Chapter 7

Project Cost

Chapter 7 Project Cost

7.1 Construction Quantities

The eight project roads have 192 disaster spots in total, with 38 spots receiving both a preliminary design and a cost estimation and the remaining 154 spots only a cost estimation.

Construction quantities for the 38 spots were estimated based on preliminary design drawings (refer to Volume 2 DRAWINGS). In calculating the quantities, construction work items mostly correspond to the restoration measures listed in Table 6.1.1 and 6.1.2.

For the remaining 154 spots, damaged area was calculated as a basis of cost estimation.

7.2 Unit Cost

Unit construction costs prepared by DOH are principally applied to each construction work item. However, some works applied in the Study have no market price due to the lack of experience in Thailand. Unit construction costs for those works were estimated based on the market price in Japan or other similar construction works in Thailand.

Unit cost of land acquisition is estimated on a basis of land price along a project road, and unit cost of compensation is also estimated based on land use along a project road.

A list of unit cost applied in the Study is shown in Appendix 5.1.

7.3 Project Cost

Project cost consists of construction cost, engineering cost and compensation cost. The construction cost comprises 90 percent of real construction costs and 10 percent of physical contingency costs.

The engineering cost was estimated as 10 percent of construction cost.

Land acquisition cost is calculated, if needed, based on 1) the right-of-way boundary as determined with DOH road inventory data, and 2) on the assumption that, the damaged area near a landslide already belongs to DOH.

Project cost for the eight project roads is tabulated in Table 7.3.1.

Appendix 5.2, 5.3 shows project cost for each disaster spot.

7.4 Maintenance Cost

Maintenance cost was estimated mainly based on the past maintenance cost of the project roads. The performance of the repair work was also taken into consideration in the estimation.

Table 7.3.1 Project Costs (1)

(×1000 baht)

Spot No.	Construction Cost	Engineering & Supervision	Compensation Cost	Total
109/1	779	78	0	857
109/2	5,575	558	10	6,143
109/3	2,272	227	103	2,602
Others				633,728
Total				643,330
1095/1	2,508	251	510	3,269
1095/2	314	32	0	346
1095/3	2,635	263	288	3,186
1095/4	112	12	62	186
Others				72,084
Total				79,071
1149/1	2,773	277	83	3,133
1149/2	185	18	0	203
Others				5,086
Total				8,422
1256/1	2,467	247	135	2,849
1256/2/3	275	28	0	303
1256/4	224	22	0	246
1256/5	1,569	157	0	1,726
1256/6	2,222	222	95	2,539
1256/7	198	20	9	227
1256/8	993	99	0	1,092
1256/9	4,186	419	0	4,605
1256/10	1,917	192	0	2,109
1256/11/12	1,184	118	0	1,302
Others				52,563
Total				69,561

Table 7.3.1 Project Costs (2)

(×1000 baht)

Spot No.	Construction Cost	Engineering & Supervision	Compensation Cost	Total
4/1	2,734	274	169	3,177
4/2/3	3,744	375	0	4,119
Others				10,548
Total				17,844
410/1	653	66	4	723
410/2	1,532	154	30	1,716
410/3	481	49	0	530
410/4	939	95	0	1,034
410/5	122	13	0	135
410/6	2,587	259	187	3,033
Others				54,600
Total				61,771
4015/1	783	78	0	861
4015/2	540	54	0	594
4015/3	516	52	0	568
4015/4	907	91	0	998
4015/5	1,419	142	0	1,561
Others				862
Total				5,444
4107/1/2	438	44	48	530
4058/1	9,899	990	0	10,889
Total				11,419
Grand Total				896,862

Chapter 8

Project Evaluation

Chapter 8 Project Evaluation

8.1 Basic Policy in Project Evaluation

The feasibility of the restoration measures of this project is evaluated in this chapter basically from the economical, technical and environmental aspects. The following sections present the basic policy applied in the evaluation procedure in addition to the overall evaluation for each project road.

8.1.1 Economic Evaluation

Benefits in the road improvement investments do not accrue to agencies responsible for making the investment but to the road users. These benefits are measured and compared with the cost of the investment. Such comparisons, however, do not mean that commercial profitability in the normal sense should not be relevant to public-service capital expenditures. These comparisons may also consider the phasing of road investment, indicating priorities in the implementation programme and the comparison of different schemes and alternatives. Finally in the Study, economic indicators must justify project implementation.

1. Procedure

There are different approaches to the economic evaluation of restoration works and preventive measures in studies on disaster-prone road sections, depending on the purpose and objectives of each study. Countermeasures can be evaluated for each individual spot, for a group of similar damage-type spots or for all the spots on a section of a road. In this analysis the last methodology was applied, as the objective here is to carry out a feasibility study on the restoration works for the disaster spots of the eight project roads, which should include the different costs for all work as the components of a cost stream and all the expected benefits for each road as a benefit stream for an individual project.

In the economic evaluation for each project road, a micro-economic approach was applied and the basic procedure is based on the analysis of both the costs, which are required to implement and maintain the project, and the benefits which are gained after completing the project. The benefits in the case of "with project" are generally defined as the savings in extra costs which are needed in the "without project" case if the project is not implemented. The procedure can be simplified as presented in the flow chart in Fig. 8.1.1.

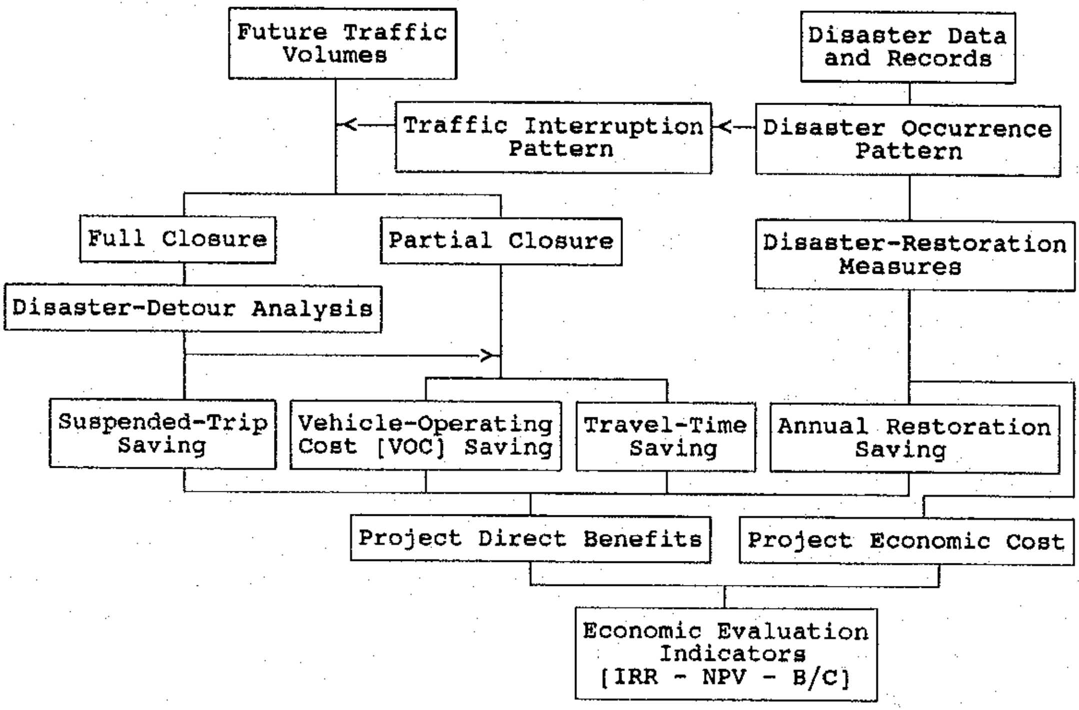

Fig. 8.1.1 Economic Evaluation Procedure

Costs and benefits are divided into direct costs/benefits, which are evaluated on a monetary basis, and indirect costs/benefits, which are assessed under the project's impact. The cost and benefit streams are shown below.

Cost Stream	Benefit Stream
Direct Cost	Direct Benefit
Construction	Detour-Cost Saving
Maintenance	Travel-Time Saving
Compensation	Annual Restoration-Work Saving
Indirect Cost	Indirect Benefit
Taxes	Socioeconomic Activities
	Transport Facilities
	Safety

2. Traffic Interruption Pattern

To estimate the benefits of the project, a traffic interruption pattern was established based on the road disaster data and past records, the road disaster occurrence pattern and the information collected during field surveys. The average annual number of days traffic was interrupted for each project road was estimated for the two cases of full closure and partial closure, in which one-lane was secured for traffic.

The incidence ratio for serious damage prepared by the Ministry of Interior, based on a history of natural disasters such as typhoons, depressions, monsoon troughs, etc., clarifies that the country is subject to serious damage once every two years on average. In addition, through analyzing records on road disasters and traffic interruptions for the past 11 years, it was concluded that the average period of time for a full road closure was about 2.5 days. Special consideration was given to Rt. 4 as it is a major national highway that handles large traffic volumes; therefore, its full closure period was reduced to one day.

Roads without available detours are given a higher priority by the district authorities of DOH in securing one lane for traffic, in order to minimize the risk of isolating local people due to a disaster's damage. Two project roads have no detours, and only partial road closure was considered in the economic evaluation.

In case of the full closure of a project road, vehicles are supposed to use available detours and urgent measures are taken to secure at least one lane for traffic as quickly as possible. The period of a partial closure depends mainly on the time required for restoration work and the importance of the road. Project roads were given three different periods of 10, 30 and 50 days of partial road closure when serious damage occurs.

The basic assumptions for partial road closure are:

- Operating Speed: reduced to 5 km/hr for all vehicles
- Road Class: downgraded to C-7 for damaged sections
- Distance: damaged length of spots + 0.2 km for approaches to each spot.

Traffic interruptions, as determined in the first part of the Study and applied in the economic analysis, are presented in Table 8.1.1 for each project road.

Table 8.1.1 Annual Average Traffic Interruption [days/year]

Rt. No.	Full Closure	Partial Closure
109	1.25	25
1095	1.25	15
1149	-	5
1256	1.25	25
4	0.50	5
410	-	25
4105	1.25	15
4107/4058	1.25	15

3. Project Economic Cost

1) Construction Cost

After estimating project construction cost for all spots on the project roads at the current market prices of 1994, which represents the financial construction cost, this was converted to economic cost to be used in the economic evaluation. Conversion is done by eliminating the transfer cost, which is composed of compound taxes such as import duties and value added taxes. These taxes, from the national economy point of view, do not represent actual consumption of goods and services. These costs include also the engineering and compensation costs. Economic construction costs for the temporary and permanent works in each project road are presented in Table 8.1.2.

2) Maintenance Cost

The maintenance costs for the project works were roughly estimated in this analysis as an average percentage of the total economic construction cost and according to DOH maintenance expenditures for similar works on the project roads. This rate was considered annually as 0.3% of the economic construction cost.

Table 8.1.2 Economic Construction Cost

(×1000 baht)

Route No.	Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total
109	Temporary Repair	9,168	9,824	8,460	8,460	8,460						44,372
	Permanent Repair	5,991	2,714	0	1,492	746	103,020	104,069	97,680	97,680	97,680	511,072
	Total	15,159	12,538	8,460	9,952	9,206	103,020	104,069	97,680	97,680	97,680	555,444
1095	Temporary Repair		423	1,016	285							1,724
	Permanent Repair	7,971	14,469	5,928	5,582	16,243		4,884	11,723	456		67,256
	Total	7,971	14,892	6,944	5,867	16,243		4,884	11,723	456		68,980
1149	Temporary Repair	44	93	97								234
	Permanent Repair	6,109	88	0			308	279	291			7,075
	Total	6,153	181	97			308	279	291			7,309
1256	Temporary Repair	1,245	5,311	1,493		2,388						10,437
	Permanent Repair	1,409	4,408	4,174	4,872	6,146	9,785	10,286	3,598		5,434	50,112
	Total	2,654	9,719	5,667	4,872	8,534	9,785	10,286	3,598		5,434	60,549
4	Temporary Repair											0
	Permanent Repair	15,210	275									15,485
	Total	15,210	275									15,485
410	Temporary Repair	5,485	2,248	138								7,871
	Permanent Repair	9,729	3,447	5,308	367	4,211	10,549	8,416	3,582			45,609
	Total	15,214	5,695	5,446	367	4,211	10,549	8,416	3,582			53,480
4015	Temporary Repair											0
	Permanent Repair	2,954	885	863								4,702
	Total	2,954	885	863								4,702
4107 4058	Temporary Repair											0
	Permanent Repair		464			9,404						9,868
	Total		464			9,404						9,868
Grand Total		65,315	44,649	27,477	21,058	47,598	123,662	127,934	116,874	98,136	103,114	775,817

4. Direct Benefits of Project

1) Savings in Vehicle Operating Cost (VOC)

The direct economic benefits of roads are calculated as savings in vehicle operating cost (VOC) and in travel-time cost. In other words, the benefits of the project are the savings in costs of extra distance and time as compared to the "without project" case. VOC depends mainly on the road condition and operating speed and it includes as running cost and fixed cost the following items:

- Fuel consumption
- Lubricants
- Vehicle maintenance (labour and parts)
- Capital consumption (depreciation)
- Interest on capital employed
- Wages
- Overheads

DOH has established a methodology for determining VOC and the data in the DOH report "Vehicle Operating Cost in Thailand, 1993" were used basically in this analysis. These data were updated by applying the actual market prices of September 1994 for the above-mentioned items to get VOC values for 1994.

Appendix 6.1 presents the estimated 1994 economic VOC values for the different road conditions and operating speeds by vehicle category.

2) Saving in Travel-Time Cost

The cost of extra travel time for passenger vehicles was estimated based on the values prepared by DOH for 1993. These values were also updated to the 1994 price level by applying the growth values in the GRP/capita for the North and South regions. Estimated time cost values of 1994 applied in this economic analysis are presented in Table 8.1.3 as a total for passengers, drivers and crew.

Table 8.1.3 Total Time Cost - 1994 [baht/hr]

Region	MC	PC	LB	HB
North	33.2493	75.8336	49.5069	288.6503
South	34.4345	90.0757	52.0717	288.9139

3) Savings in Annual Restoration

Without implementing the project, annual urgent restoration work would have to be done for spots damaged in every disaster. Savings from eliminating this work were estimated and added to the benefit stream of the each project road depending on the amount of damage. The unit cost for such restoration work was estimated on a regional basis by analyzing DOH data for the years of 1976-1992. The annual average damage cost is as follows.

- North Region: 114,718 baht/km
- South Region: 115,931 baht/km

5. Disaster-Detour Analysis:

With the full closure of a road section due to a disaster, vehicles are expected to use alternative roads as detours. Detours for each of the project roads were determined depending on the origin and destination of trips on the road and the road network in the area. In the case of there being more than one available detour, approximate traffic assignments were conducted to estimate the share of each of the available detours. In addition, the OD data and traffic assignment results of "The Toll Highway Development Study in the Kingdom of Thailand, JICA 1991" were partially used.

The road class, length and terrain for each section of the roads used in the original trip and the detoured trip were identified to conclude the operating speed and travel time for each vehicle category, as shown in Appendix 6.2. VOC and time cost values were then applied for both trips and the extra costs were concluded for the total traffic volume.

If the extra length of the detour is considerably long, trips are most likely caried out other means of transport or may be suspended if the trip transport and time costs are less than the expected benefits. In such cases, the extra cost of the transport means (such as animal, walking, etc.) was estimated as follows:

- Transport cost: 10 baht/km/person for passengers
  100 baht/km/ton for commodities
- operating speed: 4 km/hr

6. Economic Analysis

Based on the traffic interruption pattern, the direct benefits of each project road were estimated and the cost / benefit cash flow was established to conclude the economic indicators of the benefit/cost ratio (B/C), internal rate of return (IRR) and net present value (NPV). In the cash flow, the benefits start after implementing the work necessary to prevent traffic interruptions, either as temporary work or permanent work, and extend for a period of 20 years, which is the assumed life span of the permanent restoration work. A discount rate of 12% is applied for both future costs and benefits so they can be reduced to their present values.

7. Sensitivity Analysis

A sensitivity analysis was conducted for the economically feasible projects to take into account the uncertainly of disaster prediction and the potential for unexpected increases in construction costs or decrease in benefits. The cases considered in this analysis are:

- Cost + 10%
- Cost + 20%
- Benefit - 10%
- Benefit - 20%
- Cost + 10% and Benefit - 10%
- Cost + 20% and Benefit - 20%

8. Indirect Benefits of the Project

Permanent restoration works on roads are expected to produce indirect benefits that were not included in the benefit stream. Such benefits cover many socioeconomic activities and transport facilities. For example an always-efficient and reliable road network eliminates isolation and constraints imposed on the activities of local people due to unexpected disaster-related traffic interruption. Improving the transport system will enhance the living conditions and socioeconomic activities of people in the area and will provide higher levels of safety, including savings in assets, better medical care and shorter working hours.

