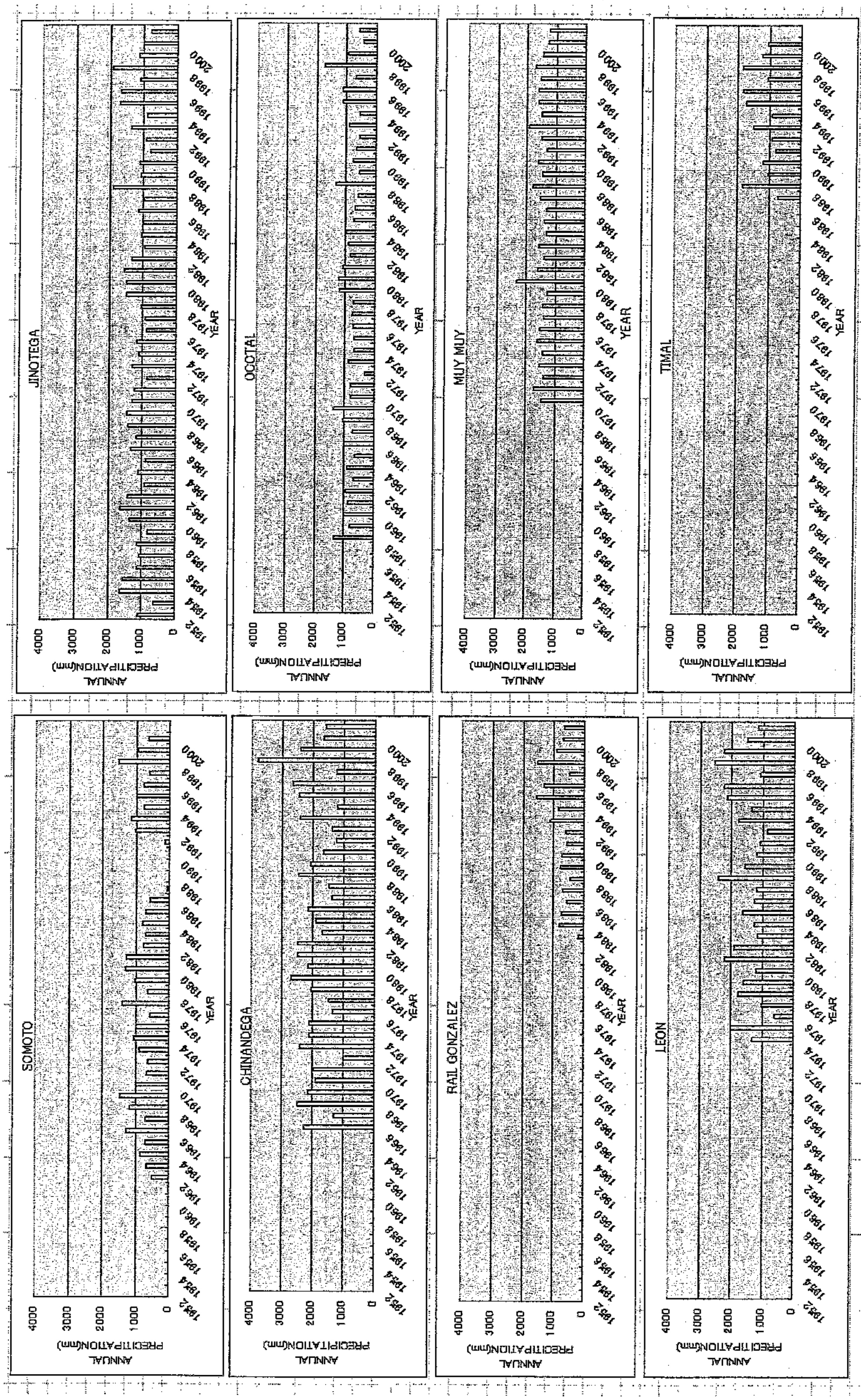


Figure 6.1.2 Annual Precipitation

6.1.2 Probability Assessment/ Analysis of Road Disaster by Type

Each route of this study roads is so featured in terms of the factors causing the slope failure. The percentage of rock collapse sites and falling stone collapse sites shows 54% for the former and 46% for the latter. Falling stone collapse easily occurs when the ground water level rises as caused by the collapse of surface sliding-fall type in weathering zone which is seen in natural slope due to localized torrential downpour. Therefore, it is called as a downpour-type collapse. This type of collapse depth is related to the thickness of weathering zone but the occurrence ratio is summarized as 90% as criterion for assuming the volume of collapsed soil.

Granite	2 – 5 m	Tuff	3 – 4 m
Andesite	4 – 6 m	Muddy Rock	3 – 4 m
Volcanic Rock Debris	6 m	Sedimentary Rock	2 – 4 m
Volcanic Pyroclastic Rock	3 – 4 m	Tuff	3 – 4 m

Figure 4.2.1 in Chapter 4 shows the summarization by taking notice of the fundamental items in the Stability Survey Table. In Nicaragua, the progress of geologic stratum weathering is fast with the influence of its climate. The factors in relation thereto is summarized here. By this method, the factors for the rock collapse by weathering are considered to be opening of crack, direction of rock faces (with gradual toppling as weathering progresses), conditions of crack, geometric factors for bedrock structure, i.e, height and gradient, or, for falling stone collapse, collapse of ground, alternation and floating stone, information on rolling stone, and added with geometric shape thereby the stability is re-calculated. As the results, such group as less than 59, 60-69, more than 70 shows clean normal distribution curve, with the peak at 30, 45, 55. It is firmly believed that this calculation is effective as the basis for extracting the check points.

Extracted points of each section is shown in a table in the next section 6.2

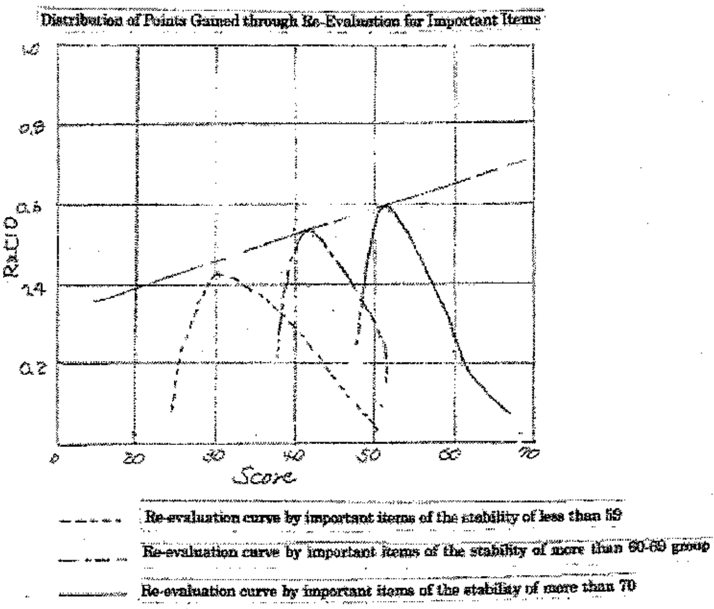


Figure 6.1.3 Distribution of Points Gained through Re-Evaluation for Important Items

6.2 Identification of Critical Spots

6.2.1 General

The influenced area of a potential road disaster impacts directly on road transport as well as indirectly on the socio-economic sector. The magnitude and probability of road disaster has been set out above by applying a probability score for each type of disaster. The disaster critical spot, by type of disaster, should be identified based on the magnitude and the probability expected. The pre-condition of the evaluation of the road disaster has been established as a spot having a score of over 70 on the stability survey, classified as a disaster critical spot, requiring either emergency countermeasures or permanent measures in order to prevent a road disaster. In case of bridge scouring a spot having a score of 90 or more is determined to be critical.

6.2.2 Identification of Disaster Critical Spots

Based on the pre-conditions for evaluation of road disasters, the following places have been identified as disaster critical spots having over 70 scores of the stability survey on each disaster potential spot. The total number of critical spots is 55, consisting of 20 spots (36%) of Rock Collapsing, 15 spots (27%) of Rock Falling, 11 spots (20%) of Bridge Scouring, 5 spots (9%) of Debris Flow and 4 spots (7%) of Slope Slide on all the objective roads.

Table 6.2.1 Total Number of Disaster Critical Spots

Road Name	Rock Fall	Rock Collapsing	Slope Slide	Debris Flow	Bridge Scouring	Total Critical Spots	Total Distance (km)	No. of Critical Spots par km
NIC. 1	7	9	0	0	6	22	237	0.09
NIC. 3	0	6	4	1	1	12	60	0.2
NIC. 5	1	0	0	0	0	1	48	0.02
NIC. 15	0	0	0	4	0	4	43	0.09
NIC. 24	0	0	0	0	0	0	77	0
NIC. 26	7	5	0	0	4	16	99	0.16
Total	15	20	4	5	11	55	564	0.10

The total number of the critical spots by road shows 22 spots (40%) on NIC.1, 16 spots (29%) on NIC.26, 12 spots (22%) on NIC.3, 4 spots (7%) on NIC.15, 1 spots (2%) on NIC.5 and 0 spots on NIC.24.

When the risk is analyzed per kilometer, the highest value is 0.2 spots/km of NIC.3, second is 0.16 spots/km of NIC.26 and third is 0.09 spots/km of NIC.1 and NIC.15.

Detailed information of each critical spot by road is shown in Tables 5.1.3 to 5.6.2. The following provides a preliminary evaluation of direct and indirect impacts of road disasters.

1) Direct Impact

a) Road Function

Based on the national road classification, the objective roads for this study are Class A (Trunk Roads), except NIC.5 which is Class B (Collector Road). The function of each road is summarized below.

Table 6.2.2 Road Functions of Objective Roads

Objective Road	Classification	Function
NIC.1	Class A	International Trunk Road
NIC.3	Class A	National Trunk Road
NIC.5	Class B	Collector connecting with population center
NIC.15	Class A	International Trunk Road
NIC.24	Class A	International Trunk Road
NIC.26	Class A	National Trunk Road

b) Traffic Volume

Traffic volume is one of the key factors to evaluate road disasters. The level of the importance on traffic demand depends directly on the total traffic volume on each road. The existing traffic volume (AADT) on each section of the objective roads is shown in Table 2.3.8.

Based on the practical application of the road classification proposed in the NTP, the following classification of the traffic demand has been introduced as shown in Table 2.3.8 in order to identify the impact level on traffic demand on each section of the objective roads.

Class A: AADT> 3,000

Class B: 3,000 >AADT> 300

Class C: AADT< 300

2) Indirect Impact

a) Commodity Movement by Road

Transportation of goods is a key element of the national economy and traffic volume of trucks on each road is an important indicator of transport role for goods movement on each road. Based on the existing traffic data on each section of the objective roads, the following 3 grades of classification of commodity movement has been introduced and the evaluation of the importance of each objective road has been conducted as shown in Table 2.3.8 (Daily vehicles).