8.1.2 Financial Considerations

The total project financial cost in 1994 current prices amounts to about 897 million baht over a period of 10 years. In the implementation program established for the project, the restoration measures during the first 5-year period have lower annual costs, which may not require special arrangements in the allocation of the budget. Work in the second 5-year period is larger and there will be a need for special considerations in budget allocation. The annual allocation of the project's financial cost is shown in Fig. 8.1.2.

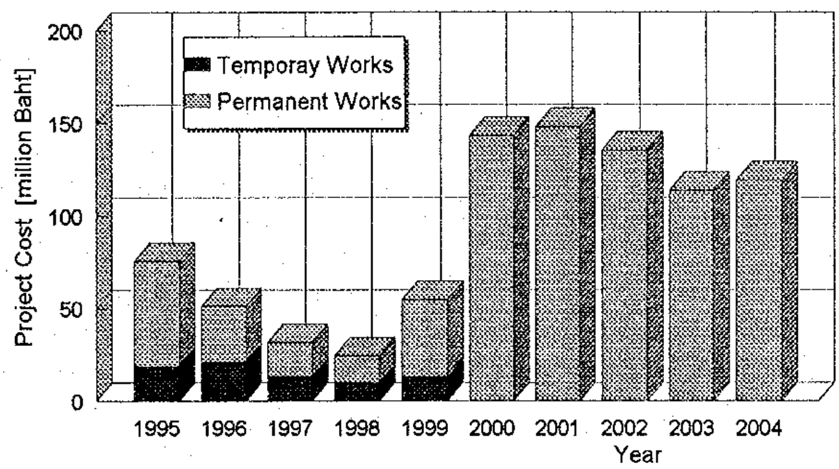

Fig. 8.1.2 Annual Allocation of Project Financial Cost

The maintenance budget of DOH, which covers restoration work for disaster-related damage, is divided into five main portions according to the following activities:

- Routine Maintenance
- Equipment and Fuel
- Periodic Maintenance
- Special Maintenance
- Emergencies

The share of each portion between 1984 and 1995 is presented in Fig. 8.1.3. Restoration work in the Study is mainly under the special maintenance budget for road and bridge damage and the emergency budget for slope related damage.

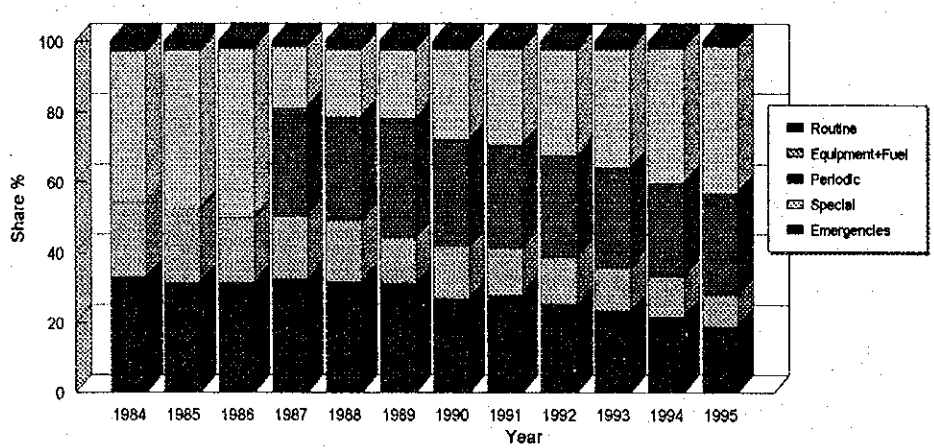

Fig. 8.1.3 DOH Maintenance Budget Allocation

For 1995, the total maintenance budget amounts to about 8,558.7 million baht, in which the allocations for special and emergency maintenance are 3,588.9 million baht and 110.0 million baht, or 41.9% and 1.3% of the budget respectively. Regarding money for the different types of disaster-related damage, Table 8.1.4 presents the DOH budget for 1993 to 1995 for restoration work for three main damage items, as well as the project cost for 1995.

Table 8.1.4 Restoration Budget and Project Cost [mil. baht]

Activity	DOH -1993	-1994	-1995	Project -1995
Road-damage restoration	167.6	187.6	211.9	1.2
Bridge-damage restoration	5.4	7.0	10.8	7.6
Slope-damage restoration	78.0	78.0	60.0	66.6

As most of the money for restoration work, about 96.5% in total, is for slope damage, the allocated budget of 1995 is less than the required estimated cost. Starting from the year 2000, the cost for slope-damage restoration will become higher, as shown in Table 8.1.5, which emphasizes the urgent necessity to reconsider budget allocation and the expansion of financial resources.

Table 8.1.5 Annual Project Cost [1000 baht]

Type	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total
Road	1,213	3,443	568		10.889	5,653					21,766
Bridge	7,613	961	431			229					9,234
Slope	66,559	46,911	30,680	24,292	43,937	137,524	147,961	135,228	113,587	119,183	865,862
Total	75,385	51,315	31,679	24,292	54,826	143,406	147,961	135,228	113,587	119,183	896,862

8.1.3 Environmental Considerations

The Study, from the viewpoint of drawing up disaster prevention measures, ascertains the adverse environmental effects that results from disasters and evaluates the impact of disaster prevention measures in either eliminating or mitigating said effects. In the Study, the effectiveness of disaster prevention measures are evaluated in dealing with disasters that affect both the socioeconomic and natural environment shown below.

1. Socioeconomic Environment

Here, the impact that road disaster prevention measures have on protecting the socioeconomic environment are assessed, by examining some of the possible damage communities can experience.

1) Isolation of Communities

When a disaster makes a road impassable, this results in communities being isolated. This in turn prevents the flow of goods and services between changwats or amphohs. If such a situation continues for a long time, and if there are no viable alternative roads, the socioeconomic consequences can be severe. Therefore, road disaster prevention work is necessary to ensure the continuous flow of traffic, which is the lifeline of any society.

2) Obstruction of Economic Activities

Impassable roads adversely affect economic activity, by cutting off the flow of people (e.g.,tourists) and goods (e.g.,industrial products). This not only slows the growth of

In the North Region, the condition of a few routes are hindering the ability to improve the lives of mountain tribes people and the ability to transport perishable foods to them.

In the South Region, a few routes are hindering the ability to improve the condition of religious minorities. Therefore, road disaster prevention work is needed to ensure economic opportunity for everyone.

3) Damage to Private Property

In areas where road disasters occur, the private property of residents, such as houses and agricultural land, can sustain damage. Damage can be especially severe in areas that experience landslides, rock slides, and flooding. Therefore, road disaster prevention work shall be carried out to eliminate or mitigate such disasters in order to protect private property.

2. Natural Environment

Since preliminary design examines only existing roads, it is not necessary for the Study to consider the alteration of topographical and geological features on a large scale, changes in flora, and drops in the groundwater level. However, the damage that the natural environment sustains from disasters are considered and evaluated below.

1) Reduction in Vegetation

Due to landslides, erosion, and the flowing out of fill material, the land area of forests and vegetation are reduced. Road disaster prevention work should focus especially on areas prone to large-scale landslides in order to protect the natural environment. Planned countermeasures for slope protection shall consist of sodding, hydroseeding, and cribwork with vegetation.

2) Change of River situation

In cases where the drainage of bridges and road crossings are damaged, or where there are large flows of debris, etc., the course of a river can change and produce flooding. Therefore, it is necessary to carry out road disaster prevention work that will ensure the smooth flow of a river.

3) Destruction of Landscape Aesthetics

Routes located in mountainous and hilly areas have a pleasant landscape. However, where landslides have occurred that expose the rocky surface of a mountain, these areas are not aesthetically in harmony. To deal with this problem, countermeasures such as sodding, hydroseeding, and cribwork with vegetation shall be carried out to improve the aesthetics of the landscape.

Also, concrete retaining walls at the foot of slopes shall be designed to be small in structure, or mat gabions will be used, to improve the aesthetics of a landscape. Shotcrete for slope protection shall not be used, since it is difficult for vegetation to survive this countermeasure.

8.1.4 Overall Evaluation

The eight project roads are evaluated independently as each road represents a separate project in this feasibility study. Economically, project cost and benefit streams were established and the three economic indicators of B/C, IRR and NPV were determined. A summary of the total results of the economic analysis is presented in Table 8.1.6, while Fig. 8.1.4 shows the relationship between the different estimated economic indicators for the restoration works of the project roads.

Table 8.1.6 Summary of Economic Indicators

Rt. No.	Economic Const. Cost [1,000 B]	ECONOMIC INDICATORS B/C	IRR %	NPV [1,000 B]
109	555,444	0.933	10.90	- 16,970
1095	68,980	2.541	24.48	69,325
1149	7,309	1.329	15.23	2,057
1256	60,549	0.963	11.51	- 1,334
4	15,485	2.886	29.07	26,608
410	53,480	2.893	25.97	67,717
4015	4,702	6.081	43.36	20,566
4107/4058	9,868	1.729	20.43	4,256

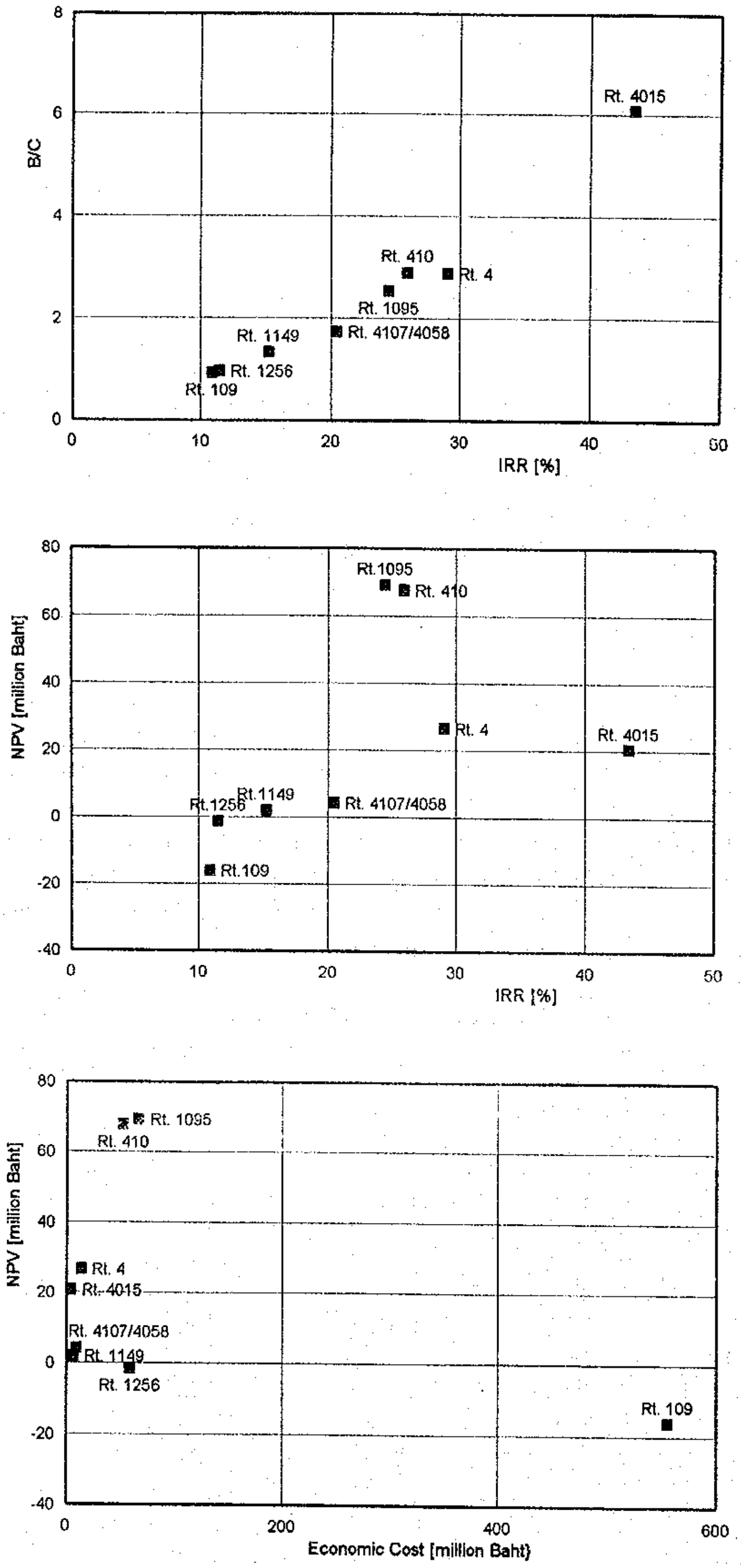

Fig. 8.1.4 Economic Evaluation of Project Roads

Granting that a project road with an IRR higher than 12% as an economically feasible one, the two project roads of Rt. 109 and Rt. 1256 are considered the only unfeasible projects, as Rt. 109 requires the highest construction cost and Rt. 1256 has the lowest ADT, which consequently produce low benefits.

Rt. 1149 comes next with a relatively higher IRR of 15.23%, but it should be taken into consideration that this road has no detour and is the only road serving the development projects in the area. The only project road in the North Region with a high IRR is Rt. 1095 at 24.48%, and there is a considerably long detour in the case of a traffic interruption.

The four project roads in the North Region are much alike in their background and function. They pass through mountainous areas containing numerous bare cut slopes that are damage prone. Their main functions are 1) to connect one changwat or amphoe to another, 2) to support the livelihood of mountain tribes people, and 3) to promote tourism.

Project roads in the South Region have in general higher IRR values that range between 20% and 43%, as they have less construction costs, except for Rt. 410 which has no detours, and considerably higher future traffic volumes.

Project road 4 is one of the four main trunk roads in the country and handles large amounts of traffic in the South Region. The major function of the road is to connect the changwats on the Andaman Sea to other changwats on the Gulf of Thailand. Accordingly, the disaster prevention program for Route 4 will contribute to the promotion of economic and social activities and to the promotion of transportation and other infrastructure throughout a wide part of the South Region.

An economic sensitivity analysis was conducted to determine the potential of each project road in case of unexpected increases in construction cost or decreases in benefits. Results are presented in Table 8.1.7 for project roads with an IRR higher than 12%.

The results of the sensitivity analysis show that the implementation of the restoration measures for the six project roads is economically viable even with a 10% increase in project cost and a 10% decrease in benefits. The most extreme case of

Table 8.1.7 Sensitivity Analysis - IRR %

Case	Rt. 1095	Rt. 1149	Rt. 0004	Rt. 0410	Rt. 4015	Rt. 4107/40
Base Case	24.48	15.23	29.07	25.97	43.36	20.43
Cost + 10%	22.98	14.11	26.78	24.49	40.89	18.75
Cost + 20%	21.66	13.12	24.83	23.18	38.74	17.31
Benefit -10%	22.83	14.00	26.54	24.33	40.64	18.58
Benefit -20%	21.06	12.67	23.96	22.58	37.77	16.66
Cost +10, Benefit -10%	21.39	12.92	24.44	22.91	38.30	17.02
Cost +20, Benefit -20%	18.49	10.73	20.39	20.01	33.66	13.94

increasing costs by 20% and decreasing benefits by the same ratio will exclude only project road Rt. 1149.

The implementation of disaster prevention measures will produce the following results: 1) promotion of social and economic activities, 2) elimination of the risks and costs associated with disasters, 3) improvement of the environment, and 4) improvement of the aesthetics of the surrounding environment.

As for the positive effects flowing from disaster prevention measures for the three project roads in the South Region, they will include those just mentioned above, as well as raising the standard of living of religious minority groups and promoting rural development.

8.2 Evaluation of Each Project Road

8.2.1 Project Road 109

This road is one of the roads that connects the two changwats of Chiang Mai and Chiang Rai. However, it is unlikely to handle inter-changwat traffic as Rt. 118 is shorter and in better condition. Traffic on the road is considered here as inter-amphoe traffic between the amphoes of Mae Suai on the eastern side and Fang, Mae Ai and Chai Prakan on the western side. The road serves many socioeconomic activities in the area.