Class A: Daily Truck Traffic > 300

Class B: 30 < Daily Truck Traffic < 300

Class C: Daily Truck Traffic < 30

B) Production of Important Industry

The main export products of Nicaragua are agricultural products valued at US$ 349 million in 1998. The major components of this are : coffee (49.6%), fish (22.6%), beef (10.9%), sugar (9.5%), banana (5.7%) and sesame (1.7%). Production volume by each type of product by each area is set out in Table 6.2.3

Based on this information, the contribution level of export products by each zone served by each objective road has been calculated through an accumulation of the proportion of export products by area as shown in Table 6.2.3

Table 6.2.3 Production of Main Export Agricultural Products

		Coffee	Fish	Beef	Sugar	Banana	Sesame	Tabaco	Total	Compo
Export Value (FOB) in 1998		US$173 mil	US$79 mil	US$38 mil	US$33 mil	US$20 mil	US$6 mil	---	US$349 mil	
Production by Direct Service zone	Zone Nº.									
(1000 metric ton)	7	0.66	---	---	237.45	---	0.21	0.02	4.15	1.2
	9	0.05	0.71	---	----	---	1.63	0.09	7.84	2.2
	11	0.08	4.52	---	2,441.9	7.19	0.35	0.20	80.43	23.0
	12	---	---	---	490.4	---	---	0.20	4.43	1.4
	13	0.06	---	---	---	---	1.00	---	1.23	0.4
	14	0.01	---	---	---	---	1.69	---	1.84	0.5
	16	14.37	---	---	---	---	---	---	38.9	11.1
	17	31.18	---	---	---	---	---	---	84.41	24.2
	18	1.69	---	---	---	---	0.07	1.57	4.66	1.3
	19	4.18	---	---	---	---	---	---	11.32	3.2
	20	4.08	---	---	---	---	---	---	11.05	3.2
Sub-Total		56.36	5.23		3,169.8	71.9	4.95	4.15	250.4	71.6
National Total		63.9	9.42		3,675.7	71.9	5.60	4.50	349.0	100.0

An analysis of direct service area by the objective roads has been introduced and the role of transportation of the export products by each objective road has been estimated as shown in Table 6.2.4

The contribution evaluation to the export industry has been summarized by introducing the following 3 classifications.

Class A: more than 20 % of production of export products by road

Class B: more than 5 % of production of export products by road

Class C: less than 5 % of production of export products by road

Table 6.2.4 Transport Role Agro-Export Production by Objective Roads

Objective Road	Zone Number	Proportion of Export of Main Agro Products	Contribution Evaluation of export production
NIC.1	7	1.2	
	12	1.3	
	16	11.1	
	17	24.2	
	18	1.3	
	19	3.2	
		42.3	A
NIC. 3	16	11.1	
	17	24.2	
		35.3	A
NIC. 5	16	11.1	
		11.1	B
NIC. 15	19	3.2	
	20	3.2	
		6.4	B
NIC. 24	11	23.0	
	14	0.5	
		23.5	A
NIC. 26	9	2.2	
	13	0.4	
	16	11.1	
		13.7	B
Total		71.6	
National Total		100	

c) Social Impact

Roads are an important factor in the social activity of a country and its regions. The local economy and the population in each area enjoy access to social and economic activities through the service provided by roads. The level of social impact by each objective road is represented a proportion of total population in each direct service area as shown in Table 6.2.5, summarized by the following classification.

Class A: more than 10 % of national population

Class B: more than 5 % of national population

Class C: less than 5 % of national population

Table 6.2.5 Existing Population Directly Influenced by the Objective Roads

Objective Road	Name of Department Covered	Nº of Zone		Existing Population in 1998	%
NIC 1	Managua	7	A	1.119,4	
	Tipitapa	12		106,8	
	Matagalpa	16		366,7	
	Estelí	18		190,1	
	Somoto	19		116,0	
	Subtotal			**1.899,0**	39,5
NIC 3	Matagalpa	16	A	366,7	
	Jinotega	17		290,7	
	Subtotal			**657,4**	13,7
NIC 5	Matagalpa	16		366,7	
	Subtotal			**366,7**	7,6
NIC 15	Somoto	19	B	116,0	
	Ocotal	20		163,7	
	Subtotal			**279,7**	5,8
NIC 24	Chinandega	11	B	291,5	
	Somotillo	14		75,9	
	Subtotal			**367,4**	7,6
NIC 26	León	9	A	237,7	
	El Sauce	13		94,1	
	Matagalpa	16		366,7	
	Subtotal			**698,5**	14,5
	Total			**3.052,6**	63,6
	National Total			**4.802,9**	100

Source: Plan Nacional de Transporte de Nicaragua

3) Conclusion

a) Direct Impact

Based on the above-mentioned methods the following evaluation includes existing and future traffic volumes for year 2019 estimated by the NTP by road as shown in Table 6.2.6. These forecasts appear high and are reviewed by this study in Chapters 10 and 11. Considering increases in future traffic demand on each objective road, the level of the direct impact by road disaster will be same (highest) class.

Table 6.2.6 Assessment of Direct Impact

Road Name	No. of Critical Spots	No. of Critical Spots/km	Road Function	Existing Traffic Volume	Future Traffic Volume,2019	Level of Direct Impact
NIC. 1	22	0.09	A	A	A	A
NIC. 3	12	0.20	A	A	A	A
NIC. 5	1	0.02	B	B	A	A
NIC. 15	4	0.09	A	B	A	A
NIC. 24	0	0	A	B	A	A
NIC. 26	16	0.16	A	B	A	A

b) Indirect Impact

Based on the above-mentioned method the evaluation proceeds as shown in Table 6.2.7. The level of the indirect impact on each road suggests that the highest impact would be on NIC.1, 3, 24 and 26 and second highest on NIC.15 and 5.

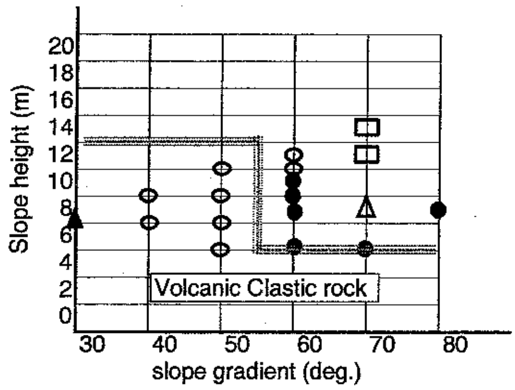
Table 6.2.7 Assessment of Indirect Impact

Road Name	No. of Critical Spots	No. of Critical Spots/km	Commodity Movement	Production of Important Industry	Social Impact	Level of Indirect Impact
NIC. 1	22	0.09	A	A	A	A
NIC. 3	12	0.20	A	A	A	A
NIC. 15	4	0.09	A	B	B	B
NIC. 24	0	0	A	A	B	A
NIC. 26	16	0.16	A	B	A	A
NIC. 5	1	0.02	B	B	B	B

c) Recommendation of Cut Slope Gradient

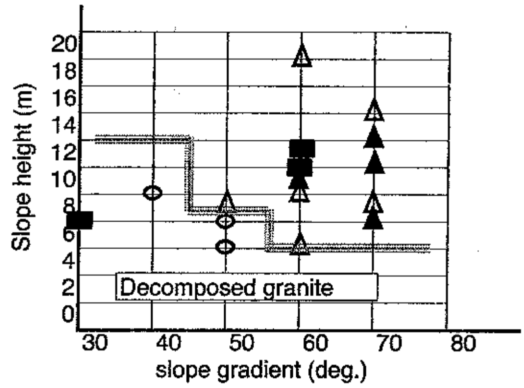
There are various features regarding cut slope gradient of the objective roads through the investigation. According to Table 6.2.1, there are cut slopes of 60 % or more in disaster critical spots. However, NIC.15 is now under construction. Therefore, the following recommendations are made, as shown in Figure 6.2.1 and 6.2.2 on NIC.15:

- The geological characteristics between Yalaguina and Ocotal are mainly volcanic clastic rock.
- The geological characteristics of Octal and Los Manos are granite (Mainly highly weathered and decomposed).
- These decomposed granites are loosened by reason of release of stress due to construction from cutting slopes.
- Volcanic clastic rock increases the risk of collapse where the thickness of weathering layer is about 3 meters or the slope gradient is steep.
- The rock falls and collapses occur when the permitted range of the relationship between slope heights and slope gradient is exceeded
- The decomposed granite requires the most safety measures to stabilize slopes.
- The most important thing for keeping slopes safe is not to exceed the permitted range of the relation slope height and slope gradient by rock characteristic.



○ : Stable (Volcanic clastic rock)
● : Rockfalls, collapsing (Volcanic clastic rock)
△ : Rockfalls, collapsing (Black schist)
▲ : Qaurternary gravel layer
□ : Andesite
═ : Limitation line between slope height and slope gradient

Figure 6.2.1 Volcanic Clastic Rock



○ : Stable, Re-cutting
△ : Gurry erosion
▲ : Collapsing
■ : After re-cutting, collapsed
═ : Limitation line between slope height and slope gradient

Figure 6.2.2 Decomposed Granite

CHAPTER 7

STUDY ON CONTERMEASURES/ ROUGH COST ESTIMATE

CHAPTER 7 STUDY ON COUNTERMEASURES/ ROUGH COST ESTIMATE

7.1 Basic Policy of Countermeasures

7.1.1 Basic Policy of Countermeasures to be Introduces

1) Countermeasures to be Applicable

The type of countermeasure, construction record and construction possibility in Nicaragua are shown in Table.7.1.1.

Table 7.1.1 Type of Countermeasure and Construction Record and Possibility in Nicaragua

Classification	Type of Countermeasure	Construction Record	Construction Possibility
(1) Earth Work	Removal	○	○
	Recutting	○	○
	Rock splitting	○	○
	Embankment	○	○
(2) Vegetation	Hydroseeding	×	○
	Vegetation	○	○
(3) Surface Drainage	Crest ditch	○	○
	Berm ditch	○	○
	Toe ditch	○	○
(4) Structure	Stone pitching	○	○
	Shotcrete	×	○
	Sprayed concrete crib	×	△
	Gabion Wall	○	○
	Stone masonry wall	○	○
	Gravity-type retaining wall	○	○
	T-shaped retaining wall	○	○
	Pilling	○	○
(5) Protection	Prevention net	×	△
	Prevention fence	×	○
	Barrier with concrete wall	×	○
	Rock bolt	×	○
	Rock shed	○	○
	Concrete dam	○	○
(6)Bridge protection	Concrete revetment	○	○
	Stone riprap	○	○
	Gabion mat for pier	○	○
	Dumped rock	○	○

Note: ○; Applicable ×; Not applicable
△; Necessity of technical advice and materials/equipment

a) Procurement of Materials and Equipment

The procurement potential of materials and equipment are shown in Tables 7.1.2 and 7.1.3.

Table 7.1.2 Procurement of Construction Material

Items	Nicaragua	Third Country	Remarks
Portoland cement	○		
Coarse aggregate	○		
Fine aggregate	○		
Plywood panel	○		
Steel form		○	
Reinforcing bar		○	
Admixture		○	
PC bar		○	

Note: ○; Possibility of procurement

Table 7.1.3 Procurement of Construction Equipment

Items	Capacity	Nicaragua	Third Country	Remarks
Bulldozer	15t	○		
Back hoe	$0.6m^3$	○		
Tire roller	10t	○		
Road roller	10t	○		
Vibrating roller	10t	○		
Dump truck	11t	○		
Truck	10t	○		
Welder	300A	○		
Truck crane	20t	○		
Truck crane	45t		○	
Trailer	20t	○		
Hydraulic breaker	1300kg		○	
Truck mixer	$4.5\ m^3$		○	
Jumbo breaker	1300kg		○	
Compressor	$5\ m^3$/min		○	
Generator	25kvA-150kvA		○	

Note: ○; Possibility of procurement

2) MTI Budget for Road Disaster

a) Existing and Past Budget

The recent past budget of the MTI has grown rapidly (both external and Government funds) as shown in Table 7.1.4.

Before Hurricane Mitch the total investment of the MTI was approximately US$50 to 60 million. After Hurricane Mitch the budget rose to double the previous level to around US$ 110 to 124 million. The proportion due to external resources rose to more than 50% of the budget, with a corresponding drop in Government funding, due to budget limitations.

In late 2001, the MTI prepared a original budget for a total of 895 million Cordobas (64 million US$). After the negotiation with the Cabinet, it became clear that approximately 10% of the original budget of MTI would become the subject of budget review. Hence, the level of the final budget is likely to be around 60 millions US$, made up by 72% in external finance and 28% from the Government's own funds.

Table 7.1.4 Investment by Sources (1990-2001) in Millions

Year	External				Internal				Total	
	Amount C$	Exchange Rate	Amount $	%	Amount C$	Exchange Rate	Amount $	%	Amount C$	Amount $
1997	232.23	9.48	24.50	51.60	217.80	9.48	22.97	48.4	450.03	47.5
1998	349.34	10.5821	33.01	49.96	349.91	10.5821	33.07	50.04	699.24	66.1
1999	712.82	11.809	60.36	48.55	755.33	11.809	63.96	51.45	1468.15	124.3
2000	827.48	12.6844	65.24	55.07	675.02	12.6844	53.22	44.93	1502.50	118.5
2001	828.60	12.7	65.24	57.82	604.46	12.7	47.60	42.18	1433.06	112.8
2002	581.67	13.9	41.85	71.70	229.57	13.9	16.52	28.3	811.25	58.4
Total	3532.13		290.20		2832.08		237.33		6364.21	527.5

b) Future Requirement and Road Disaster Budget

Owing to the deterioration of transport infrastructure in Nicaragua, MTI prepared a Medium Term Plan 2002 – 2006 in order to develop the country's road infrastructure, as shown in Table 7.1.5. The total bid to Government amounted to 8 billion Cordobas (577 millions US$) for the coming 4 years, comprising 23.5% from on-going projects, 24.7% from committed projects and 51.8% from new projects seeking finance.

The consequence of this is that the average annual amount required would be 140 million US$, more than doubl the budget of the financial year 2002.

At the same time, the NTP also estimated the availability of future funds for MTI based on an analysis of past budgets, total project requirements, and the general forecasts for income and expenditure by each Ministry between during 1999 to 2003 as shown in Table 7.1.6. The average annual expenditure expected by MTI is around 99.2 million US$, in the period 1999 to 2003, according to Central Government estimates.

The resulting proposed average annual budget of the NTP is expected to be about 100 million US$ excluding any expenditure needed for the emergency repair of infrastructure affected by natural disaster and disaster prevention.

Based on the above review, the future average annual budget allocated to MTI is likely to be about 100 million US$ for the expected infrastructure projects of rehabilitation, improvement and maintenance. In addition, in order to prepare for emergency repairs to natural disasters and disaster prevention it is recommended that approximately 15-20% of the total routine and a part of periodic maintenance cost amounting to approximately 10-15% of the total annual investment, has to be either invested in disaster prevention measures or saved as a contingency for emergency repairs.

Table 7.1.5 Road Infrastructure Development Plan 2002- 2006

PROJECT	Dist (km)	Amount (million $)	Amount (million C$)	% advance	Probable date of completion	Donner
A: On Going						
A -1 Rehabilitation & improvement of the Trunk Road (airport - San Benito)	23,0	6,04	83,9	85	april-02	BM
A - 2 Adoquin	96,9	11,42	158,68		mayo-02	BM
A - 3 Rehabilitation & improvement of the Trunk Road Panamerican North (San Benito El Espino)	204,0	49,23	684,27	88	april-02	BID
A - 4 Construction 4 bridges	0,3	17,77	247	98	feb-02	Japan
A - 5 Construction El Guasaule bridge	0,2	5,63	78,2	70	dec-02	Japan
A - 6 Rehabilition & Improvement of Trunk Road San Benito - San Lorenzo	79,6	20,41	283,75	76	aug-02	Denmark
A - 7 Rehabilitation and Improvement of Trunk Road Yalagüina-Las Manos	43,6	23,42	325,5	79	jul-02	Sweden
A - 8 Construction El Arroyo bridge	0,0	1,41	19,65	79	mar-02	Own fund
Sub total	**447,6**	**135,32**	**1880,95**			
%			**23,5**			
B: Commited 2002-2004					**Probable starting date**	
B - 1 Adoquin	280,0	33,81	470	0	2002	BM
B - 2 Rehabilitation of Trunk Road Las Piedrecitas-Nagarote	38,4	14,41	200,35	0	feb-02	BM
Nagorote-Izapa	15,0	6,47	89,9	0	feb-02	BM
La Subasta-Aeropuerto	3,5	3,55	49,4	0	mar-02	BM
Muhan-Nueva Guinea	21,0	6,50	90,3	0	mar-02	BM
Nueva Guinea-La Chona.	35,0	6,44	89,5	0	mar-02	BM
La Chona-El Rama	34,3	8,08	112,3	0	mar-02	BM
B - 3 Rehabilitation of Trunk Road San Lorenzo-Muhan	88,0	42,00	583,8	0	april-02	BID
B - 4 Rehabilitation of Vado and Caja Quebrada Honda Bridges	0,48	0,24	3,4	0	march 2002	BID
B - 5 Repair of Section, La Poma-Pacayita	2,2	0,29	4,0	0	april-02	BID
B - 6 Rehabilitation of Trunk Road Tipitapa-Masaya-Las Flores	22,5	4,68	65,0	0	may-02	OPEP
B - 7 Widening Managua-Masaya	15,0	16,00	222,44	0	jul-02	Spain
Sub total	**555,38**	**142,47**	**1980,39**			
%			**24,7**			
C: Negotiation of Finance						
C - 1	122,0	50,0	695			Venezuela
C - 2	218,5	85,1	1182,89			Kuwait
C - 3	22,0	5,0	69,5			BCIE
C - 4	24,6	14,2	196,824			EU
C - 5	34,3	0,3	4,17			Spain
C - 6	74,5	0,3	4,17			
C - 7	72,0	19,0	264,1			BCIE
C - 8	55,1	16,0	222,4			BID
C - 9	0,222	12,0	166,8			Japan
C - 10	18,0	11,0	152,9			BCIE
C - 11	89,0	22,0	305,8			X
C - 12	57,7	15,2	211,28			X
C - 13	152,6	49,0	681,1			X
Sub total	**940,5**	**299,06**	**4156,934**			
%			**51,8**			
Total		**576,9**	**8018,3**			
%			**100%**			

Note: The exchange rate used is C$13.9 per $1.00

Therefore, approximately 1.5-3% of the annual budge for MTI has to be allocated for expenditure towards either emergency repairs or disaster prevention.

Table 7.1.6 General Perspective of Expenditure of Central Government

Type of Project	1999-2003	Executor Agent	1999-2003
Bridges and Roads	407.2	MTI	396.9
Hospitals and Heath Center	122.5	MINSA	94.0
		MITRAB	0.9
		INATEC	0.4
Housing	194.8	INVUR	179.2
Schools	99.7	SAS	15.2
Water and sanitation	11.3	INIFOM	10.7
Electricity	29.6	MECD	70.3
		ENACAL	11.3
Others	5.0	ENEL	29.6
		Other	4.5
		Supplementary Social Fund	57.0
Total	870.0	Total	870.0

Source: FMI/ Nicaragua Staff Report for the 1999 Article IV Consultation and Request for the Second Annual Arrangement Under the ESAF

7.1.2 Objectives of Countermeasures

The objectives of countermeasures for road disasters can be expressed as follows:

i) To prevent the occurrence of an unexpected disaster;
ii) To keep traffic moving without closing a road section;
iii) To protect property, whether public or private; and/or
iv) To minimise the maintenance and rehabilitation costs of roads.

Countermeasures at disaster critical spots are divided into the following three categories as per the disaster conditions set out in Sub-section 4.2.6.

- Emergency Countermeasures
- Permanent Countermeasures
- Temporary Countermeasures

The applicability of countermeasures against slope failures and bridge foundation scouring are shown in Tables 7.1.7 and Table 7.1.8.

1) Emergency Countermeasures

Emergency countermeasures focus on the requirement to allow traffic and people to continue to pass on a given road section before the anticipated occurrence of some kind of road damage. Therefore, disaster critical spots, such as highly critical rock fall spots, slope damage, high critical bridge foundations and so on, should be urgently removed by measures such as stabilizing vulnerable rocks, or introducing gabions around bridge foundations.

2) Permanent Countermeasures

Permanent countermeasure focus on the following:

i) Where the life of any emergency countermeasure or temporary countermeasure which is about to expire; or

ii) Potential damage spots that are located on an important part of the road network.

3) Temporary Countermeasures

Temporary Countermeasure focus on the following:

i) Sites where permanent countermeasures are not feasible;

ii) Sites where, should road damage occur, permanent repair works would take a long time; or

iii) Sites where further disasters are not anticipated in the near future.

Table 7.1.7 Applicability of Countermeasures against Slope Failures

Classification	Type of Work	Type of Slope Failure											
		Rock-fall/ Collapsing			Rock collapsing			Slope Damage			Debris Flow		
		E	T	P	E	T	P	E	T	P	E	T	P
(1) Earth Work	Removal	○	○	○	○	○	○	○	○	○	○	○	○
	Recutting	○	○	○	○	○	○	○	○	○	○	○	○
	Rock splitting	○	○	○	○	○	○	×	×	×	○	○	○
	Embankment	○	○	○	×	×	×	○	○	○	△	△	×
(2) Vegetation	Hydroseeding	○	○	○	△	△	△	○	○	○	○	○	○
	Vegetation	○	○	○	×	×	×	○	○	○	○	○	○
(3) Surface Drainage	Crest ditch	○	○	○	△	△	○	○	○	○	×	×	×
	Berm ditch	△	○	○	△	○	○	△	○	○	×	×	×
	Toe ditch	△	○	○	△	○	○	△	○	○	×	×	×
(4) Structure	Stone pitching	○	○	△	×	×	×	○	○	△	×	×	×
	Shotcrete	△	○	○	△	○	○	△	△	△	△	○	○
	Sprayed concrete crib	×	△	○	×	△	○	×	△	○	×	△	○
	Gabion Wall	○	○	△	○	○	△	○	○	△	○	○	△
	Stone masonry wall	△	○	○	△	○	○	△	○	○	△	△	△
	Gravity-type retaining wall	△	○	○	△	○	○	△	○	○	△	△	△
	T-shaped retaining wall	×	△	○	×	△	○	×	△	○	×	△	△
	Pilling	×	×	×	×	×	×	△	○	○	×	×	×
(5) Protection	Prevention net	△	△	×	△	○	○	×	×	×	×	×	×
	Prevention fence	×	△	○	△	○	○	×	×	×	×	×	×
	Barrier with concrete wall	×	△	○	△	○	○	×	×	×	×	×	×
	Rock bolt	△	×	×	○	○	○	×	×	×	×	×	×
	Rock shed	×	×	△	×	△	○	×	×	×	×	△	○
	Concrete dam	×	×	×	×	×	×	×	×	×	×	○	○

Table 7.1.8 Applicability of Countermeasures against Bridge Foundation Scouring

Classification	Type of work	Abutment			Pier		
		E	T	P	E	T	M
Bridge protection	Concrete revetment	×	○	○	×	○	○
	Stone riprap	△	○	○	○	○	○
	Gabion mat for pier	×	×	×	○	○	△
	Dumped rock	○	×	×	○	×	×

Note: E; Emergency Countermeasure, T; Temporary Countermeasure,
P; Permanent Countermeasure
○; Most Applicable, △; Applicable, ×; Not applicable

7.2 Classification of Countermeasures

This section discusses how to select the desirable restoration measure from the potential candidates listed in Table 7.1.2. The classification procedure is expressed as a flow chart in order to reach a final solution, for each type of work and damage.