The shortest available detour for this route, which is about an extra 100 km, is a route north of Chiang Rai using Rt. 1 and Rt. 1089. The main parameters used in the economic evaluation are:

- Extra trip length: 100 km
- Extra time: 1.31 - 1.82 hrs.
- Length of partially closed road sections: 28.6 km

The cost / benefit cash flow and results of the economic evaluation for this road are presented in Table 8.2.1. Benefits are expected to be generated after the first five years of construction in which most of the spots will be restored either temporarily or permanently. Construction activities during the following years are mostly to provide permanent repairs at all locations.

Compared with other project roads, this road has the highest construction cost and a low IRR of 10.9%.

This route connects the two local centers of Amphoe Fang and Amphoe Mae Suai, which supply northern mountain tribes people with important services and goods.

After disaster prevention work is carried out, the following positive effects can be expected: 1) minimization of travel time from Amphoe Fang to Amphoe Mae Suai, 2) an improvement in the standard of living of mountain tribes, and 3) an aesthetic improvement in the existing huge cut slopes that have no vegetation.

Table 8.2.1 Cost - Benefit Cash Flow of Rt. 0109

[Unit: Baht]

Year	COST		BENEFIT					COST [C]	BENEFIT [B]	B - C	Discounted C	Discounted B
	Construction	Maintenance	Full Closure		Partial Closure		Restoration					
			VOC Saving	Time Saving	VOC Saving	Time Saving	Saving					
1995	15,159,000							15,159,000		(15,159,000)	13,534,821	
1996	12,538,000	45,477						12,583,477		(12,583,477)	10,031,471	
1997	8,460,000	83,091						8,543,091		(8,543,091)	6,080,803	
1998	9,952,000	83,091						10,035,091		(10,035,091)	6,377,482	
1999	9,206,000	112,947						9,318,947		(9,318,947)	5,287,821	
2000	103,020,000	140,565	1,481,493	354,702	1,684,187	28,736,504	3,235,048	103,160,565	35,491,934	(67,668,631)	52,264,353	17,981,318
2001	104,069,000	449,625	1,564,158	376,291	1,780,877	30,527,151	3,235,048	104,518,625	37,483,525	(67,035,100)	47,278,918	16,955,643
2002	97,680,000	761,832	1,681,377	405,257	1,914,620	32,882,447	3,235,048	98,441,832	40,118,749	(58,323,083)	39,759,005	16,203,290
2003	97,680,000	1,054,872	1,798,596	434,223	2,048,363	35,237,744	3,235,048	98,734,872	42,753,973	(55,980,899)	35,604,785	15,417,511
2004	97,680,000	1,347,912	1,915,815	463,189	2,182,106	37,593,040	3,235,048	99,027,912	45,389,197	(53,638,715)	31,884,337	14,614,107
2005		1,640,952	2,033,034	492,154	2,315,849	39,948,337	3,235,048	1,640,952	48,024,422	46,383,470	471,734	13,805,874
2006		1,640,952	2,150,253	521,120	2,449,591	42,303,634	3,235,048	1,640,952	50,659,646	49,018,694	421,192	13,003,069
2007		1,640,952	2,350,342	568,737	2,674,660	46,118,610	3,235,048	1,640,952	54,947,397	53,306,445	376,064	12,592,525
2008		1,640,952	2,550,431	616,353	2,899,729	49,933,587	3,235,048	1,640,952	59,235,148	57,594,196	335,771	12,120,685
2009		1,640,952	2,750,520	663,969	3,124,797	53,748,564	3,235,048	1,640,952	63,522,898	61,881,946	299,796	11,605,396
2010		1,640,952	2,950,609	711,586	3,349,866	57,563,540	3,235,048	1,640,952	67,810,649	66,169,697	267,675	11,061,386
2011		1,640,952	3,150,698	759,202	3,574,935	61,378,517	3,235,048	1,640,952	72,098,400	70,457,448	238,995	10,500,724
2012		1,640,952	3,423,196	822,349	3,878,946	66,384,609	3,235,048	1,640,952	77,744,148	76,103,196	213,389	10,109,817
2013		1,640,952	3,695,694	885,496	4,182,958	71,390,700	3,235,048	1,640,952	83,389,896	81,748,944	190,526	9,682,132
2014		1,640,952	3,968,191	948,643	4,486,970	76,396,792	3,235,048	1,640,952	89,035,644	87,394,692	170,112	9,230,037
2015		1,640,952	4,240,689	1,011,790	4,790,981	81,402,884	3,235,048	1,640,952	94,681,391	93,040,439	151,886	8,763,673
2016		1,640,952	4,513,186	1,074,937	5,094,993	86,408,975	3,235,048	1,640,952	100,327,139	98,686,187	135,612	8,291,287
2017		1,640,952	4,894,806	1,158,178	5,520,622	93,055,769	3,235,048	1,640,952	107,864,422	106,223,470	121,082	7,959,095
2018		1,640,952	5,276,425	1,241,419	5,946,251	99,702,562	3,235,048	1,640,952	115,401,705	113,760,753	108,109	7,602,907
2019		1,640,952	5,658,045	1,324,660	6,371,880	106,349,355	3,235,048	1,640,952	122,938,988	121,298,036	96,526	7,231,678
											251,702,266	234,732,154

B / C	**0.933**
IRR %	**10.90**
NPV (Baht)	**(16,970,112)**

8.2.2 Project Road 1095

For inter-changwat trips, this mountainous road connects Chiang Mai with Mae Hong Son and is considered the shortest road between the two changwats. The project section of the road is a direct connection between A. Pai and the changwat of Mae Hong Son.

There is a detour for inter-changwat traffic via Rt. 108, which is about 113 km longer, so realistically intra-changwat trips would use another means of transport or not be carried out as Rt. 108 is too long. Therefore, traffic volumes were divided into inter- and intra- changwat trips with both being equal in number. The main parameters used in the economic evaluation are:

- Extra trip length: 113 km
- Extra time: 2.0 - 2.8 hrs.
- Length of partial-closure sections: 19.05 km

The cost / benefit cash flow and results of the economic evaluation for this road are presented in Table 8.2.2. The benefits are expected to start after the first five years of construction in which most of the spots will be restored either temporarily or permanently. Construction activities during the following years are mostly for permanent repairs at all locations. Restoring the damaged spots on the route will produce an IRR of about 24.5%, which makes restoration work on this road economically viable.

If this route becomes impassable because of a disaster, the traffic between Chiang Mai and Mae Hong Son would be significantly affected due to the lack of an appropriate detour. Accordingly, disaster prevention greatly contributes to regional economic activity.

Most of the route passes through a national park, and there are many spots for tourists. However, it also has numerous cut slopes that have been damaged by landslides and erosion. Therefore, proper measures to prevent such damage to these cut slopes would produce both aesthetic and ecological improvements.

Table 8.2.2 Cost - Benefit Cash Flow of Rt. 1095

[Unit: Baht]

Year	COST		BENEFIT						COST [C]	BENEFIT [B]	B - C	Discounted C	Discounted B
	Construction	Maintenance	Full Closure		Partial Closure		Suspended	Restoration	Total	Total			
			VOC Saving	Time Saving	VOC Saving	Time Saving	Trip Saving	Saving					
1995	7,971,000								7,971,000		(7,971,000)	7,116,964	
1996	14,892,000	23,913							14,915,913		(14,915,913)	11,890,875	
1997	6,944,000	68,589							7,012,589		(7,012,589)	4,991,422	
1998	5,867,000	89,421							5,956,421		(5,956,421)	3,785,413	
1999	16,243,000	107,022							16,350,022		(16,350,022)	9,277,442	
2000		155,751	912,100	294,933	3,063,888	9,489,227	3,394,180	275,897	155,751	17,430,224	17,274,473	78,908	8,830,694
2001	4,884,000	155,751	968,783	313,045	3,255,072	10,075,225	3,608,666	275,897	5,039,751	18,496,687	13,456,936	2,279,727	8,366,962
2002	11,723,000	170,403	1,039,158	334,725	3,491,143	10,781,002	3,883,936	275,897	11,893,403	19,805,861	7,912,458	4,803,546	7,999,255
2003	456,000	205,572	1,109,533	356,405	3,727,214	11,486,779	4,159,207	275,897	661,572	21,115,035	20,453,463	238,569	7,614,293
2004		206,940	1,179,908	378,086	3,963,285	12,192,556	4,434,478	275,897	206,940	22,424,209	22,217,269	66,629	7,219,995
2005		206,940	1,250,283	399,766	4,199,356	12,898,333	4,709,748	275,897	206,940	23,733,383	23,526,443	59,490	6,822,781
2006		206,940	1,320,658	421,447	4,435,427	13,604,110	4,985,019	275,897	206,940	25,042,557	24,835,617	53,116	6,427,801
2007		206,940	1,428,075	454,310	4,796,996	14,681,519	5,408,385	275,897	206,940	27,045,182	26,838,242	47,425	6,198,058
2008		206,940	1,535,493	487,174	5,158,564	15,758,928	5,831,752	275,897	206,940	29,047,807	28,840,867	42,344	5,943,757
2009		206,940	1,642,910	520,037	5,520,133	16,836,337	6,255,118	275,897	206,940	31,050,432	30,843,492	37,807	5,672,798
2010		206,940	1,750,328	552,901	5,881,702	17,913,746	6,678,484	275,897	206,940	33,053,058	32,846,118	33,756	5,391,670
2011		206,940	1,857,745	585,765	6,243,270	18,991,155	7,101,851	275,897	206,940	35,055,683	34,848,743	30,140	5,105,662
2012		206,940	1,992,695	626,466	6,695,606	20,326,606	7,638,882	275,897	206,940	37,556,153	37,349,213	26,910	4,883,787
2013		206,940	2,127,646	667,168	7,147,942	21,662,058	8,175,913	275,897	206,940	40,056,624	39,849,684	24,027	4,650,845
2014		206,940	2,262,596	707,870	7,600,279	22,997,509	8,712,944	275,897	206,940	42,557,094	42,350,154	21,453	4,411,756
2015		206,940	2,397,546	748,571	8,052,615	24,332,960	9,249,976	275,897	206,940	45,057,565	44,850,625	19,154	4,170,511
2016		206,940	2,532,497	789,273	8,504,951	25,668,412	9,787,007	275,897	206,940	47,558,036	47,351,096	17,102	3,930,315
2017		206,940	2,701,747	843,468	9,084,448	27,450,554	10,415,666	275,897	206,940	50,771,781	50,564,841	15,270	3,746,346
2018		206,940	2,870,997	897,663	9,663,946	29,232,697	11,044,326	275,897	206,940	53,985,526	53,778,586	13,634	3,556,680
2019		206,940	3,040,248	951,858	10,243,444	31,014,840	11,672,986	275,897	206,940	57,199,272	56,992,332	12,173	3,364,650
												44,983,298	114,308,616

B / C	**2.541**
IRR %	**24.48**
NPV (Baht)	**69,325,317**

8.2.3 Project Road 1149

This road is important for development projects and national security in the northern territories, with a nearby depot for urgent restoration work in the case of an interruption to traffic. As there is no alternative to the road, only a partial closure for 5 days was considered in the economic evaluation of the road. The length of the partially closed sections is 6.05 km. The cost / benefit cash flow and results of the economic evaluation for this road are presented in Table 8.2.3.

Benefits start after completion of main construction work in the first three years. An IRR of 15.23% is slightly higher than the 12% limit, but this road has also considerable indirect socioeconomic benefits.

For this route, the prevention of disasters will contribute mainly to the promotion of tourism and a more aesthetic environment.

Table 8.2.3 Cost - Benefit Cash Flow of Rt. 1149

[Unit: Baht]

Year	COST		BENEFIT			COST [C]	BENEFIT [B]	B - C	Discounted C	Discounted B
	Construction	Maintenance	VOC Saving	Time Saving	Restoration Saving	Total	Total			
1995	6,153,000					6,153,000		(6,153,000)	5,493,750	
1996	181,000	18,459				199,459		(199,459)	159,007	
1997	97,000	19,002				116,002		(116,002)	82,568	
1998		19,002	239,720	671,830	75,714	19,002	987,264	968,262	12,076	627,424
1999		19,002	255,403	721,369	75,714	19,002	1,052,486	1,033,484	10,782	597,209
2000	308,000	19,002	271,087	770,907	75,714	327,002	1,117,708	790,706	165,669	566,266
2001	279,000	19,926	286,770	820,446	75,714	298,926	1,182,930	884,004	135,219	535,098
2002	291,000	20,763	309,697	889,317	75,714	311,763	1,274,728	962,965	125,916	514,841
2003		21,636	332,623	958,189	75,714	21,636	1,366,526	1,344,890	7,802	492,783
2004		21,636	355,549	1,027,060	75,714	21,636	1,458,324	1,436,688	6,966	469,541
2005		21,636	378,476	1,095,932	75,714	21,636	1,550,121	1,528,485	6,220	445,623
2006		21,636	401,402	1,164,803	75,714	21,636	1,641,919	1,620,283	5,553	421,440
2007		21,636	435,503	1,270,623	75,714	21,636	1,781,840	1,760,204	4,958	408,352
2008		21,636	469,605	1,376,442	75,714	21,636	1,921,761	1,900,125	4,427	393,230
2009		21,636	503,706	1,482,262	75,714	21,636	2,061,682	2,040,046	3,953	376,662
2010		21,636	537,807	1,588,082	75,714	21,636	2,201,603	2,179,967	3,529	359,129
2011		21,636	571,909	1,693,901	75,714	21,636	2,341,524	2,319,888	3,151	341,030
2012		21,636	616,111	1,833,239	75,714	21,636	2,525,064	2,503,428	2,814	328,358
2013		21,636	660,314	1,972,576	75,714	21,636	2,708,604	2,686,968	2,512	314,487
2014		21,636	704,517	2,111,914	75,714	21,636	2,892,145	2,870,509	2,243	299,819
2015		21,636	748,720	2,251,251	75,714	21,636	3,075,685	3,054,049	2,003	284,684
2016		21,636	792,922	2,390,589	75,714	21,636	3,259,225	3,237,589	1,788	269,351
2017		21,636	846,157	2,555,962	75,714	21,636	3,477,832	3,456,196	1,596	256,622
									6,244,504	8,301,948

B/C	**1.329**
IRR %	**15.23**
NPV (Baht)	**2,057,444**

8.2.4 Project Road 1256

In the case of this road being unpassable between the two amphoes of Pua and Bo Klua, there is the detour of Rt. 1081 and Rt. 1169 to the south. The main parameters used in the economic evaluation are:

- Extra trip length: 47 km
- Extra time: 0.34 - 0.67 hrs.
- Length of partially closed sections: 15.05 km

The cost / benefit cash flow and results of the economic evaluation for this road are presented in Table 8.2.4. Benefits are expected to start after the first five years of construction, in which most of the spots will be restored either temporarily or permanently. Construction activities during the following years are mostly to provide permanent repairs at all locations. The IRR for this road is 11.51%.

The main role of this route is to connect small villages located in an mountainous area. In this respect, disaster prevention promotes communication between communities. In addition, the standard of living of mountain tribes will improve due to the more reliable transportation. This route is also important in terms of national security.

Table 8.2.4 Cost - Benefit Cash Flow of Rt. 1256 [Unit: Baht]

Year	COST		BENEFIT					COST [C]	BENEFIT [B]	B - C	Discounted C	Discounted B
	Construction	Maintenance	Full Closure		Partial Closure		Restoration	Total	Total			
			VOC Saving	Time Saving	VOC Saving	Time Saving	Saving					
1995	2,654,000							2,654,000		(2,654,000)	2,369,643	
1996	9,719,000	7,962						9,726,962		(9,726,962)	7,754,275	
1997	5,667,000	37,119						5,704,119		(5,704,119)	4,060,079	
1998	4,872,000	54,120						4,926,120		(4,926,120)	3,130,638	
1999	8,534,000	68,736						8,602,736		(8,602,736)	4,881,423	
2000	9,785,000	94,338	171,464	49,992	1,339,070	3,987,175	404,381	9,879,338	5,952,082	(3,927,256)	5,005,180	3,015,510
2001	10,286,000	123,693	179,385	52,150	1,399,226	4,171,652	404,381	10,409,693	6,206,794	(4,202,899)	4,708,816	2,807,639
2002	3,598,000	154,551	189,698	55,031	1,481,903	4,420,983	404,381	3,752,551	6,551,996	2,799,445	1,515,592	2,646,241
2003		165,345	200,012	57,911	1,564,580	4,670,313	404,381	165,345	6,897,198	6,731,853	59,625	2,487,199
2004	5,434,000	165,345	210,326	60,792	1,647,257	4,919,644	404,381	5,599,345	7,242,399	1,643,054	1,802,839	2,331,859
2005		181,647	220,640	63,673	1,729,934	5,168,974	404,381	181,647	7,587,601	7,405,954	52,219	2,181,254
2006		181,647	230,953	66,553	1,812,610	5,418,305	404,381	181,647	7,932,803	7,751,156	46,624	2,036,153
2007		181,647	242,596	69,991	1,906,067	5,710,940	404,381	181,647	8,333,974	8,152,327	41,629	1,909,932
2008		181,647	254,239	73,428	1,999,523	6,003,575	404,381	181,647	8,735,145	8,553,498	37,169	1,787,384
2009		181,647	265,881	76,866	2,092,979	6,296,210	404,381	181,647	9,136,316	8,954,669	33,186	1,669,171
2010		181,647	277,524	80,303	2,186,435	6,588,845	404,381	181,647	9,537,488	9,355,841	29,631	1,555,771
2011		181,647	289,167	83,740	2,279,891	6,881,480	404,381	181,647	9,938,659	9,757,012	26,456	1,447,509
2012		181,647	302,777	87,334	2,394,406	7,197,217	404,381	181,647	10,386,205	10,204,558	23,621	1,350,618
2013		181,647	316,388	90,927	2,509,102	7,512,953	404,381	181,647	10,833,751	10,652,104	21,090	1,257,872
2014		181,647	329,999	94,520	2,623,707	7,828,690	404,381	181,647	11,281,297	11,099,650	18,831	1,169,496
2015		181,647	343,610	98,113	2,738,312	8,144,427	404,381	181,647	11,728,843	11,547,196	16,813	1,085,617
2016		181,647	357,220	101,706	2,852,918	8,460,164	404,381	181,647	12,176,389	11,994,742	15,012	1,006,287
2017		181,647	372,631	105,544	2,983,784	8,806,656	404,381	181,647	12,672,996	12,491,349	13,403	935,115
2018		181,647	388,042	109,383	3,114,651	9,153,147	404,381	181,647	13,169,604	12,987,957	11,967	867,641
2019		181,647	403,453	113,221	3,245,517	9,499,638	404,381	181,647	13,666,211	13,484,564	10,685	803,892
											35,686,448	34,352,158

B / C	**0.963**
IRR %	**11.51**
NPV (Baht)	**(1,334,291)**

8.2.5 Project Road 4

This road handles heavy traffic volumes and is the main trunk road in the South Region. The interruption to traffic period for this main road was reduced to 0.5 days for full closure and 5 days for partial closure. Traffic on the road is divided between the two changwats of Trang and Phatthalung and between Trang and southern changwats, especially Songkhla. The shares were found to be approximately 75% and 25%, respectively. The first group of trips can use the northern detour of Rt. 4151 and the second group can use the southern detour of Rt. 406 and Rt. 416 in the case this route is inpassable. The main parameters used in the economic evaluation are:

- Extra trip length - 1: 92 km
- Extra trip length - 2: 57 km
- Extra time - 1: 1.56 - 2.11 hrs.
- Extra time - 2: 1.00 - 1.32 hrs.
- Length of partially closed sections: 4.3 km

The cost / benefit cash flow and results of the economic evaluation for this road are presented in Table 8.2.5. The main construction work will be completed during the first year and benefits will start in the second year,with a high IRR of more than 29%.

Route 4 is one of the trunk roads connecting the east and west coasts of peninsula in the South Region. Therefore,anything that would disrupt the smooth flow of traffic would significantly affect the socioeconomic environment of the area. Accordingly, disaster prevention for this route is important for protecting the livelihood of the area.

In the case of disaster spot 4/2/3, disaster prevention will protect local inhabitants that live along the river from risks inherent in living there (such as flooding).

Table 8.2.5 Cost - Benefit Cash Flow of Rt. 0004 [Unit: Baht]

Year	COST		BENEFIT					COST [C]	BENEFIT [B]	B - C	Discounted C	Discounted B
	Construction	Maintenance	Full Closure		Partial Closure		Restoration	Total	Total			
			VOC Saving	Time Saving	VOC Saving	Time Saving	Saving					
1995	15,210,000							15,210,000		(15,210,000)	13,580,357	
1996	275,000	45,630	1,434,580	217,089	343,708	1,492,405	52,749	320,630	3,540,531	3,219,901	255,604	3,161,188
1997		46,455	1,562,367	235,200	369,573	1,616,556	52,749	46,455	3,836,444	3,789,989	33,066	3,058,389
1998		46,455	1,690,153	253,311	395,437	1,740,707	52,749	46,455	4,132,356	4,085,901	29,523	2,941,330
1999		46,455	1,817,939	271,423	421,301	1,864,858	52,749	46,455	4,428,269	4,381,814	26,360	2,814,245
2000		46,455	1,945,725	289,534	447,165	1,989,009	52,749	46,455	4,724,182	4,677,727	23,536	2,680,628
2001		46,455	2,073,512	307,645	473,030	2,113,160	52,749	46,455	5,020,095	4,973,640	21,014	2,543,336
2002		46,455	2,215,930	326,736	500,384	2,242,795	52,749	46,455	5,338,594	5,292,139	18,762	2,414,909
2003		46,455	2,358,349	345,826	527,739	2,372,430	52,749	46,455	5,657,093	5,610,638	16,752	2,284,805
2004		46,455	2,500,768	364,917	555,094	2,502,065	52,749	46,455	5,975,593	5,929,138	14,957	2,154,859
2005		46,455	2,643,186	384,007	582,449	2,631,700	52,749	46,455	6,294,092	6,247,637	13,355	2,026,529
2006		46,455	2,785,605	403,098	609,804	2,761,335	52,749	46,455	6,612,591	6,566,136	11,924	1,900,962
2007		46,455	2,967,114	426,068	642,681	2,916,818	52,749	46,455	7,005,430	6,958,975	10,646	1,798,119
2008		46,455	3,148,624	449,039	675,559	3,072,300	52,749	46,455	7,398,270	7,351,815	9,506	1,695,492
2009		46,455	3,330,133	472,009	708,436	3,227,782	52,749	46,455	7,791,109	7,744,654	8,487	1,594,215
2010		46,455	3,511,642	494,980	741,313	3,383,265	52,749	46,455	8,183,948	8,137,493	7,578	1,495,177
2011		46,455	3,693,152	517,950	774,190	3,538,747	52,749	46,455	8,576,788	8,530,333	6,766	1,399,060
2012		46,455	3,897,605	542,680	810,480	3,704,304	52,749	46,455	9,007,817	8,961,362	6,041	1,311,938
2013		46,455	4,102,058	567,409	846,770	3,869,860	52,749	46,455	9,438,846	9,392,391	5,394	1,227,424
2014		46,455	4,306,511	592,139	883,060	4,035,417	52,749	46,455	9,869,875	9,823,420	4,816	1,145,959
2015		46,455	4,510,964	616,868	919,349	4,200,974	52,749	46,455	10,300,904	10,254,449	4,300	1,067,861
											14,108,743	40,716,426

B / C	2.886
IRR %	29.07
NPV (Baht)	26,607,683

8.2.6 Project Road 410

There are no detours for this road in the case of a traffic interruption. In addition, it is the only road serving a very large area with many socioeconomic activities. There is a depot for the road for urgent restoration work in the case of disaster-related damage. Only partial road closure was considered in the analysis, with the length of partially closed sections being 29.85 km. The cost / benefit cash flow and results of the economic evaluation for this road are presented in Table 8.2.6.

This road has much restoration work to be done. Benefits are expected to be generated after the first five years of construction, in which most of the spots will be restored either temporarily or permanently. Construction activities during the following years are mostly to permanently repair all locations. An IRR of about 26% shows that the restoration work for this road is economically feasible.

This route supports the local transport and economic activities of the area, and there is no alternative for it should it become impassable. Most of the population in the area is composed of religious minority groups that live mainly in the South Region.

Given this situation, the project will provide stability to local transport and economic activities. In addition, it will help promote the National Program, which aims to improve the standard of living of religious minority groups.

Most of the route consists of cut slopes and fill slopes. The slopes are damage prone and unsightly. If vegetation is used to protect these slopes, the damage could be stemmed and the environment improved.

Table 8.2.6 Cost - Benefit Cash Flow of Rt. 0410

[Unit: Baht]

Year	COST		BENEFIT			COST [C]	BENEFIT [B]	B - C	Discounted C	Discounted B
	Construction	Maintenance	VOC Saving	Time Saving	Restoration Saving	Total	Total			
1995	15,214,000					15,214,000		(15,214,000)	13,583,929	
1996	5,695,000	17,085				5,712,085		(5,712,085)	4,553,639	
1997	5,446,000	33,423				5,479,423		(5,479,423)	3,900,145	
1998	367,000	34,524				401,524		(401,524)	255,176	
1999	4,211,000	47,157				4,258,157		(4,258,157)	2,416,193	
2000	10,549,000	78,804	4,961,807	10,707,129	272,322	10,627,804	15,941,257	5,313,453	5,384,376	8,076,337
2001	8,416,000	104,052	5,291,524	11,385,642	272,322	8,520,052	16,949,488	8,429,436	3,854,039	7,667,087
2002	3,582,000	114,798	5,690,443	12,267,339	272,322	3,696,798	18,230,105	14,533,307	1,493,075	7,362,833
2003		114,798	6,089,363	13,149,037	272,322	114,798	19,510,721	19,395,923	41,397	7,035,762
2004		114,798	6,488,282	14,030,734	272,322	114,798	20,791,338	20,676,540	36,962	6,694,254
2005		114,798	6,887,201	14,912,432	272,322	114,798	22,071,955	21,957,157	33,002	6,345,160
2006		114,798	7,286,121	15,794,129	272,322	114,798	23,352,572	23,237,774	29,466	5,994,024
2007		114,798	7,781,287	16,882,865	272,322	114,798	24,936,474	24,821,676	26,309	5,714,796
2008		114,798	8,276,454	17,971,600	272,322	114,798	26,520,375	26,405,577	23,490	5,426,594
2009		114,798	8,771,620	19,060,335	272,322	114,798	28,104,277	27,989,479	20,973	5,134,546
2010		114,798	9,266,787	20,149,070	272,322	114,798	29,688,179	29,573,381	18,726	4,842,785
2011		114,798	9,761,953	21,237,805	272,322	114,798	31,272,081	31,157,283	16,720	4,554,602
2012		114,798	10,398,966	22,650,977	272,322	114,798	33,322,265	33,207,467	14,928	4,333,214
2013		114,798	11,035,979	24,064,149	272,322	114,798	35,372,450	35,257,652	13,329	4,106,981
2014		114,798	11,672,992	25,477,320	272,322	114,798	37,422,634	37,307,836	11,901	3,879,483
2015		114,798	12,310,005	26,890,492	272,322	114,798	39,472,819	39,358,021	10,626	3,653,589
2016		114,798	12,947,018	28,303,663	272,322	114,798	41,523,004	41,408,206	9,487	3,431,565
2017		114,798	13,723,393	30,123,541	272,322	114,798	44,119,256	44,004,458	8,471	3,255,470
2018		114,798	14,499,768	31,943,419	272,322	114,798	46,715,509	46,600,711	7,563	3,077,716
2019		114,798	15,276,143	33,763,297	272,322	114,798	49,311,762	49,196,964	6,753	2,900,681
									35,770,673	103,487,480

B / C	**2.893**
IRR %	**25.97**
NPV (Baht)	**67,716,807**

8.2.7 Project Road 4015

The only available detour for this project road is Rt. 41 to the south to connect western amphoes with the changwat of Nakhon Si Thammarat. The main parameters used in the economic evaluation are:

- Extra trip length: 71 km
- Extra time: 1.25 - 1.77 hrs.
- Length of partially closed sections: 2.0 km

The cost / benefit cash flow and results of the economic evaluation for this road are presented in Table 8.2.7. Work on the road will take 3 years, and with the low construction cost the road has a high IRR of 43.36%.

Most of the traffic on this route is local traffic that transports local agro-based products to the main market in Nakhon Si Thammarat.

The highest rainfall intensity and annual rainfall have been recorded in this area, which have resulted in debris flows, river channel shifting, and the collapse of numerous road and bridges.

Given these conditions, disaster prevention will mainly protect the local economy and eliminate the risks associated with a disaster.

Table 8.2.7 Cost - Benefit Cash Flow of Rt. 4015

[Unit: Baht]

Year	COST		BENEFIT					COST [C]	BENEFIT [B]	B - C	Discounted C	Discounted B
	Construction	Maintenance	Full Closure		Partial Closure		Restoration	Total	Total			
			VOC Saving	Time Saving	VOC Saving	Time Saving	Saving					
1995	2,954,000							2,954,000		(2,954,000)	2,637,500	
1996	885,000	8,862						893,862		(893,862)	712,581	
1997	863,000	11,517						874,517		(874,517)	622,464	
1998		14,106	1,328,288	346,515	423,768	951,724	42,894	14,106	3,093,190	3,079,084	8,965	1,965,778
1999		14,106	1,405,340	369,109	449,105	1,014,559	42,894	14,106	3,281,006	3,266,900	8,004	1,861,731
2000		14,106	1,482,392	391,703	474,441	1,077,394	42,894	14,106	3,468,823	3,454,717	7,147	1,757,414
2001		14,106	1,559,443	414,296	499,777	1,140,229	42,894	14,106	3,656,639	3,642,533	6,381	1,654,078
2002		14,106	1,663,983	443,479	532,971	1,221,374	42,894	14,106	3,904,702	3,890,596	5,697	1,577,044
2003		14,106	1,768,523	472,662	566,166	1,302,519	42,894	14,106	4,152,764	4,138,658	5,087	1,497,528
2004		14,106	1,873,062	501,846	599,360	1,383,665	42,894	14,106	4,400,827	4,386,721	4,542	1,416,948
2005		14,106	1,977,602	531,029	632,554	1,464,810	42,894	14,106	4,648,889	4,634,783	4,055	1,336,445
2006		14,106	2,082,141	560,212	665,749	1,545,955	42,894	14,106	4,896,952	4,882,846	3,621	1,256,926
2007		14,106	2,230,107	601,975	713,023	1,661,733	42,894	14,106	5,249,732	5,235,626	3,233	1,203,103
2008		14,106	2,378,073	643,739	760,297	1,777,510	42,894	14,106	5,602,513	5,588,407	2,886	1,146,385
2009		14,106	2,526,039	685,503	807,571	1,893,288	42,894	14,106	5,955,294	5,941,188	2,577	1,088,010
2010		14,106	2,674,004	727,266	854,844	2,009,065	42,894	14,106	6,308,075	6,293,969	2,301	1,028,984
2011		14,106	2,821,970	769,030	902,118	2,124,843	42,894	14,106	6,660,856	6,646,750	2,054	970,116
2012		14,106	3,013,047	821,279	963,360	2,269,721	42,894	14,106	7,110,302	7,096,196	1,834	924,621
2013		14,106	3,204,124	873,529	1,024,602	2,414,598	42,894	14,106	7,559,748	7,545,642	1,638	877,738
2014		14,106	3,395,201	925,778	1,085,844	2,559,476	42,894	14,106	8,009,194	7,995,088	1,462	830,287
2015		14,106	3,586,279	978,028	1,147,086	2,704,354	42,894	14,106	8,458,640	8,444,534	1,306	782,928
2016		14,106	3,777,356	1,030,277	1,208,327	2,849,231	42,894	14,106	8,908,086	8,893,980	1,166	736,187
2017		14,106	4,028,868	1,099,480	1,288,707	3,041,430	42,894	14,106	9,501,380	9,487,274	1,041	701,087
											4,047,541	24,613,337

B / C	**6.081**
IRR %	**43.36**
NPV (Baht)	**20,565,796**

8.2.8 Project Road 4107/4058

In addition to the local traffic on this road, a considerable amount of traffic was assumed to be between Narathiwat and Yala, as this is the shortest road between the two changwat centers. As the detour of Rt. 42 and Rt. 410 (which is in better condition) did not show any savings in travel time, the traffic volume was not divided and traffic there was considered as local traffic between amphoes in the area. The main parameters used in the economic evaluation are:

- Extra trip length: 43 km
- Extra time: 0.8 - 1.15 hrs.
- Length of partial- closure sections: 0.5 km

The cost / benefit cash flow and results of the economic evaluation for this road are presented in Table 8.2.8. The main restoration works for this road will be completed by the forth year. Generated benefits give a relatively high IRR of 20%.

This route supports the daily life of religious minority groups and promotes rural development in the most southern areas of the country. Most damage is flood related.

For this route, it can be said that disaster prevention will mainly contribute to the social activities of the local inhabitants.