7.2.1 Rock-fall/ Collapsing

1) Emergency of Countermeasures

Emergency countermeasures focus on maintaining traffic and people flow before the occurrence of road damage. When further rock-falls and collape are anticipated, the following measures will be effective in preventing rock falls and collapse from reaching the road pavement:

- Installation of a barrier along the road's shoulder to trap rocks and collapses (these barriers can be made of earth, gabion mats, etc);
- Removal of unstable rocks from the slope surface; and /or
- Installation of a crest ditch along the tops of the slopes.

The selection procedure for emergency countermeasures for rock-fall/collapsing is shown in Figure.7.2.1.

2) Temporary/ Permanent Countermeasures

The objectives of temporary and permanent prevention measures are to restore the original functions of a damaged road and to maintain those functions. To achieve this, temporary and permanent repair works are carried out as a part of any restoration measures. Temporary repair work refers to the short service life of a job, while permanent repair work refers to a long service life.

The flow chart in Figure 7.2.2 and Figure 7.2.3 explain the selection procedure for a temporary and permanent countermeasure.

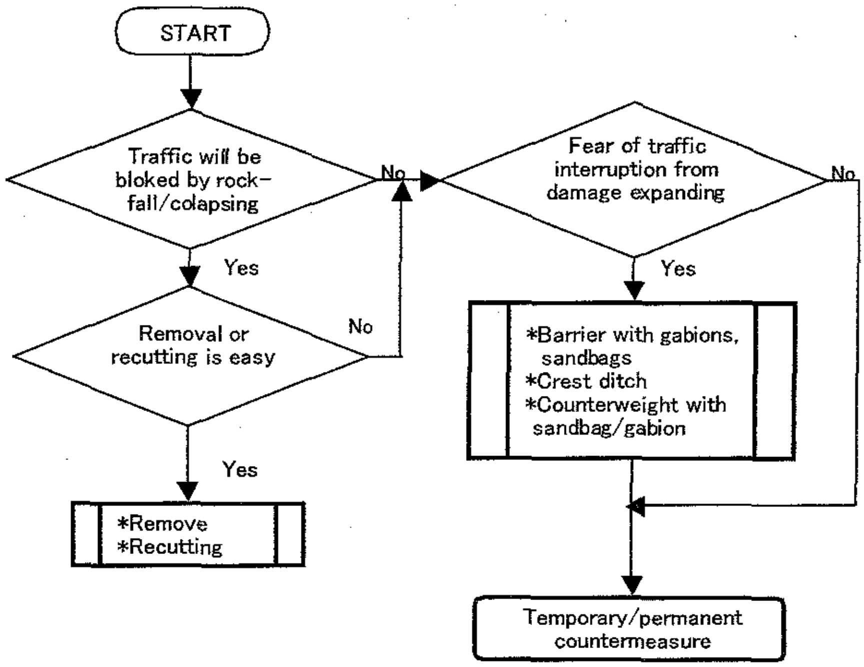


Figure 7.2.1 Selection of Emergency Countermeasure in Case of Rackfall/ Collapsing

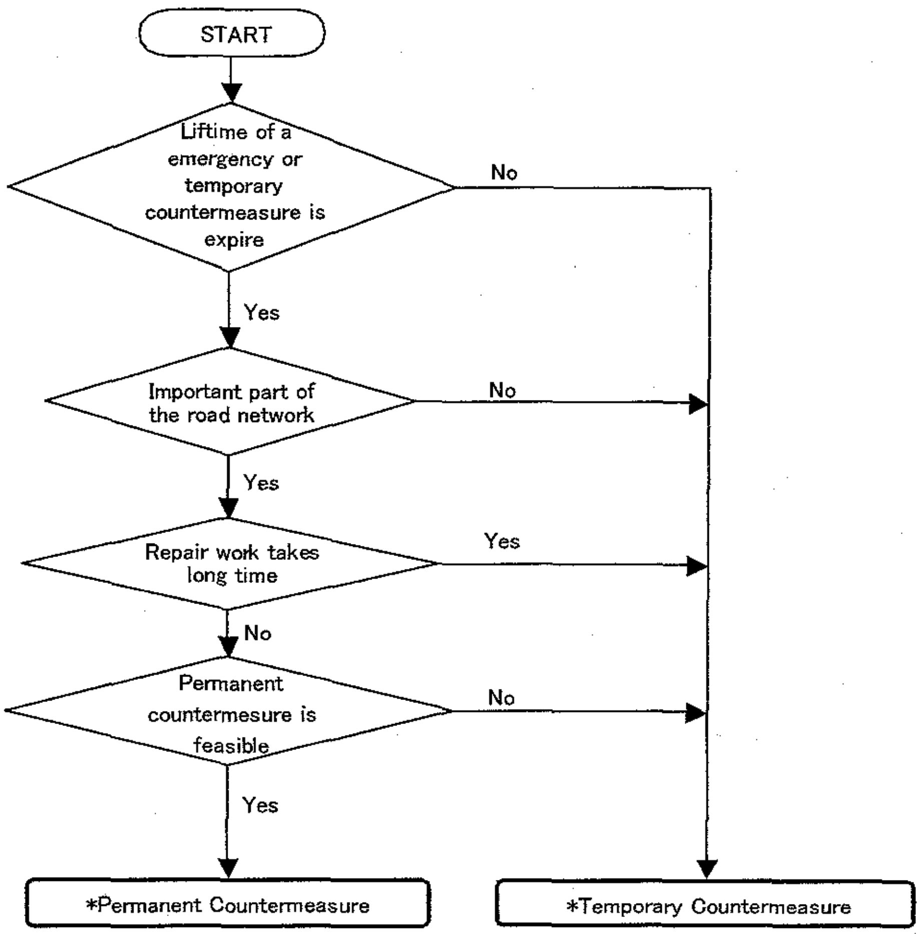


Figure 7.2.2 Selection of a Temporary and Permanent Countermesure

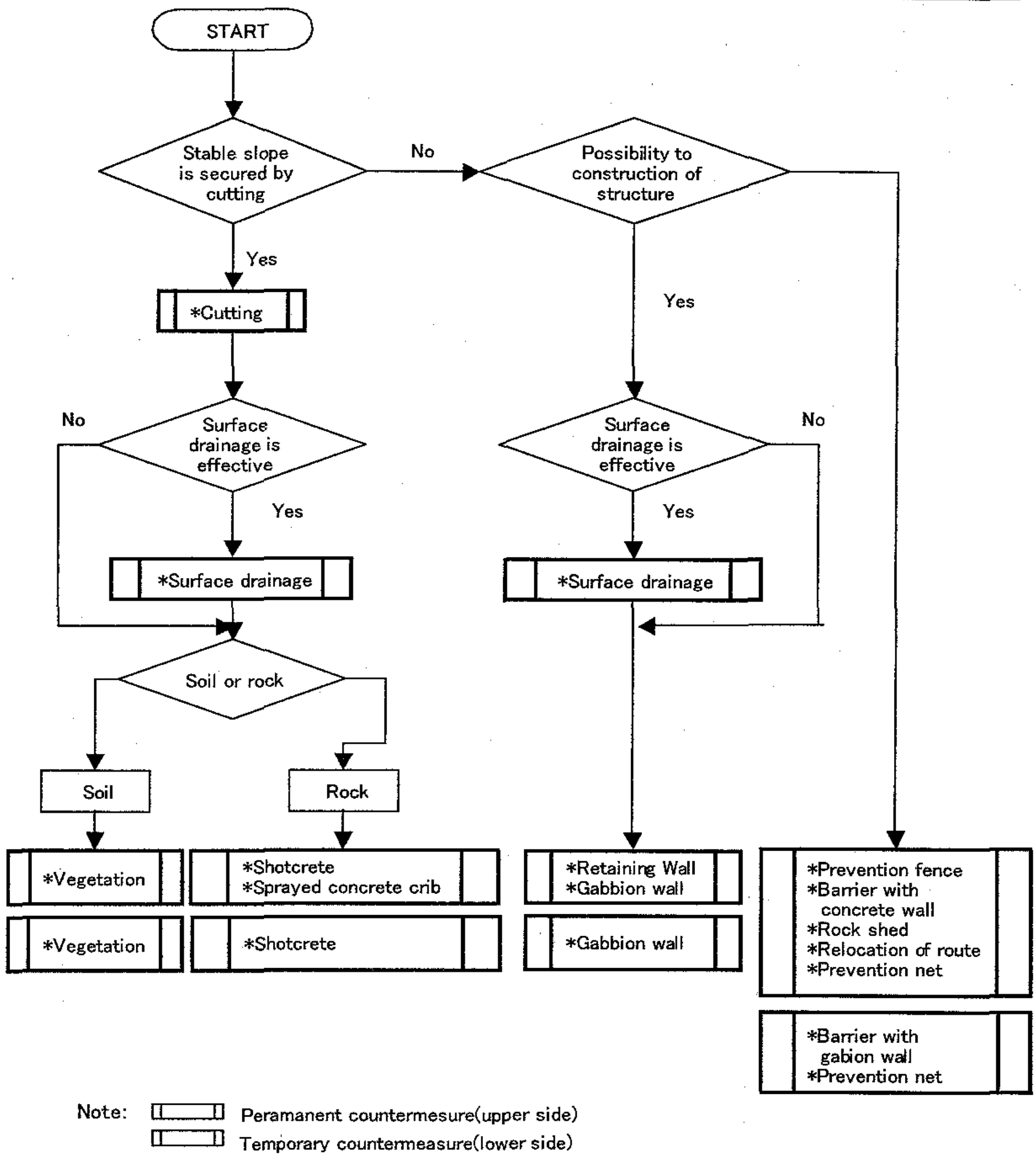


Figure 7.2.3 Selection of Temporary and Permanent Countermeasure for Rockfall/ Collapsing

7.2.2 Rock Collapsing

1) Emergency of Countermeasures

In order to reopen a road closed to traffic by rock collapsing, the highest priority shall be given to prompt removal of fallen rocks. If further rock collapse is anticipated, the following measures will be effective in preventing rocks that collapse from reaching the road's surface.

- Installation of a barrier along the road's shoulder to catch rocks collapsing (The barrier can be made of earth, gabion mats, etc.);
- Removal of unstable rocks, before collapse, from the slope surface.

A selection procedure for emergency of countermeasures in the case of rock collapsing is shown in Figure.7.2.4.

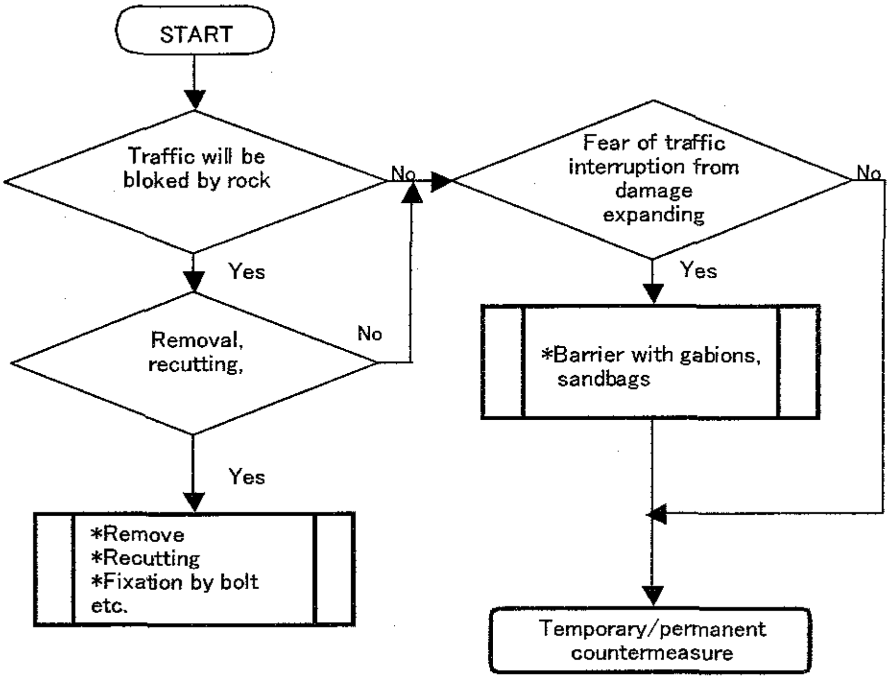


Figure 7.2.4 Selection of Emergency Countermeasure in Case of Rock Collapsing

2) Temporary/ Permanent Countermeasures

The objectives of temporary and permanent measures to prevent disasters are to restore the original functions of a damaged road and to maintain those functions. To achieve this, temporary and permanent repair works are carried out as a part of the restoration measures. Temporary repair work refers to the short service life of a job, while permanent repair work refers to a long service life.