Table 8.2.8 Cost - Benefit Cash Flow of Rt. 4107/4058

[Unit: Baht]

Year	COST		BENEFIT					COST [C]	BENEFIT [B]	B - C	Discounted C	Discounted B
	Construction	Maintenance	Full Closure		Partial Closure		Restoration	Total	Total			
			VOC Saving	Time Saving	VOC Saving	Time Saving	Saving					
1995												
1996	464,000							464,000		(464,000)	369,898	
1997		1,392						1,392		(1,392)	991	
1998		1,392						1,392		(1,392)	885	
1999	9,404,000	1,392						9,405,392		(9,405,392)	5,336,872	
2000		29,604	750,657	174,229	90,442	624,064	44,054	29,604	1,683,445	1,653,841	14,998	852,886
2001		29,604	793,288	183,220	95,590	652,794	44,054	29,604	1,768,945	1,739,341	13,391	800,181
2002		29,604	844,111	194,535	101,808	687,018	44,054	29,604	1,871,525	1,841,921	11,957	755,878
2003		29,604	894,933	205,850	108,027	721,242	44,054	29,604	1,974,105	1,944,501	10,675	711,882
2004		29,604	945,756	217,165	114,245	755,466	44,054	29,604	2,076,685	2,047,081	9,532	668,637
2005		29,604	996,579	228,480	120,463	789,690	44,054	29,604	2,179,265	2,149,661	8,510	626,487
2006		29,604	1,047,402	239,795	126,681	823,914	44,054	29,604	2,281,845	2,252,241	7,599	585,693
2007		29,604	1,110,445	255,234	134,507	869,750	44,054	29,604	2,413,988	2,384,384	6,784	553,224
2008		29,604	1,173,488	270,673	142,332	915,585	44,054	29,604	2,546,132	2,516,528	6,058	520,989
2009		29,604	1,236,531	286,113	150,157	961,421	44,054	29,604	2,678,276	2,648,672	5,409	489,311
2010		29,604	1,299,574	301,552	157,982	1,007,257	44,054	29,604	2,810,419	2,780,815	4,829	458,440
2011		29,604	1,362,617	316,992	165,807	1,053,093	44,054	29,604	2,942,563	2,912,959	4,312	428,568
2012		29,604	1,444,953	337,931	176,115	1,113,489	44,054	29,604	3,116,542	3,086,938	3,850	405,274
2013		29,604	1,527,289	358,871	186,422	1,173,885	44,054	29,604	3,290,521	3,260,917	3,437	382,052
2014		29,604	1,609,625	379,810	196,729	1,234,281	44,054	29,604	3,464,500	3,434,896	3,069	359,153
2015		29,604	1,691,961	400,750	207,037	1,294,677	44,054	29,604	3,638,478	3,608,874	2,740	336,776
2016		29,604	1,774,297	421,689	217,344	1,355,073	44,054	29,604	3,812,457	3,782,853	2,447	315,071
2017		29,604	1,874,282	448,352	230,088	1,432,339	44,054	29,604	4,029,114	3,999,510	2,184	297,300
2018		29,604	1,974,267	475,014	242,832	1,509,604	44,054	29,604	4,245,771	4,216,167	1,950	279,720
2019		29,604	2,074,253	501,677	255,576	1,586,869	44,054	29,604	4,462,428	4,432,824	1,741	262,495
											5,834,118	10,090,016

B / C	**1.729**
IRR %	**20.43**
NPV (Baht)	**4,255,898**

Chapter 9

Project Implementation Program

Chapter 9 Project Implementation Program

9.1 Implementation Schedule

The implementation program for the proposed project roads is shown in Table 9.1.1. Yearly disbursement for each project road is also presented in the same table.

The program is prepared based on following assumptions.

- All temporary repair works will be implemented in the first five years.

- Temporary repair work precedes permanent repair work by five years.

- Permanent repair work for high-priority project roads will be implemented at an early stage.

- Repair work for bridges and landslides will be implemented at an early stage.

In the table below, T stands for temporary repair work and P stands for permanent repair work.

Table 9.1.1 **Project implementation Program (1)**

Proposal for Project Implementation Program (1)

(X 1000 baht)

Year / Spot No.	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total
109/1		T 330					P 527				857
109/2		T 490					P 5,653				6,143
109/3	P 2,602										2,602
Others	15,100	13,682	9,800	11,526	10,663	119,504	114,273	113,060	113,060	113,060	633,728
Total	17,702	14,502	9,800	11,526	10,663	119,504	120,453	113,060	113,060	113,060	643,330
1095/1	P 3,269										3,269
1095/2	P 346										346
1095/3		P 3,186									3,186
1095/4		P 186									186
Others	5,466	13,618	7,953	6,702	18,597		5,653	13,568	527		72,084
Total	9,081	16,990	7,953	6,702	18,597	0	5,653	13,568	527	0	79,071
1149/1	P 3,133										3,133
1149/2	T 51					P 152					203
Others	3,903	210	113			204	321	335			5,086
Total	7,087	210	113	0	0	356	321	335	0	0	8,422
1256/1		P 2,849									2,849
1256/2/3	T 74					P 229					303
1256/4			T 56					P 190			246
1256/5	T 732					P 994					1,726
1256/6		T 764					P 1,775				2,539
1256/7						P 227					227
1256/8		P 1,092									1,092
1256/9						P 4,605					4,605
1256/10		T 1,150					P 959				2,109
1256/11/12	T 634					P 668					1,302
Others	1,611	5,309	6,472	5,640	9,817	4,605	9,056	3,930		6,123	52,563
Total	3,051	11,164	6,528	5,640	9,817	11,328	11,790	4,120	0	6,123	69,561

Table 9.1.1 Project implementation Program (2)

Proposal for Project Implementation Program (2)

(X 1000 baht)

Year / Spot No.	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total
4/1	P 3,177										3,177
4/2/3	P 4,119										4,119
Others	10,230	318									10,548
Total	17,526	318	0	0	0	0	0	0	0	0	17,844
410/1	P 723										723
410/2	T 658					P 1,058					1,716
410/3	P 530										530
410/4		T 53					P 981				1,034
410/5						P 135					135
410/6	P 3,033										3,033
Others	12,574	6,523	6,286	424	4,860	11,025	8,763	4,145			54,600
Total	17,518	6,576	6,286	424	4,860	12,218	9,744	4,145	0	0	61,771
4015/1	P 861										861
4015/2		P 594									594
4015/3			P 568								568
4015/4	P 998										998
4015/5	P 1,561										1,561
Others		431	431								862
Total	3,420	1,025	999	0	0	0	0	0	0	0	5,444
4107/1/2		P 530									530
4058/1					P 10,889						10,889
Total	0	530	0	0	10,889	0	0	0	0	0	11,419
Grand Total	75,385	51,315	31,679	24,292	54,826	143,406	147,961	135,228	113,587	119,183	896,862

9.2 Preparation of Project Fund

The Study investigates the feasibility of implementing restoration measures in disaster-prone areas on eight selected project roads that have a high priority. The total financial construction cost required for the eight project roads is about 897 million baht over a period of ten years. The project roads have a total length of 378.64 km, in which about 38.5 km is subject to different types of disaster-related damage with 191 damage spots in total.

As the DOH is responsible for more than 50,000 km of national and provincial highway, restoring these high-priority, eight project roads is a short-term target towards larger objectives and the long-term task of covering more roads in disaster-prone areas in the future.

Restoring damaged roads in dangerous locations for existing highways is not less importance than constructing new roads. In fact, priority should be given to the rehabilitation and restoration of existing facilities to prolong their useful lives and acquire their assumed benefits by reducing the transport operating cost and avoiding huge investments for major rehabilitation. In addition, implementing low-cost substandard measures will result in repetitions of the same damage, or the damage becoming increasingly worse with every disaster.

The national budget allocates a sizable percentage of its money to the road sector, however, the present road budget is still insufficient to meet demand. In addition, the share for the road sector is not increasing in the national budget as the government has other priorities.

With the total extension of the highway network increasing, the financial cost of road maintenance, which includes the restoration works in the Study, is also increasing. However, the maintenance budget is not increasing at the same pace and will not be able to maintain the network in efficient condition. If the maintenance budget is not increased considerably, other financial sources should be considered to implement the project.

At present, the maintenance budget is locally funded without foreign assistance, as foreign-assisted projects are mainly for new roads construction and/or roads widening. With the present level and annual growth in the maintenance budget, it can be said that the budget is insufficient at present and in years to come.

As investments in road maintenance, rehabilitation and improvement works have no place with the private sector, which is more interested in income-generating projects such as toll roads and bridges, international financial institutions do assist in such projects in many countries at present. Funding through foreign loans from such financial institutions may present an additional funding source to the local maintenance budget, which can not cover the investments required for implementing the project in the short-term or meeting long-term objectives.

For this purpose, and based on the Study, a plan for a foreign-assisted project should be formulated with the objective of restoring disaster-related damaged facilities on the highways as a policy for the highway sector. The total amount of the loan is determined based on the overall implementation program, which may involve multi-stage financing of similar groups participating in different sub-projects.

Chapter 10

Profiles of Project Roads

Chapter 10 Profiles of the Project Roads

10.1 Route 109 [Fig.10.1.1]:

The proposed project road originates at the junction with Route 118 at Mae Suai and ends at the junction with Route 107 at Fang with a total length of 72.86 kilometers. The route is expected to be one of the important links between Chiang Mai and Chiang Rai after the completion of pavement work.

Since the route crosses mountain passes, it is situated mainly in mountainous terrain, except for about 10 kilometers of hilly terrain and flat alluvial sections at the starting and ending sections. The alignment of the route is tortuous in the mountainous terrain with numerous low radius curves.

The route was constructed in a phased manner. Approximately half of the route, starting from Amphoe Mae Suai, was initially opened to traffic, followed by the section to Amphoe Fang. The initial section has been paved using a double-surface treatment with a soil aggregate shoulder, while the western sector to Fang is currently under reconstruction to be an all-weather road. Most of the road damage observed on this project road is cut slope related, i.e., gully erosions, landslides and rockfalls. A number of severely eroded fill slopes were also seen. In particular, gully erosion was very extensive along the previously constructed section. Up to now, slope damage on the newly constructed section has not been serious since the slopes are still young.

Route 109	Description
Changwat	: Chiang Rai and Chiang Mai
Road Class	: Class 5 (Control No. 0100) Class 3 (Control No. 0200)
Cross Section(m)	: 6.0 (0100), 1.5 + 6.0 + 1.5 (0200)
Surface Type	: SA (0100),SA/DBST/SA (0200)
Length (km)	: 72.86
AADT<'93>	: 1,724
Damage Types For Study	: Erosion on a cut slope : Landslide on a cut slope : Rockfalls on a cut slope
Project Cost	: 643,330,000 baht (at 1994 prices)
NPV	: -16,970,000 baht
B/C	: 0.933
IRR	: 10.90 %

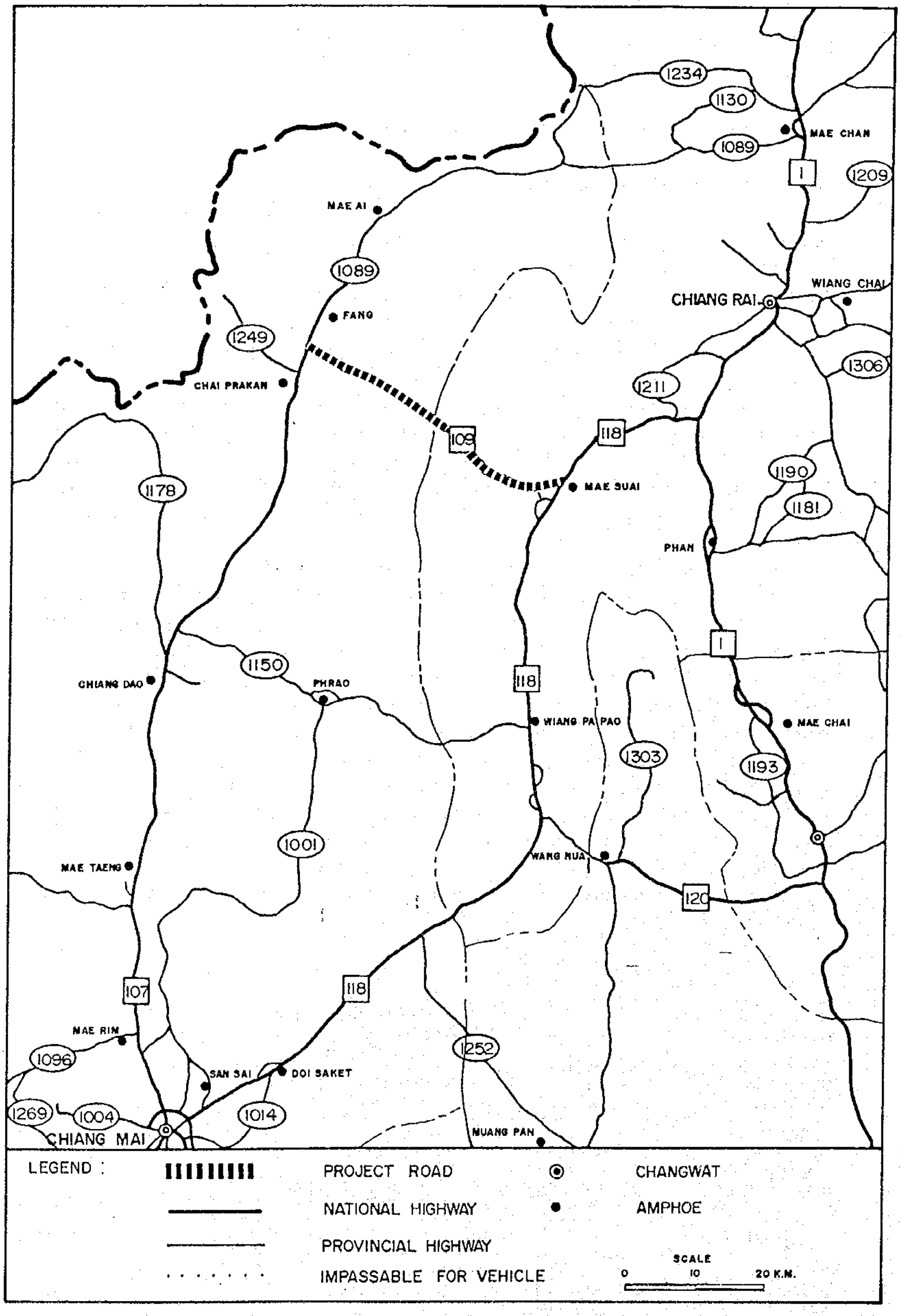

Fig. 10.1.1 Project Road 109

10.2 Route 1095 [Fig.10.2.1]:

Mae Hong Son is located in a northern border region between Thailand and Burma and is rather isolated from other major cities. This project road was selected so as to ensure access between Chiang Mai and Mae Hong Son, through Route 1095, for all weather conditions. Other alternative routes to Mae Hong Son from Chiang Mai are Route 108 and Route 108/1009/1192/1088/1263. Both of these, however, are much longer than Route 1095 and the latter alternative is in poor condition.

The proposed project road originates at the junction with Route 1226 in King Amphoe Pangmapha and ends at Mae Hong Son with a length of 55.30 km. The road is mainly situated in mountainous terrain that is mostly covered by secondary and primary forest.

The alignment of the road is very tortuous in order to adapt to the mountainous geography and to avoid bridge structures. Though the surface of the road has been paved with a single-surface treatment, the width of the carriageway is obviously sub-standard.

Road damage observed on the road is mostly related to land-slides except for a few rockfalls.

Route 1095	Description
Changwat	: Mae Hong Son
Road Class	: Class 4
Cross Section(m)	: 1.0 + 5.0 + 1.0
Surface Type	: SA/SGST/SA
Length(km)	: 55.30
AADT<'93>	: 1,969
Damage Types	: Landslides on a cut slopes
For Study	: Rockfalls on a cut slopes
Project Cost	: 79,071,000 baht (at 1994 prices)
NPV	: 69,325,000 baht
B/C	: 2.541
IRR	: 24.48 %

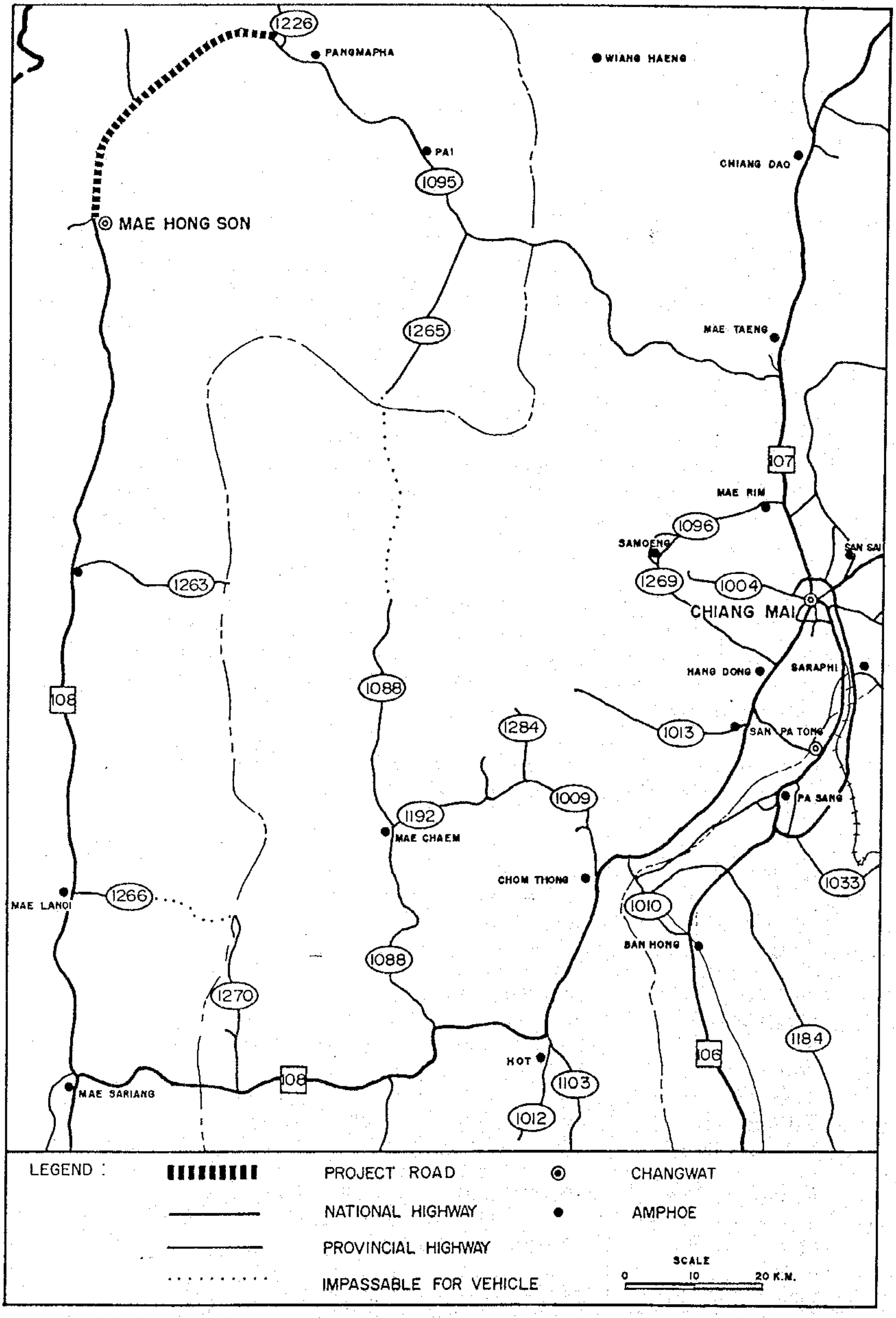

Fig. 10.2.1 Project Road 1095

10.3 Route 1149 [Fig.10.3.1]:

Route 1149 is located in the border area north of Chiang Rai. It starts at the junction with Route 1 and is linked to a military road which ends at the junction with Route 1 in Amphoe Mae Sai. The initial half of the link, with a length of 14.80 kilometers, has been selected as a project road. The main function of the route is for the promotion of tourism.

About 3 km of the project road from Route 1 is situated in rather flat terrain, with the rest being located in mountainous terrain. The project road contains mainly cut-slope sections with a few fill-embankment sections. The whole length of the road is paved with double-surface treatment. The alignment of the road is very tortuous in the mountainous terrain.

Some of the cut slopes along the road have been damaged by erosion and landslides, though they have been rather well protected with vegetation and shotcrete.

Route 1149	Description
Changwat	: Chiang Rai
Road Class	: Class 4
Cross Section(m)	: 1.75 + 5.5 + 1.75
Surface Type	: SA/DBST/SA
Length(km)	: 14.80
AADT<'93>	: 1,178
Damage Types	: Landslide on a cut slope
For Study	: Erosion on a cut slope
Project Cost	: 8,422,000 baht (at 1994 prices)
NPV	: 2,057,000 baht
B/C	: 1.329
IRR	: 15.23 %

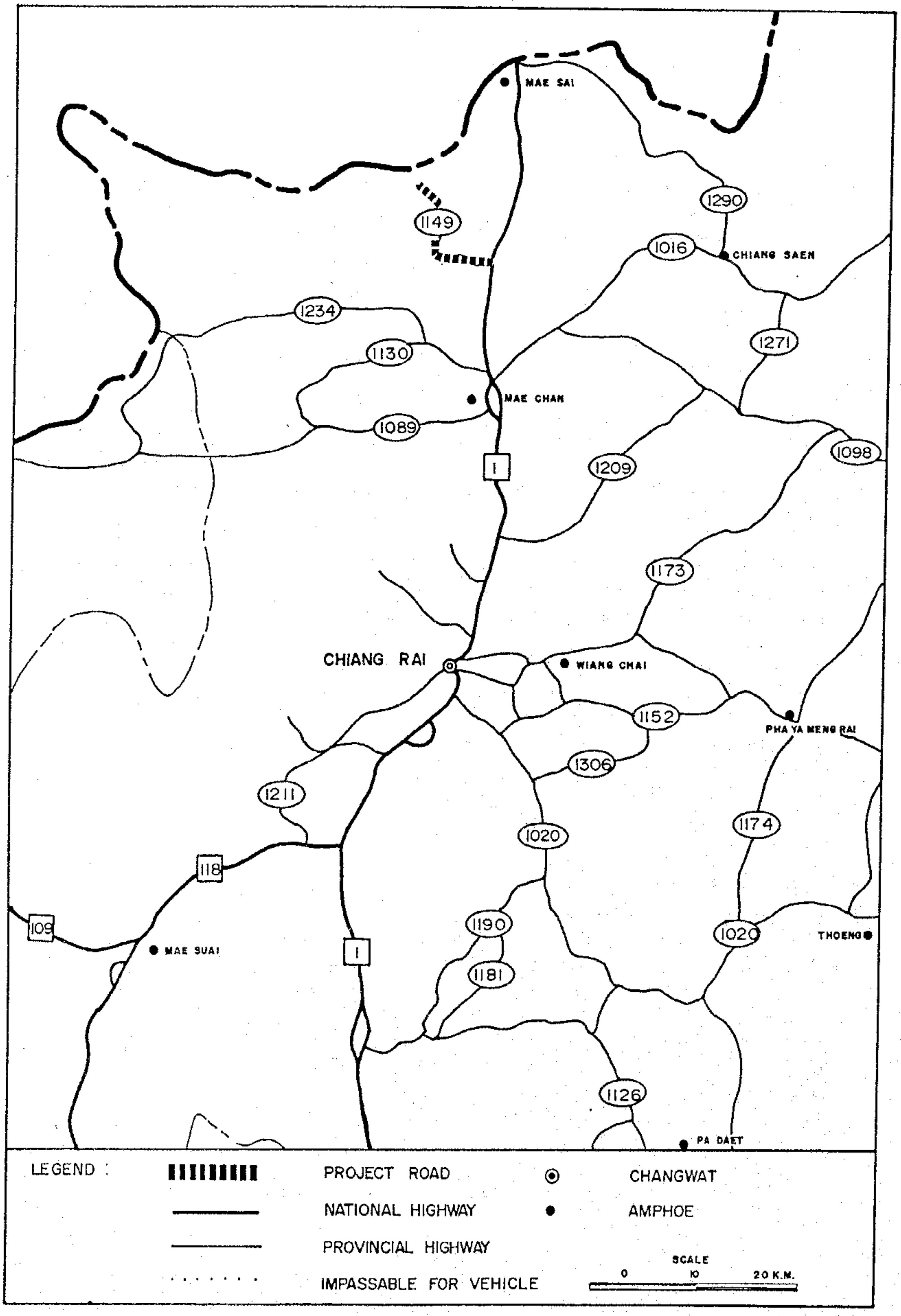

Fig. 10.3.1 Project Road 1149

10.4 Route 1256 [Fig.10.4.1]:

Route 1256 originates at the junction with Route 1081 in Amphoe Pua and ends at the junction with Route 1081 in King Amphoe Bo Klua. The entire route is proposed as a project road and has a total length of 46.89 km. The main role of the route is to promote tourism and support mountain tribes.

About 6 km of the beginning section is situated in flat terrain with low embankments, with the remaining 41 km being situated in hilly and mountainous terrain mainly with cut slopes. Some cut-slope surfaces are protected by shotcrete. The surface of the entire road is paved with a single-surface treatment. The existing carriageway is very narrow and sub-standard.

Damage observed along the road in the flat terrain sector are related to flooding, such as the scouring of abutment protection and road flooding. In the mountainous terrain sector, various types of damage are observed on the cut and fill slopes, i.e., erosion, landslides and rockfalls.

Route 1256	Description
Changwat	: Nan
Road Class	: Class 4
Cross Section(m)	: 1.25 + 3.5 + 1.25
Surface Type	: SA/SGST/SA
Length(km)	: 46.89
AADT<'93>	: 844
Damage Types For Study	: Scouring of abutment
	: Scouring of river bank
	: Overflow crossing "at-grade" road
	: Erosion on a cut slope
	: Landslide on a cut slope
	: Rockfall on a cut slope
	: Landslide on a fill slope
Project Cost	: 69,561,000 baht (at 1994 prices)
NPV	: -1,334,000 baht
B/C	: 0.963
IRR	: 11.51 %

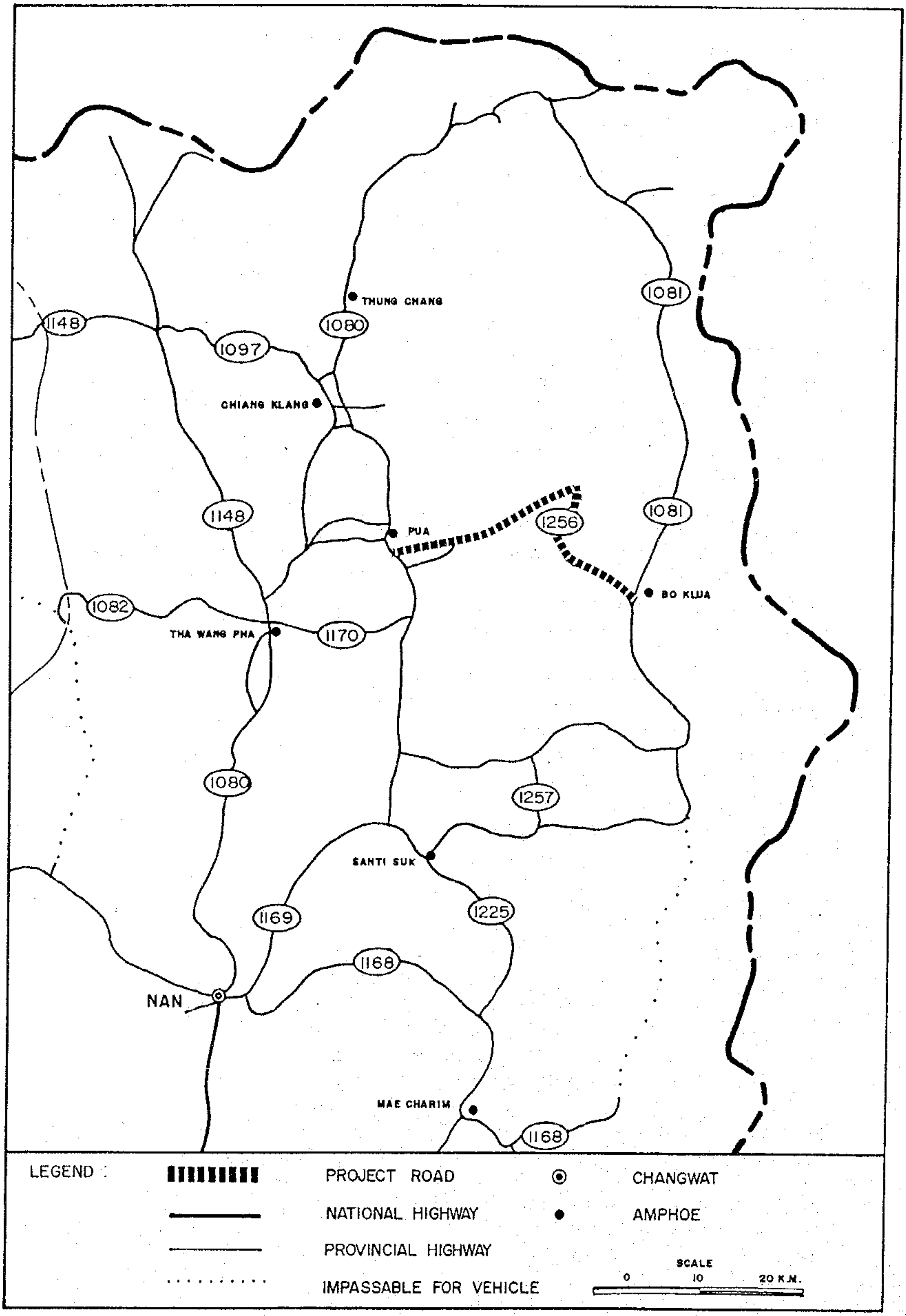

Fig. 10.4.1 Project Road 1256

10.5 Route 4 [Fig.10.5.1]:

The proposed project road originates at the junction with Route 41 at Phatthalung and ends at the junction with Route 403 at Trang. The total length of the road is 52.95 km. The road is the only trunk road across the peninsula in this area. In this context, this road must be kept free from traffic interruptions caused by natural disasters.

The middle third of the road is situated in hilly or mountainous terrain and the remaining two thirds, at the beginning and ending of the road, are located in flat terrain.

The entire road is paved with asphaltic concrete with a single-surface treatment shoulder, and its alignment in the mountainous terrain is not overly tortuous for a mountain pass.

Two kinds of road damage are observed along the road. One is flood related and the other is cut-slope related. Though the cut slopes are mostly protected by shotcrete, slope failures are still occurring.