The flow chart in Figure 7.2.2 and Figure 7.2.5 explain the selection procedure for a temporary and permanent countermeasure.

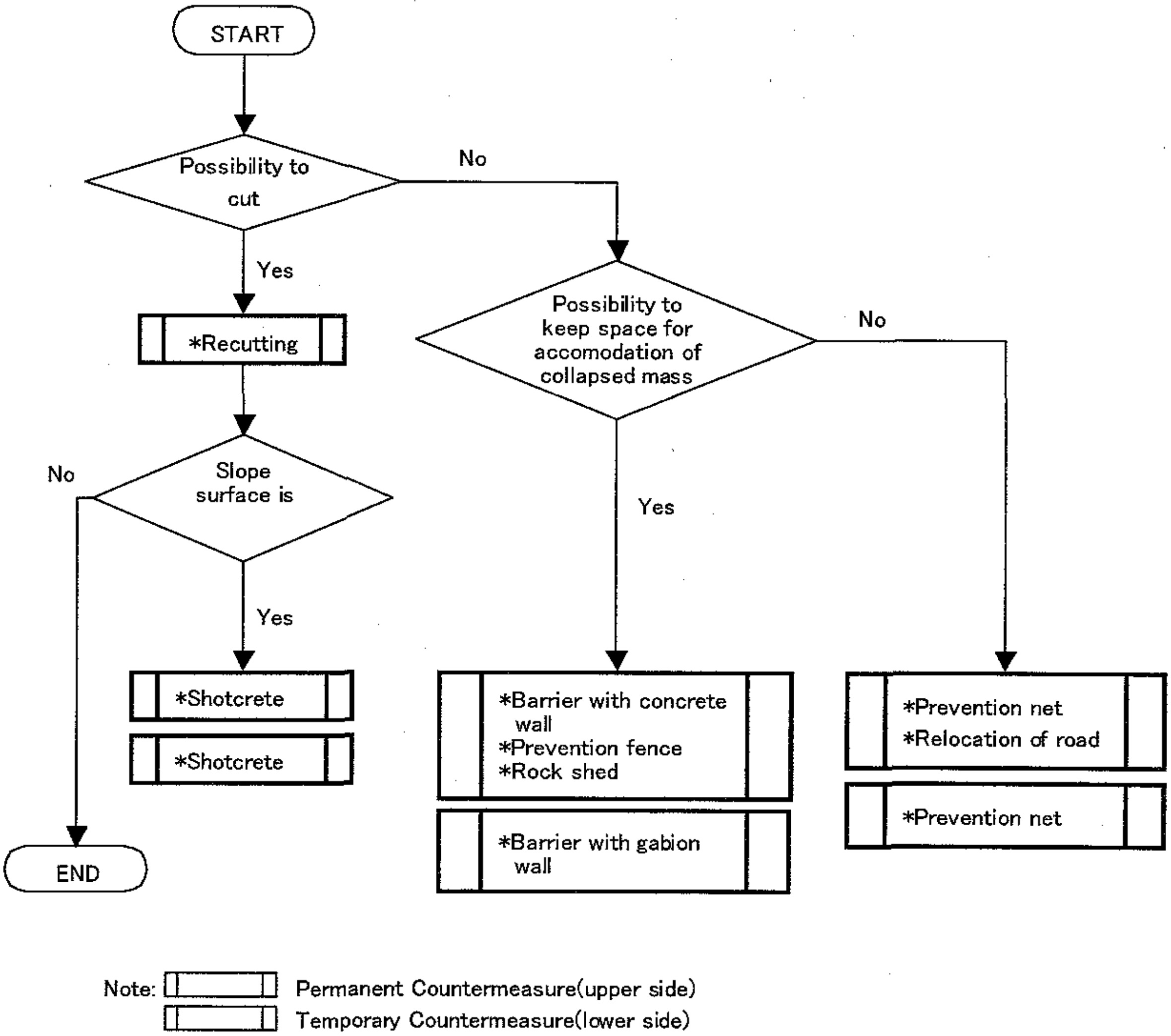


Figure 7.2.5 Selection of Temporary and Permanent Countermeasures for Rock Collapsing

7.2.3 Slope Damage

1) Emergency of Countermeasures

Emergency countermeasure focus on keeping traffic moving without closing a road section, before the occurrence of some unforeseen road damage. If further slope damage is anticipated, the following measures will be effective in preventing slope damage from reaching the road's surface:

- Placing counterweights made of earth, sandbag, or gabion mats;
- Driven pile;
- Installing a retaining wall made of gabion mats.

As an indirect countermeasure, the groundwater level of slope can be lowered to increase the strength of the soil. To achieve this, the following can be applied.

- Cutting a surface ditch along the top of the slope and on the surface of slope to prevent run-off water from permeating into the slope.

- Covering the surface of slope with a sheet for the same purpose.

A selection procedure for emergency of countermeasures in the case of slope damage is shown in Figure.7.2.6.

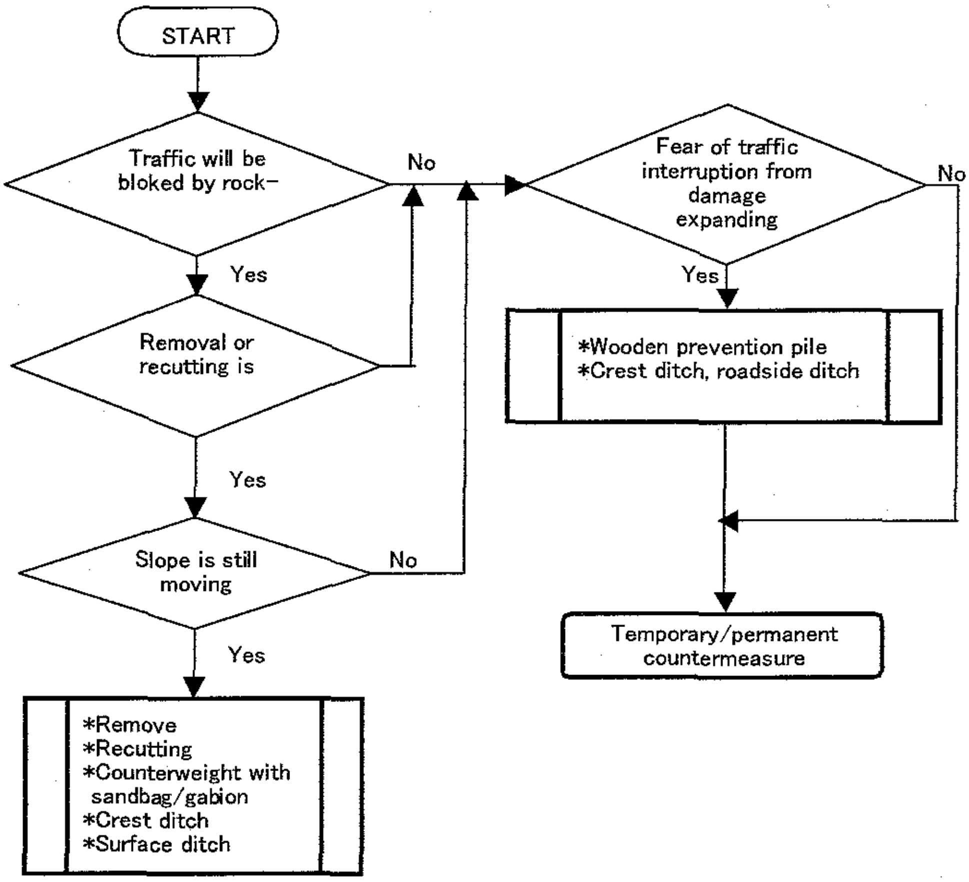


Figure 7.2.6 Selection of Emergency Countermeasure in Case of Slope Damage

2) Temporary/ Permanent Countermeasures

The objectives of temporary and permanent prevent disasters are to restore the original functions of a damaged road and to maintain those functions. To achieve this, temporary and permanent repair works are carried out as a part of the restoration measures. Temporary repair work refers to the short service life of a job, while permanent repair work refers to a long service life.

The flow charts in Figure 7.2.2 and Figure 7.2.7 explain the selection procedures for a temporary and permanent countermeasure.