Route 4		Description
Changwat	:	Phatthalung and Trang
Road Class	:	Class 3 (Control No. 3800)
		Class 3 (Control No. 3900)
Cross Section(m)	:	2.0 + 6.0 + 2.0
Surface Type	:	ST/ASC/ST
Length(km)	:	52.95
AADT<'93>	:	5,632
Damage Types	:	Scouring of abutment
For Study	:	Scouring of river bank
	:	Erosion on a cut slope
	:	Landslide on a cut slope
Project Cost	:	17,844,000 baht (at 1994 prices)
NPV	:	26,608,000 baht
B/C	:	2.886
IRR	:	29.07 %

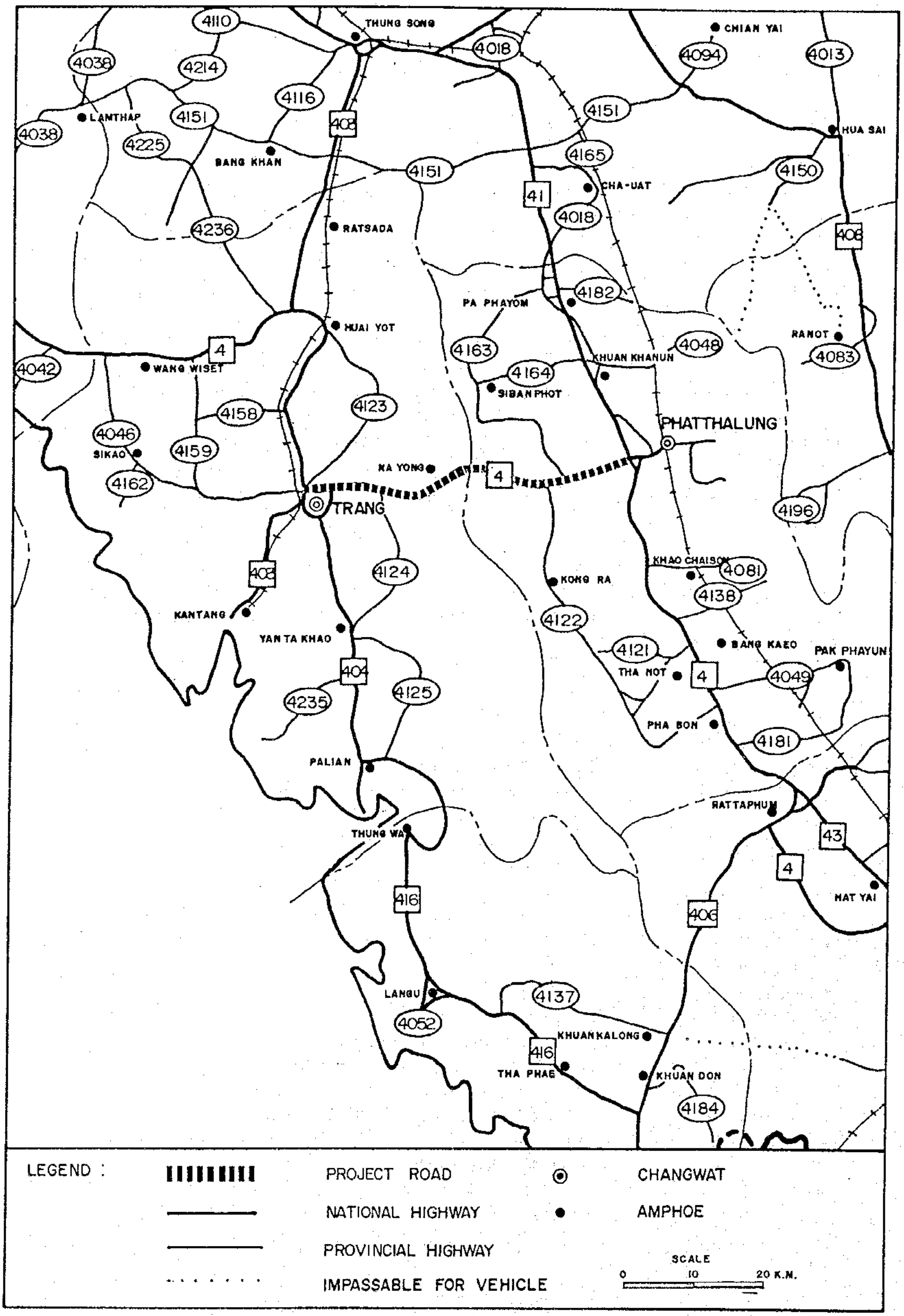

Fig. 10.5.1 Project Road 4

10.6 Route 410 [Fig.10.6.1]:

Route 410 plays an important role as an international traffic route between Thailand and Malaysia. It also serves the function of supporting the religious minorities inhabiting southernmost area. The proposed project road, which is a part of Route 410, originates at the junction with Route 4077 in Amphoe Bannag Sata and ends at the junction with Route 4062 for a total of 79.91 km.

About 27 km of the beginning section of the road is situated in relatively flat terrain. The remaining 52 km is situated in hilly and mountainous terrain where a severely twisting alignment is used to skirt the reservoir of the Banglang Dam.

The initial 35.9 km of the project road is paved with penetration macadam with soil aggregate shoulders. The next 31.6 km is paved using a double-surface treatment with soil aggregate shoulders, and the last 2.4 km consists of penetration macadam with soil aggregate shoulders.

Road damage observed on the road is mostly related to cut slopes except for a few damaged fill slopes. Most of the damage is concentrated on the southern half of the road.

Route 410:	Description
Changwat	: Yala
Road Class	: Class 4 (Control No. 0301)
	Class 4 (Control No. 0302)
	Class 1 (Control No. 0401)
	Class 4 (Control No. 0402)
Cross Section(m)	: 1.75 + 5.5 + 1.75 (0301,0302,0402)
	: 2.0 + 7.0 + 2.0 (0401)
Surface Type	: SA/UPM/SA(0301,0302,0402), SA/DBST/SA(0401)
Length(km)	: 79.91
AADT<'93>	: 419 (0402)
Damage Types For Study	: Road flooding
	: Landslide on a cut slope
	: Landslide on a fill slope
	: Rockfalls on a cut slope
Project Cost	: 61,771,000 baht (at 1994 prices)
NPV	: 67,717,000 baht
B/C	: 2.893
IRR	: 25.97 %

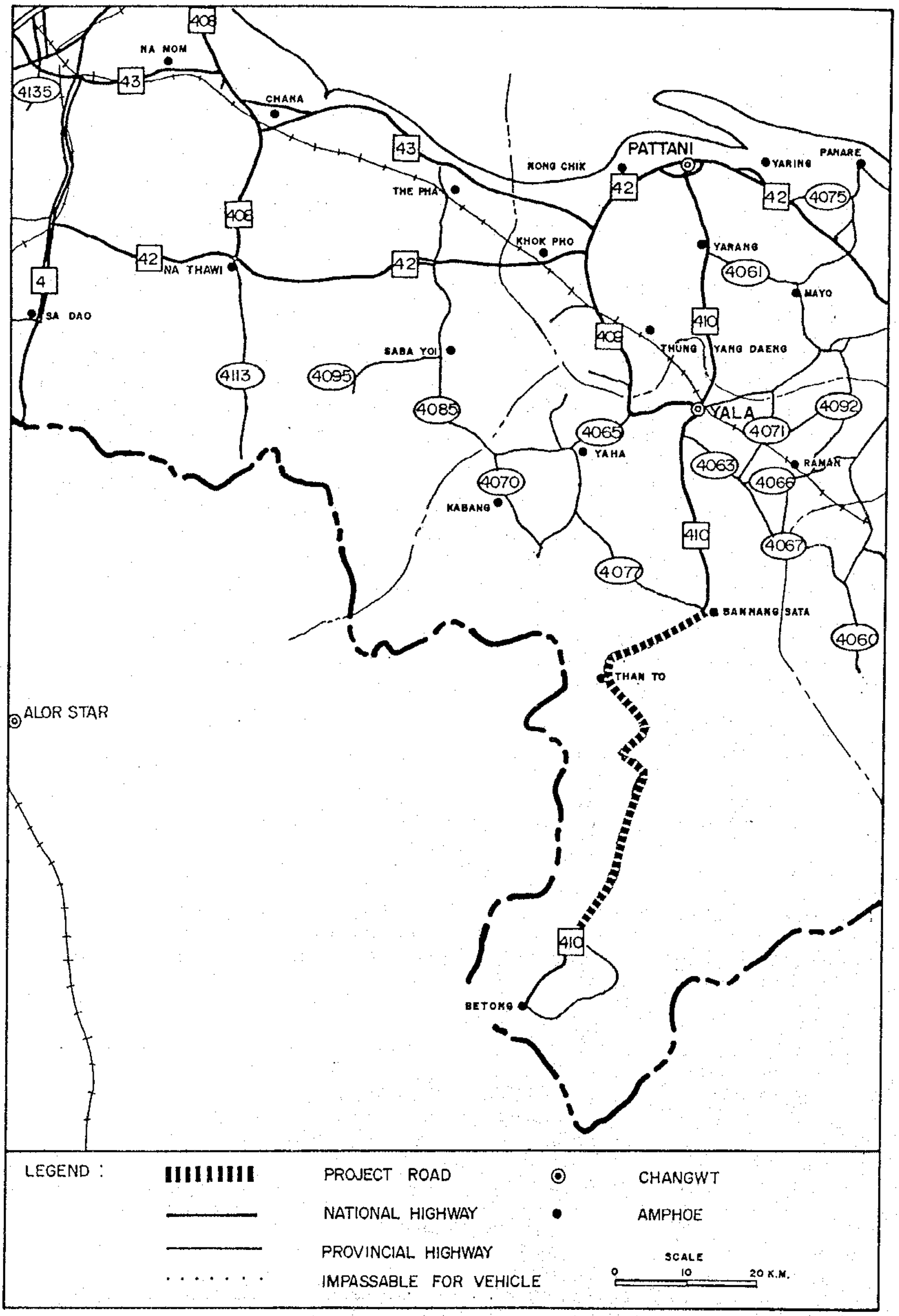

Fig. 10.6.1 Project Road 410

10.7 Route 4015 [Fig.10.7.1]:

Route 4015 is situated in an area inland from Nakhon Si Thammarat, which is one of the most disaster-prone areas in Thailand. Rainfall intensity in the area is also one of the highest in Thailand. The route plays a role as an alternative route for transversing the peninsula and linking Route 401 and Route 41 in the shortest distance.

The project road is a part of Route 4015 and originates at the intersection with Route 4016 and ends at the intersection with Route 4230, totaling 23.88 km. About 12 km of the initial section is situated in hilly terrain following a valley floor, with the remainder of the road being situated in flat alluvial terrain.

The surface of the road is paved using a double-surface treatment with soil aggregate shoulders.

Road damage observed on the road is mostly induced by flooding, i.e., washing out of road embankments, abutment scouring and erosion of approach roads.

Route 4015	Description
Changwat	: Nakhon Si Thammarat
Road Class	: Class 4
Cross Section(m)	: 1.5 + 5.0 + 1.5
Surface Type	: SA/DBST/SA
Length(km)	: 23.88
AADT<'93>	: 1,901
Damage Types for Study	: Scouring of road embankment
	: Washing out of road embankment
	: Scouring of abutment
	: Collapsing of abutment protection
	: Erosion of approach road to bridge
Project Cost	: 5,444,000 baht (at 1994 prices)
NPV	: 20,566,000 baht
B/C	: 6.081
IRR	: 43.36 %

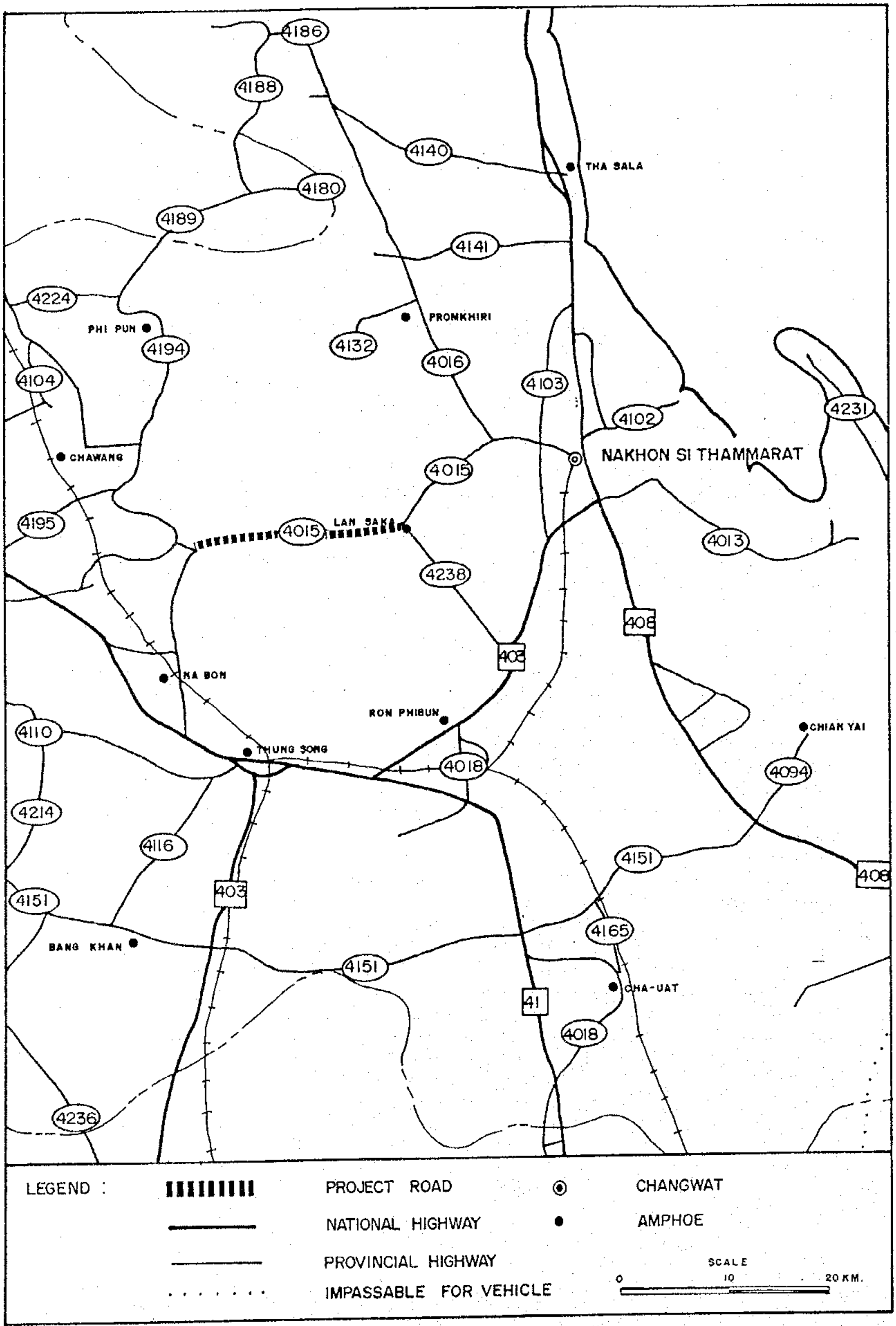

Fig. 10.7.1 Project Road 4015

10.8 Route 4107/4058 [Fig.10.8.1]:

The shortest distance between Changwat Narathiwat and Yala follows routes 4107/4058/ 4067/4063. This route follows the base of the mountain range. The route is situated in one of the most flood-prone areas in the country and the highest rainfall intensity in Thailand has been recorded in this area.

The proposed project road, which is a part of the route mentioned above, originates at the intersection with Route 4060 in Amphoe Ruso and ends at the intersection with Route 42 in Amphoe Yi-Ngo. The first 11 km is situated in flat terrain along the foot of mountains, with the next 10 km running through a valley floor. The remainder of the road passes over flat alluvial terrain. The total length of the project road is 32.05 km.

The road is paved using a double-surface treatment with soil aggregate shoulders for both Route 4107 and Route 4058.

A number of streams flowing down from the mountains have caused road damage. This damage is mostly related to bridges collapsing, i.e., scouring of abutments, collapsing of abutment protection and overflow.

Route 4107/4058	Description
Changwat	: Narathiwat
Road Class	: Class 5 (Control No. 0200)
	Class 2 (Control No. 0100)
Cross Section(m)	: 1.75 + 5.5 + 1.75 (Route 4107)
	: 1.5 + 5.0 + 1.5 (Route 4058)
Surface Type	: SA/DBST/SA
Length(km)	: 32.05
AADT<'93>	: 1,219(R4107), 1,706(R4058)
Damage Type	: Scouring of abutment
for Study	: Collapsing of abutment protection
	: Overflow
Project Cost	: 11,419,000 baht (at 1994 prices)
NPV	: 4,258,000 baht
B/C	: 1.729
IRR	: 20.43 %