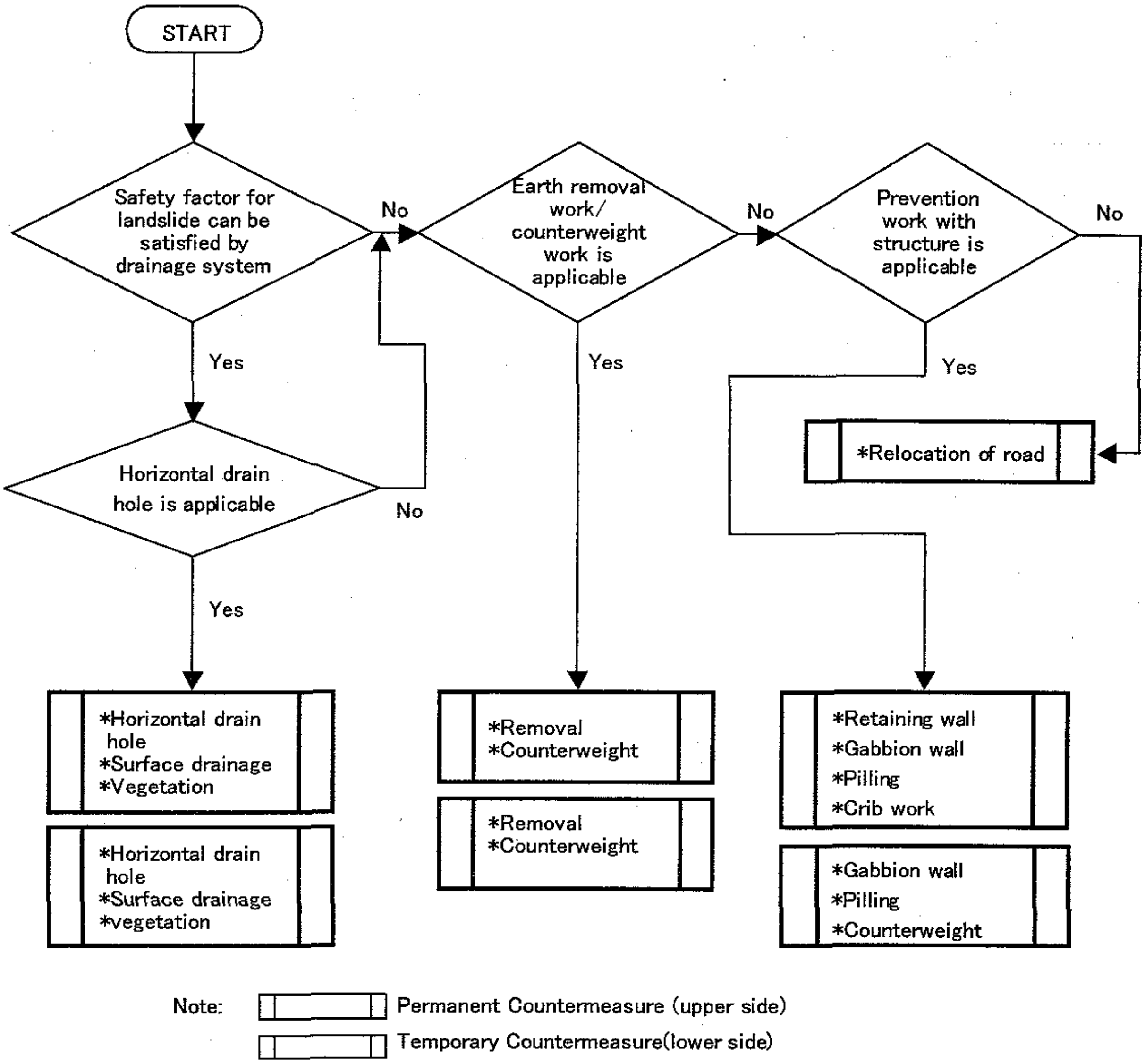


Figure 7.2.7 Selection of Countermeasure for Slope Damage

7.2.4 Debris Flow

1) Emergency of Countermeasures

Emergency countermeasure focuses on pass smoothly without closing a road section to traffic and people before the unforeseen occurrence of some road damage. If further debris flows are anticipated, the following measures will be effective in preventing debris flow from reaching the road's surface:

- Debris removal;
- Locking debris by fences, retaining walls, and dams;
- Traffic control.

2) Temporary/ Permanent Countermeasures

The objectives of temporary and permanent prevent disasters and to maintain original functions. To achieve this, temporary and permanent repair work is carried out as a part of the restoration measures. Temporary repair work refers to the short service life of a job, while permanent repair work refers to a long service life.

The flow chart in Figure 7.2.8 explains the selection procedure for an emergency and temporary/permanent countermeasure.

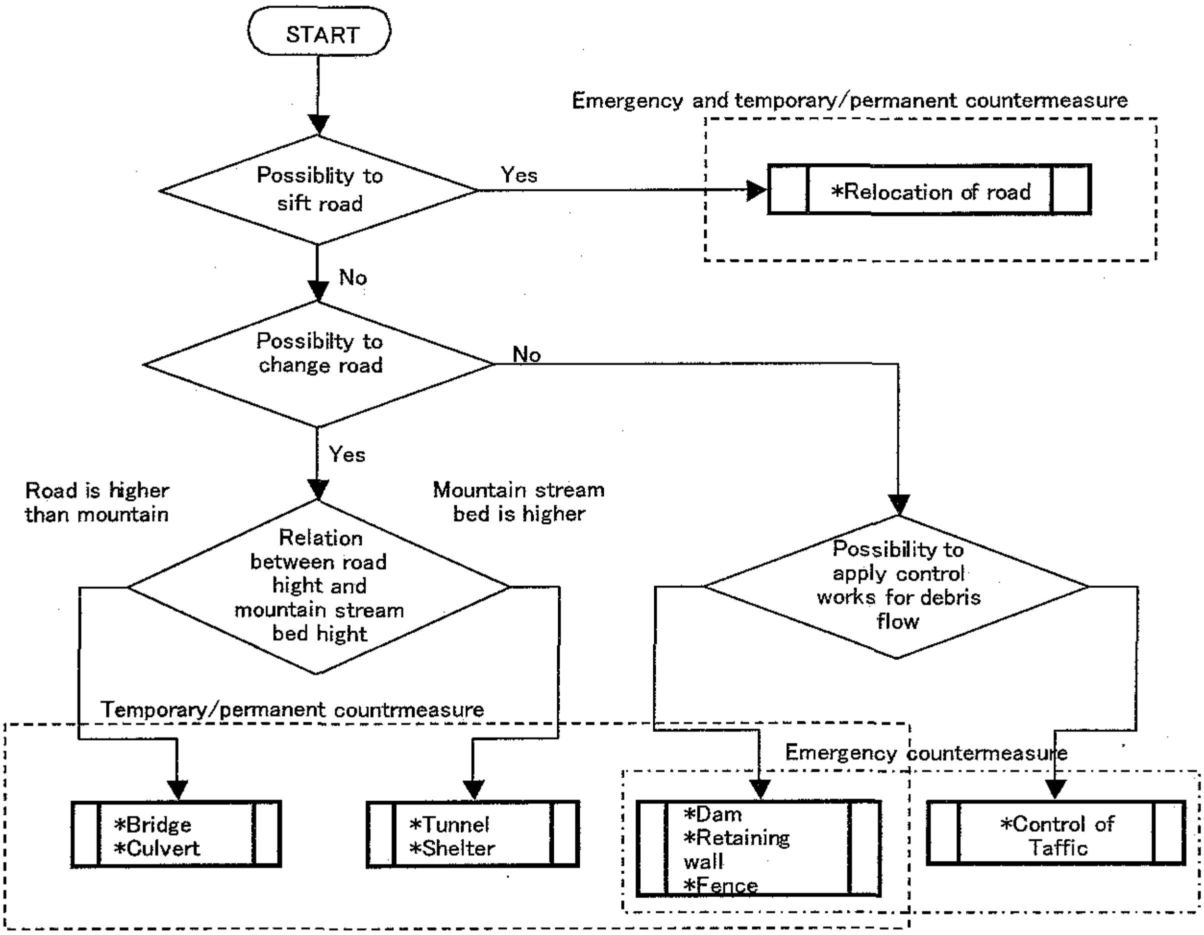


Figure 7.2.8 Selection Countermeasure for Debris Flow

7.2.5 Bridge Foundation Scouring

1) Emergency of Countermeasures

Emergency countermeasures focus on the prevention of bridge collapse, or the collapse of embankments of approach road. If there is any further damage on site, the following emergency countermeasures shall be applied:

- The protection of abutments, piers, approach roads and/or riverbanks adjacent to abutments using gabion mats.

A selection procedure for emergency countermeasures in the case of bridge foundation scouring is shown in Figure.7.2.9.

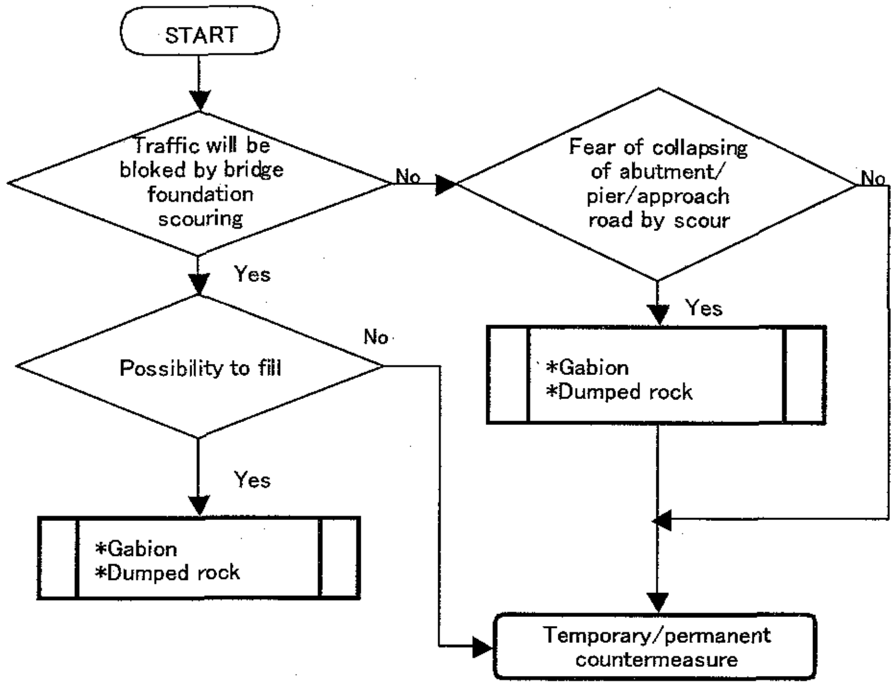


Figure 7.2.9 Sellection of Emergency Countermeasure in Case of Bridge Foundation Scouring

2) Temporary/ Permanent Countermeasures

Where rivers are on a flood plain, river channels are prone to shift and this can result in the scouring of abutments, piers and access road embankments. When the above-mentioned damage occurs, the damaged portions should be restored using the measures below:

- Restoration of abutment and pier scouring: For abutments : cylinder gabions, stone riprap or concrete revetments are applicable; while for pier scouring : mat gabions should be used.
- Restoration of access road scouring: Earth and gravel fill can be used to repair damage, while gabion mats, stone riprap or concrete revetments should be used to maintain repaired portions in good condition.

In addition, the following measures shall be applied to eliminate causes of damage:

- Stabilization of river channel: The stream's channel shall be prevented from scouring using dumped rock and/or cylinder gabions.

The flow chart in Figure 7.2.10 explains the selection procedure for temporary and permanent countermeasures.

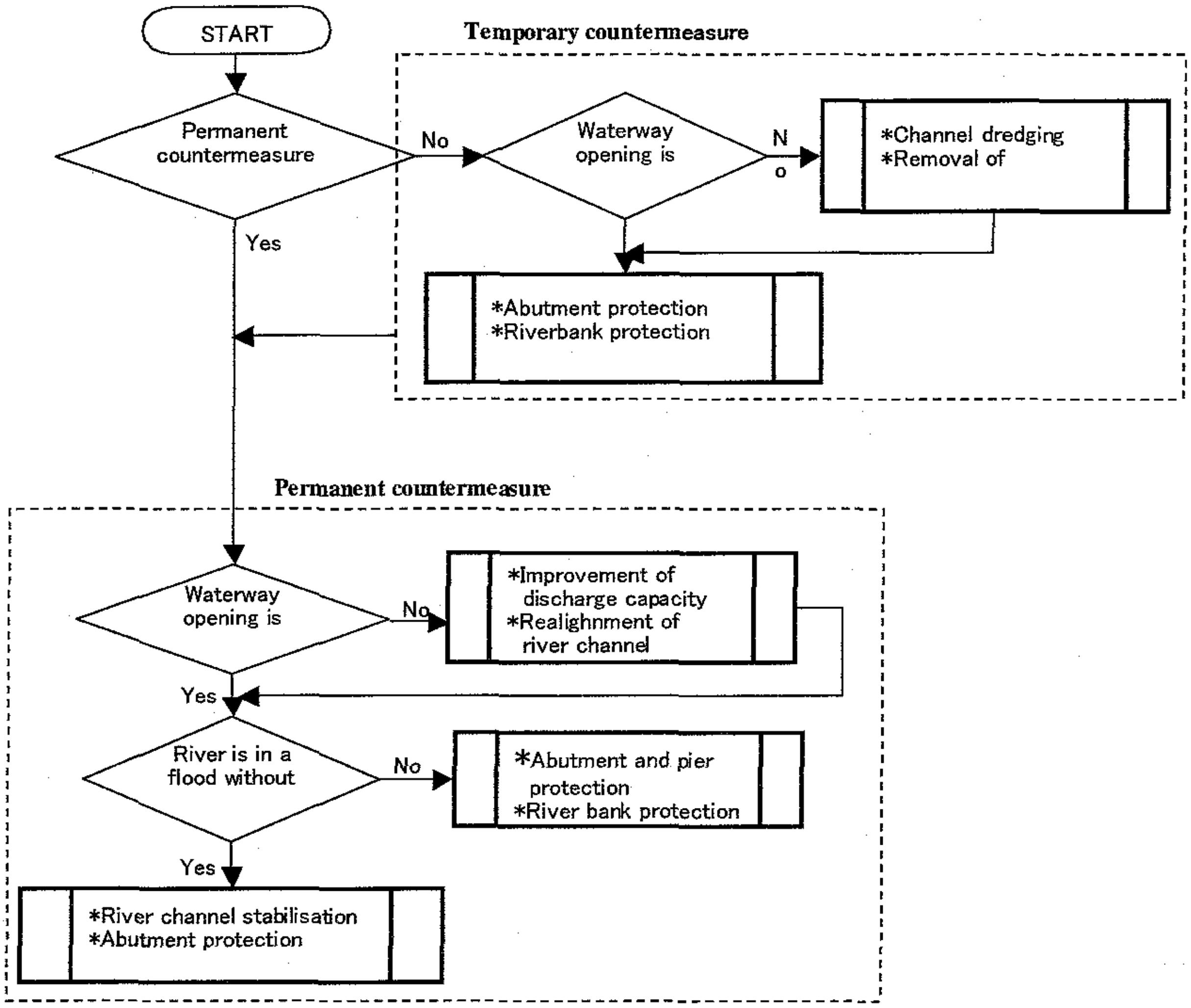


Figure 7.2.10 Selection of Tenporary/ Permanent Countermeasure in the Case of the Bridge Foundation Scouring

7.2.6 Identification of Countermeasures for Disaster Critical Spots

Countermeasures for disaster critical spots are classified into six groups, by purpose and application. The relation between objectives of prevention countermeasures and the types of work are shown in Figure 7.2.11.

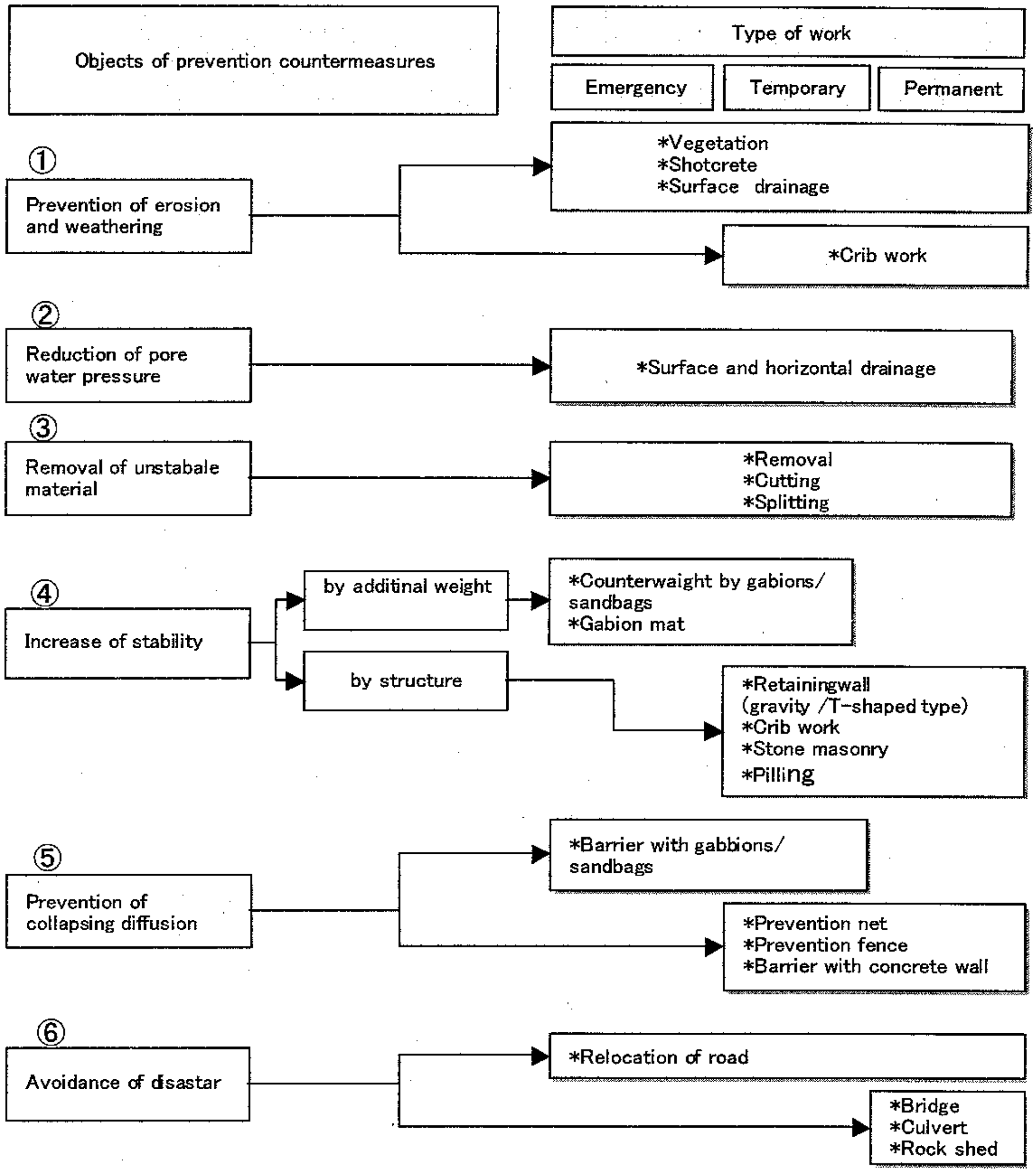


Figure 7.2.11 Relation between Objects of Prevention Countermeasures and Type of Work

7.3 Recommendation of Countermeasures for Each Objective Route

The study team recommends that the type of countermeasure for each critical spot is based on Section 7.2. The resulting recommendations on countermeasures are shown in Tables 7.3.1-Table 7.3.8.

7.3.1 NIC.1

Table 7.3.1 Type of Countermeasure for Slope Failure on NIC.1

No	Location (km)	Classification of Road Disaster	Grade	Type of Countermeasure		Quantity (m^2)
1	60.9	Rock-fall	70	Barrier with gabion wall +	T	440(m)
2	73.2	Rock-fall	78	Prevention net	T	7,000
3	168.4	Rock-fall	84	Prevention net	T	19,703
4	168.6	Rock collapsing	72	Prevention net	T	5,363
5	169.8	Rock collapsing	72	Prevention net	T	6,466
6	170.7	Rock collapsing	72	Recutting + Shotcrete	P	15,242
7	171.3	Rock collapsing	78	Recutting + Shotcrete	P	8,754
8	175.0	Rock collapsing	76	Recutting + Shotcrete	P	2,252
9	176.2	Rock collapsing	74	Recutting + Shotcrete	P	4,988
10	178.7	Rock-fall	76	Prevention net	T	7,760
11	187.3	Rock collapsing	73	Recutting + Shotcrete	P	2,540
12	204.7	Rock collapsing	73	Prevention net	T	2,217
13	214.7	Rock-fall	70	Recutting + Shotcrete	P	1,935
14	232.5	Rock collapsing	75	Prevention net	T	3,695
15	233.7	Rock-fall	73	Recutting + Surface drainage +Vegetation	T	8,407
16	235.6	Rock-fall	73	Recutting + Shotcrete	P	1,389

Note: E; Emergency countermeasure, T; Temporary countermeasure
P; Permanent countermeasure

Table 7.3.2 Type of Countermeasure for Bridge Foundation Scouring on NIC.1

No	Location	Classification of Road Disaster	Grade	Type of Countermeasure		Quantity (m^2)
1	113+190	Bridge foundation scouring	90	Gabion mat	T	252
2	135+640	Bridge foundation scouring	100	Gabion mat	T	18
3	150+330	Bridge foundation scouring	90	Gabion mat	T	666
4	151+850	Bridge foundation scouring	100	Gabion mat	T	117
5	226+890	Bridge foundation scouring	100	Gabion mat	T	41
6	233+245	Bridge foundation scouring	100	Gabion mat	T	18

7.3.2 NIC.3

Table 7.3.3 Type of Countermeasure for Slope Failure on NIC.3

No	Location (km)	Classification of Road Disaster	Grade	Type of Countermeasure		Quantity (m^2)
1	3.9	Rock collapsing	74	Recutting	T	1,046
2	6.9	Rock collapsing	72	Recutting	T	1,369
3	7.4	Rock collapsing	80	Recutting	T	1,049
4	22.1	Rock collapsing	74	Recutting	T	5,287
5	32.7	Rock collapsing	70	Recutting + Shotcrete	P	1,836
6	32.9	Slope damage	73	Recutting + Embankment +Counterweight +Vegetation	P	3,460
7	35.2	Debris flow	83	Dam	P	100(m)
8	35.9	Slope damage	71	Recutting + Embankment +Counterweight +Vegetation	P	4,352
9	38.9	Slope damage	90	Recutting + Embankment +Counterweight +Vegetation	P	4,526
10	39.4	Slope damage	90	Recutting + Embankment +Counterweight +Vegetation	P	284
11	40.0	Rock collapsing	81	Recutting + Prevention net	P	2,272

Table 7.3.4 Type of Countermeasure for Bridge Foundation Scouring on NIC.3

No	Location	Classification of Road Disaster	Grade	Type of Countermeasure		Quantity (m^2)
1	119+050	Bridge foundation scouring	100	Reconstruction wing wall	P	8

7.3.3 NIC.5

Table 7.3.5 Type of Countermeasure for Slope Failure on NIC.5

No	Location (km)	Classification of Road Disaster	Grade	Type of Countermeasure		Quantity (m^2)
1	24.6	Rock-fall/collapsing	76	Recutting + Surface drainage + Vegetation	T	55,600

7.3.4 NIC.15

Table 7.3.6 Type of Countermeasure for Slope Failure on NIC.15

No	Location (km)	Classification of Road Disaster	Grade	Type of Countermeasure		Quantity (m)
1	13.6	Debris flow	70	Gabion wall	T	100
2	11.7	Debris flow	70	Gabion wall	T	70
3	11.1	Debris flow	70	Dam	T	65
4	9.9	Debris flow	70	Dam	T	45

7.3.5 NIC.24

The critical spot is nothing for NIC.24.

7.3.6 NIC.26

Table 7.3.7 Type of Countermeasure for Slope Failure on NIC.26

No	Location (km)	Classification of Road Disaster	Grade	Type of Countermeasure		Quantity (m^2)
1	9.0	Rock-fall/collapsing	71	Recutting	T	841
2	12.7	Rock-fall/collapsing	70	Recutting	T	2,724
3	19.9	Rock-fall/collapsing	71	Recutting	T	6,683
4	20.9	Rock-fall/collapsing	72	Recutting	T	1,595
5	24.7	Rock-fall/collapsing	70	Recutting + Shotcrete	T	2,050
6	29.3	Rock-fall/collapsing	76	Barrier with gabion	T	77(m)
7	29.8	Rock collapsing	73	Prevention net	T	956
8	33.6	Rock-fall/collapsing	72	Recutting + shotcrete	T	780
9	34.0	Rock collapsing	80	Recutting	T	2,472
10	34.2	Rock-fall/collapsing	85	Recutting + shotcrete	T	9,641
11	37.0	Rock collapsing	86	Prevention net	T	2,226
12	45.5	Rock collapsing	71	Prevention net	T	6,472

Table 7.3.8 Type of Countermeasure for Slope Failure on NIC.26

No	Location	Classification of Road Disaster	Grade	Type of Countermeasure		Quantity (m^2)
1	107+533	Bridge foundation scouring	100	Gabion mat	T	90
2	108+154	Bridge foundation scouring	90	Gabion mat	T	54
3	155+785	Bridge foundation scouring	90	Gabion mat	T	248
4	170+952	Bridge foundation scouring	100	Gabion mat	T	369

7.4 Rough Cost Estimate

7.4.1 Construction Quantity

The six routes have 30 disaster critical spots in total. Construction quantities for all the critical spots are estimated based on countermeasure types and drawings in this study. A list of construction quantities is shown in Table 7.4.1.

Table 7.4.1 Construction Quantity

Classification	Type of Work	Remarks	Unit	Quantities
(1)Surface drainage	Crest ditch	0.5×0.5 1:1	m	670
	Berm ditch	U-0.3×0.3	m	2,355
	Toe ditch		m	715
	Vertical ditch	U-0.3×0.3	m	613
(2)Horizontal drainage	Horizontal drain hole	PVC PIPE	m	400
(3)Vegetation	Seed spraying with pump		m^2	30,754
	Seed-mix spraying with a gun		m^2	0
(4)Structure	Shotcrete	t=10cm	m^2	53,879
	Sprayed concrete crib		m^2	0
	Concrete block crib		m^2	0
	Gabion mat		m^3	770
(5)Structural support	Stone riprap wall		m^2	0
	Gravity-type retaining wall		m^3	0
	Gabion wall		m^3	2,440
	T-shaped retaining wall		m^3	2,108
	Prevention piles		m^3	0
	Foot protection with stone riprap		m^3	0
	Foot protection with concrete		m^3	0
(6)Earth work	Removal		m^3	11,087
	Rock cutting		m^3	50,017
	Rock pre-splitting	Rock blasting	m^3	111
	Soil cutting		m^3	79,344
	Embankment		m^3	52,241
(7)Rockfall preventione dvice	Prevention net		m^2	64,130
	Prevention fence		m^2	0
	Barrier with gabion mat		m^3	308
	Barrier with concrete wall		m^3	0
(8)Anchoring	Rock bolt		each	0
(9)Riverbank protection	Concrete revetments		m^3	0
	Gabion mat		m^3	1,958
	Stone riprap with mortar		m^3	0
(10)Abutment and pier protection	Gabion foot protection		m^3	0
	Sheet-pile toe wall		m^2	0

7.4.2 Unit Cost

Unit construction costs were prepared by MTI and the study team, based on estimates from four construction companies. A simple average of the unit costs of the four construction companies was used. However some of the works recommended in this study are unable to be priced locally, as there is a lack of experience in Nicaragua. Unit costs for those works were estimated based on the market price in Japan. A list of unit costs is shown in Table 7.4.2.

Table 7.4.2 Unit Costs

Classification	Type of Work	Remarks	Unit	Unit Cost (US$)
(1)Surface drainage	Crest ditch	0.5×0.5 1:1	m	65.12
	Berm ditch	U-0.3×0.3	m	49.49
	Toe ditch		m	60.78
	Vertical ditch	U-0.3×0.3	m	49.49
(2)Horizontal drainage	Horizontal drain hole	PVC PIPE ϕ0.04	m	27.00
(3)Vegetation	Seed spraying with pump		m^2	6.05
	Seed-mix spraying with a gun		m^2	8.14
(4)Structure	Shotcrete	t=10cm	m^2	48.30
	Gabion mat		m^3	43.67
(5)Structural support	Stone riprap wall		m^2	66.91
	Gravity-type retaining wall		m^3	120.10
	Gabion wall		m^3	143.97
	T-shaped retaining wall		m^3	424.24
	Foot protection with stone riprap		m^3	66.91
	Foot protection with concrete		m^3	391.25
(6)Earth work	Removal		m^3	5.87
	Rock cutting		m^3	92.83
	Rock pre-splitting	Rock blasting	m^3	109.50
	Soil cutting		m^3	5.93
	Embankment		m^3	14.70
(7)Rockfall prevention device	Prevention net		m^2	33.65
	Barrier with gabion mat		m^3	97.49
	Barrier with concrete wall		m^3	625.13
(8)Anchoring	Rock bolt		each	218.25
(9)Riverbank protection	Concrete revetments		m^3	380.20
	Gabion mat		m^3	97.49
	Stone riprap with mortar		m^3	66.91
(10)Abutment and pier protection	Gabion foot protection		m^3	43.67

7.4.3 Rough Cost for Each Objective Route

Rough costs for each objective route are shown in Tables 7.4.3- Table7.4.10.

Table 7.4.3 Construction Cost of Countermeasure for Slope Failure on NIC.1

No	Location	Classification of road Disaster	Type of Countermeasure		Quantity (m^3)	Cost (×1000US$)
1	60.9	Rock-fall	Barrier with gabion wall +	T	440(m)	253
2	73.2	Rock-fall	Prevention net	T	7,000	236
3	168.4	Rock-fall	Prevention net	T	19,703	812
4	168.6	Rock collapsing	Prevention net	T	5,363	315
5	169.8	Rock collapsing	Prevention net	T	6,466	364
6	170.7	Rock collapsing	Recutting + Shotcrete	P	15,242	1,772
7	171.3	Rock collapsing	Recutting + Shotcrete	P	8,754	639
8	175.0	Rock collapsing	Recutting + Shotcrete	P	2,252	184
9	176.2	Rock collapsing	Recutting + Shotcrete	P	4,988	385
10	178.7	Rock-fall	Prevention net	T	7,760	456
11	187.3	Rock collapsing	Recutting + Shotcrete	P	2,540	197
12	204.7	Rock collapsing	Prevention net	T	2,217	125
13	214.7	Rock-fall	Recutting + Shotcrete	P	1,935	175
14	232.5	Rock collapsing	Prevention net	T	3,695	208
15	233.7	Rock-fall	Recutting + Surface drainage +Vegetation	P	8,407	116
16	235.6	Rock-fall	Recutting + Shotcrete	P	1,389	152
Total						6,389

Note: E; Emergency countermeasure, T; Temporary countermeasure
P; Permanent countermeasure

Table 7.4.4 Construction Cost of Countermeasure for Bridge Foundation Scouring on NIC.1

No	Location	Classification of road Disaster	Type of Countermeasure		Quantity (m^3)	Cost (×1000us$)
1	113+190	Bridge foundation scouring	Gabion mat	T	252	25
2	135+640	Bridge foundation scouring	Gabion mat	T	18	2
3	150+330	Bridge foundation scouring	Gabion mat	T	666	65
4	151+850	Bridge foundation scouring	Gabion mat	T	117	12
5	226+890	Bridge foundation scouring	Gabion mat	T	41	4
6	233+245	Bridge foundation scouring	Gabion mat	T	18	2
Total						110

Table 7.4.5 Construction Cost of Countermeasure for Slope Failure on NIC.3

No	Location (km)	Classification of road Disaster	Type of Countermeasure		Quantity (m^2)	Cost (×1000us$)
1	3.9	Rock collapsing	Recutting	T	1,046	70
2	6.9	Rock collapsing	Recutting	T	1,369	91
3	7.4	Rock collapsing	Recutting	T	1,049	35
4	22.1	Rock collapsing	Recutting	T	5,287	177
5	32.7	Rock collapsing	Recutting + Shotcrete	P	1,836	174
6	32.9	Slope damage	Recutting + Embankment +Counterweight +Vegetation	P	3,460	670
7	35.2	Debris flow	Dam	P	100(m)	429
8	35.9	Slope damage	Recutting + Embankment +Counterweight +Vegetation	P	4,352	248
9	38.9	Slope damage	Recutting + Embankment +Counterweight +Vegetation	P	4,526	191
10	39.4	Slope damage	Recutting + Embankment +Counterweight +Vegetation	P	284	30
11	40.0	Rock collapsing	Recutting + Prevention net	P	2,272	133
Total						2,248

Table 7.4.6 Construction Cost of Countermeasure for Bridge Foundation Scouring on NIC.3

No	Location	Classification of road Disaster	Type of Countermeasure		Quantity (m^3)	Cost (×1000us$)
1	119+050	Bridge foundation scouring	Reconstruction wing wall	P	8	3

Table 7.4.7 Construction Cost of Countermeasure for Slope Failure on NIC.5

No	Location (km)	Classification of road Disaster	Type of Countermeasure		Quantity (m^2)	Cost (×1000us$)
1	24.6	Rock-fall/collapsing	Recutting + Surface drainage + Vegetation	T	55,600	744

Table 7.4.8 Construction Cost of Countermeasure for Slope Failure on NIC.15

No	Location (km)	Classification of road Disaster	Type of Countermeasure		Quantity (m)	Cost (×1000us$)
1	13.6	Debris flow	Gabion wall	T	100	58
2	11.7	Debris flow	Gabion wall	T	70	40
3	11.1	Debris flow	Dam	P	65	279
4	9.9	Debris flow	Dam	P	45	193
Total						570

Table 7.4.9 Construction Cost of Countermeasure for Slope Failure on NIC.26

No	Location (km)	Classification of road Disaster	Type of Countermeasure		Quantity (m^2)	Cost (×1000us$)
1	9.0	Rock-fall/collapsing	Recutting	T	841	56
2	12.7	Rock-fall/collapsing	Recutting	T	2,724	115
3	19.9	Rock-fall/collapsing	Recutting	T	6,683	446
4	20.9	Rock-fall/collapsing	Recutting	T	1,595	121
5	24.7	Rock-fall/collapsing	Recutting + Shotcrete	P	2,050	159
6	29.3	Rock-fall/collapsing	Barrier with gabion	T	77(m)	44
7	29.8	Rock collapsing	Prevention net	T	956	52
8	33.6	Rock-fall/collapsing	Recutting + shotcrete	P	780	60
9	34.0	Rock collapsing	Recutting	T	2,472	191
10	34.2	Rock-fall/collapsing	Recutting + shotcrete	P	9,641	748
11	37.0	Rock collapsing	Prevention net	T	2,226	131
12	45.5	Rock collapsing	Prevention net	T	6,472	364
Total						2,527

Table 7.4.10 Construction Cost of Countermeasure for Bridge Foundation Scouring on NIC.26

No	Location	Classification of road Disaster	Type of Countermeasure		Quantity (m^2)	Cost (×1000us$)
1	107+533	Bridge foundation scouring	Gabion mat	T	90	9
2	108+154	Bridge foundation scouring	Gabion mat	T	54	5
3	155+785	Bridge foundation scouring	Gabion mat	T	248	24
4	170+952	Bridge foundation scouring	Gabion mat	T	369	36
Total						74

7.4.4 Total Cost

Total construction cost estimates for each route are shown in Table 7.4.11

Table 7.4.11 Total Cost of Each Route

Route No.	Costs (×1000US$)
NIC.1	6,499
NIC.3	2,251
NIC.5	744
NIC.15	570
NIC.24	0
NIC.26	2,601
Total	12,665

US$1=C$13.9

7.5 Investment Schedule

The rough cost estimate for all 55 sites was round 12.7 million US dollars. According to Sub-section 7.1.1, the MTI budget decreased after Hurricane Mitch. Furthermore, a high proportion (70%) all of the budget of MTI is from external sources.

However, if the construction costs of disaster critical spots in this Study are funded over 10 years, it would be possible for MTI pay for them. The maintenance budget of the MTI is set at around 2.7 million US$ in 2002, (approximately 2.6 % of the total MTI budget)

Therefore, a part of the MTI budget, should be allocated for the routine or periodic countermeasure work for disaster prevention.