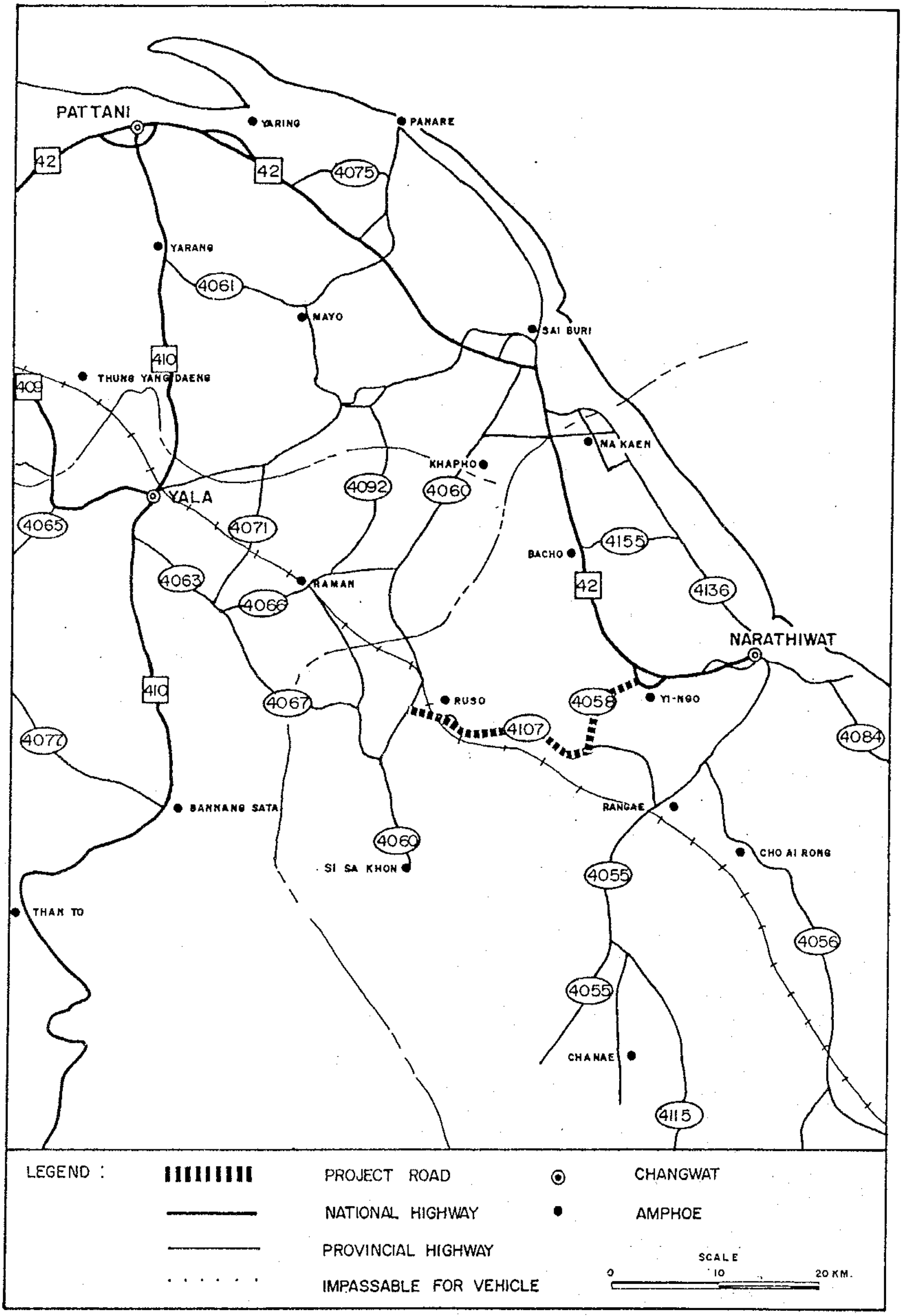

Fig. 10.8.1 Project Road 4107/4058

PART 3

RECOMMENDATIONS FOR A MANAGEMENT AND OPERATIONS SYSTEM

Chapter 11

Management and Operations System to Cope with Road Damage

Chapter 11 Management and Operations System to Cope with Road Damage

11.1 Present Management and Operations System

11.1.1 Existing Organizations for Management and Operations

1. General Flow of Management and Operations System

The general concept of a management and operations system is shown in Fig.11.1.1. Management and operation work differs in times of disaster and in normal daily maintenance, as illustrated in this figure. The object of this report is to recommend a management and operations system to cope with disasters. Therefore, we will discuss a management and operations system for disasters only.

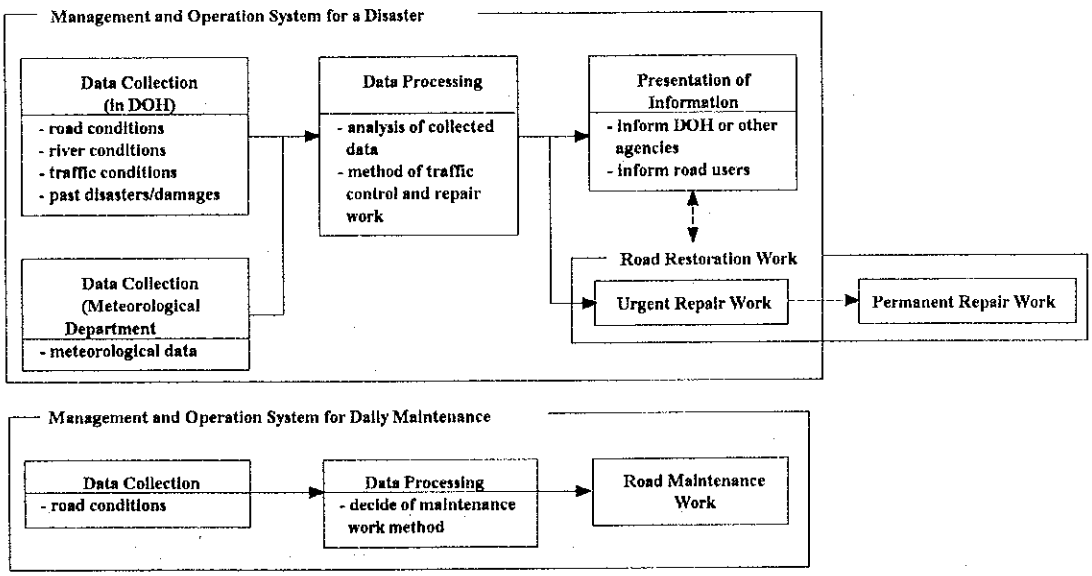

Fig.11.1.1 Concept of Management and Operations System

In a disaster, management and operation work is classified into the following four processes:

- Data Collection
- Data Processing
- Presentation of Information
- Road Restoration Work

Road restoration work is classified into urgent repair work and permanent repair work. Permanent repair work is long term in nature and not applied for disaster relief. Therefore, road restoration work will be taken to means urgent repair work from hereon.

Concretely, the tasks of the above four processes are defined as below:

1) Data Collection

- Collect data on meteorological and traffic conditions using detectors or a patrolling system.
- Detect road damage or a disaster in the same manner.

2) Data Processing

- Manage the meteorological and traffic data.
- Exchange data between DOH and other related agencies.
- Grasp promptly the road conditions using the above data.
- Analyze the data.
- Anticipate disasters and damage.
- Judge the necessity of route closures.
- Indicate or transmit to local offices (depots) the necessity of route closures.

3) Presentation of Information

- Transmit information on road conditions and route closures to related agencies such as the local police department.
- Inform road users of road conditions and route closures.

4) Road Restoration Work (urgent repair work)

- Summon road restoration work staff.
- Close or restrict use of routes.
- Inspect road damage.

- Draw up countermeasures.
- Procure the necessary equipment, materials and budget.
- Terminate traffic restrictions.

2. Organizations

Fig.11.1.2 shows the existing organizational chart for road management in DOH. In this figure, the positions or sections with colored mesh are responsible for management and operations in times of disaster. The number of division offices is fifteen, with four to seven district offices in each division.

Table 11.1.1 shows the average road length being managed and the number of maintenance staff in each organization. In a disaster, depot staff carry out emergency restoration work, such as traffic control and the repairing of road damage. Depot engineers also employ temporary laborers.

Table 11.1.1 Road Length and Number of Staff

Organization	Road length to manage (average)	Numbers of staff for maintenance
Head Office	54,000 km.	-
Division Office	3,500 - 4,000 km.	123
District Office	600 - 700 km.	45
Depot	80 - 100 km.	4

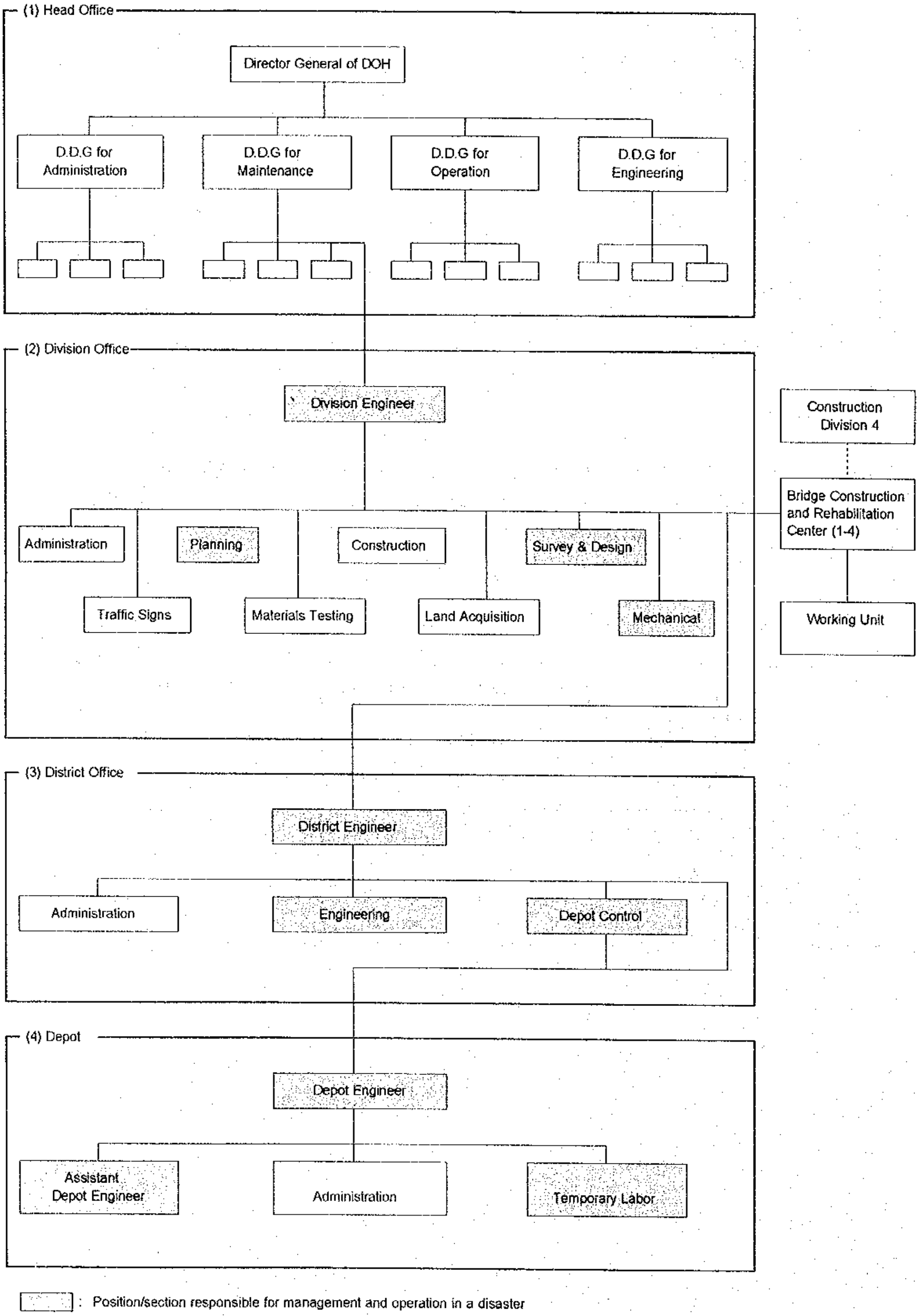

Fig. 11.1.2 Organizational Chart

When a serious disaster such as a large-scale flood occurs, the Thai Government organizes a temporary committee to cope with the disaster under the control of the Prime Minister. He is in charge of all of the ministries to cope with the disaster. As for road disasters, there are guidelines for damage control for each responsible position and section shown in Fig.11.1.2. However, temporary organizations for coping with road damages are not considered in the ordinary organizational setup.

However, in Japan, temporary headquarters and branches to cope with disasters are set up in ordinary road-related organizations. They collect information on the weather, road damage and traffic conditions, and carry out necessary countermeasures according to the scale of the road damage. The organizations and systems to cope with disasters in Japan are presented in Appendix 6-1.

3. Responsibility of Each Organization

The responsibility of each organization in a disaster is defined below.

1) Head Office: to approve an action program and budget for urgent repair work

2) Division Office: to approve the action program and budget

3) District Office: to decide on appropriate methodology and the budget

4) Depot: to carry out the urgent repair work

11.1.2 Data Collection

1. Data Item

The data necessary to grasp road damage and prepare countermeasures is classified below.

1) Meteorological Data

- Rainfall
- Temperature

2) Road Conditions

- Pavement conditions
- Bridge conditions
- Obstructions on road
- Road damage
- Slope damage

3) River Condition

- Water level
- Discharge volume

4) Traffic Conditions

- Traffic accident
- Traffic volume/congestion

Table 11.1.2 shows the methods to collect the above data. The procedures to collect data are basically classified into that using a detector and that using a patrolling system. In addition, the agencies that collect data are classified. As shown in Table 11.1.2, DOH collects the data for roads and traffic conditions via patrols.

Table 11.1.2 Existing Data Collection Methods

Data Item	Procedure			Collector		REMARKS
	Detector	Patrol	Other	DOH	Other Agencies	
1. Meteorological Data						
- Rainfall	O				O	Received from Meteorological Department
- Temperature	O				O	
2. Road Condition						
- Pavement Conditions	O	O		O		
- Condition of Bridges		O		O		
- Obstruction		O		O		
- Road Damage		O		O		
- Slope Damage		O		O		
3. River Conditions						
- Water level		O		O	O	Received from Irrigation Department
- Amount of water	O				O	
4. Traffic Conditions						Some Information Received from Police Department
- Traffic Accidents		O		O	O	
- Traffic Volume		O		O		

However, as for meteorological data and river data, DOH receives these data from other agencies, such as the Meteorological Department, which belongs to the Ministry of Transport and Communications, and the Irrigation Department, which belongs to the Ministry of Agriculture. The division engineer or the district engineer requests these data from the related departments after a disaster. It takes approximately one week to one month to actually receive these data. The time depends on the seriousness of the disaster.

2. Data Collection Procedure

1) Detector

As for detectors, DOH only operates traffic counters. There were 71 permanent counter stations and 2321 coverage stations in 1993. Traffic volume data are reported to the head office to prepare the traffic statistics.

2) Patrolling System

Patrols are made five days a week by depot engineers. The road length to patrol is approximately 80 to 100 kilometers per depot. It takes almost one week to patrol a whole road section managed by a depot. In a disaster, patrols are made more frequently than usual.

When patrol staff detect some road damage or hazard, they must inform the district engineer of the situation via wireless telephone.

3) Other Procedures

a) Information from Road Users and Roadside Service

DOH sometimes receives information on road conditions from road users. Especially, truck drivers visit district offices or depots to inform the staff there. In addition, there is some information from roadside inhabitants.

b) Information from Helicopter

In a serious disaster, the army or police operate helicopters to inspect the situation.

11.1.3 Data Processing

1. Management of Road Information

The section responsible for managing and processing road information is the Statistical Section of the Administration Division in the head office. However, there are not any sections that provide real-time information on meteorological, road and river conditions in times of a disaster.

2. Judgment on Hazardousness and Transmission of Decisions

There are some important matters to judge or decide on for when and how urgent repair work should be executed at a site in a disaster. They are:

- The summoning of urgent working staff;
- the closing of a road; and
- the execution of urgent repair work.

Generally, the district engineer is responsible for making such judgments and decisions. However, as for the approval of an action program and its budget, the chief of the Maintenance Section in the head office and the chiefs of planning sections in division offices are responsible. The decisions are transmitted by telephone in DOH as illustrated in Fig.11.1.3.

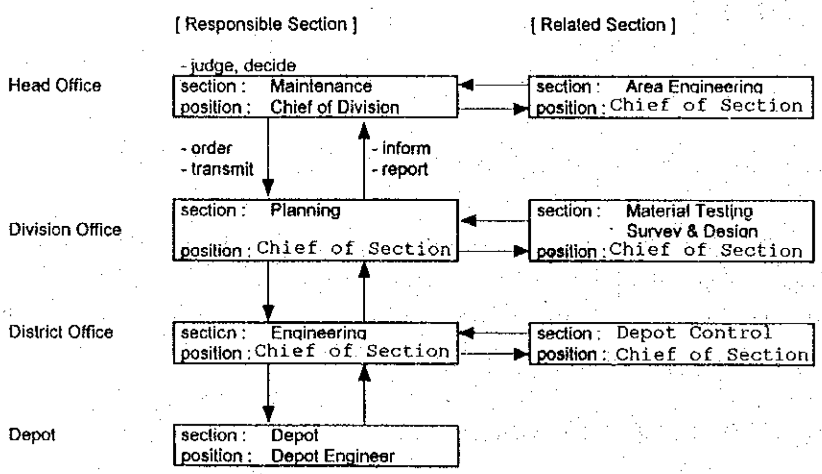

Fig.11.1.3 Communication Network in DOH

11.1.4 Presentation of Information

1. Presentation of Information to Road Users

1) Traffic Control in a Disaster

Traffic control carried out by DOH in a disaster is classified into traffic regulation and detour guidance. Traffic regulation is classified into road closure and partial road closure. These control measures are executed in principle after patrol staff confirm road damage. At present, there is not any standard for closing a road before road damage occurs. However, patrol staff sometimes closes a road before there is damage if they judge that the potential of that damage is very high.

2) Presentation of Information

Fig.11.1.4 shows the typical method of controlling traffic in a disaster. The staff in charge of closing a road are depot staff, such as the depot engineer, assistant depot engineer and temporary laborers. In addition, the local police are also involved in closing a road off.

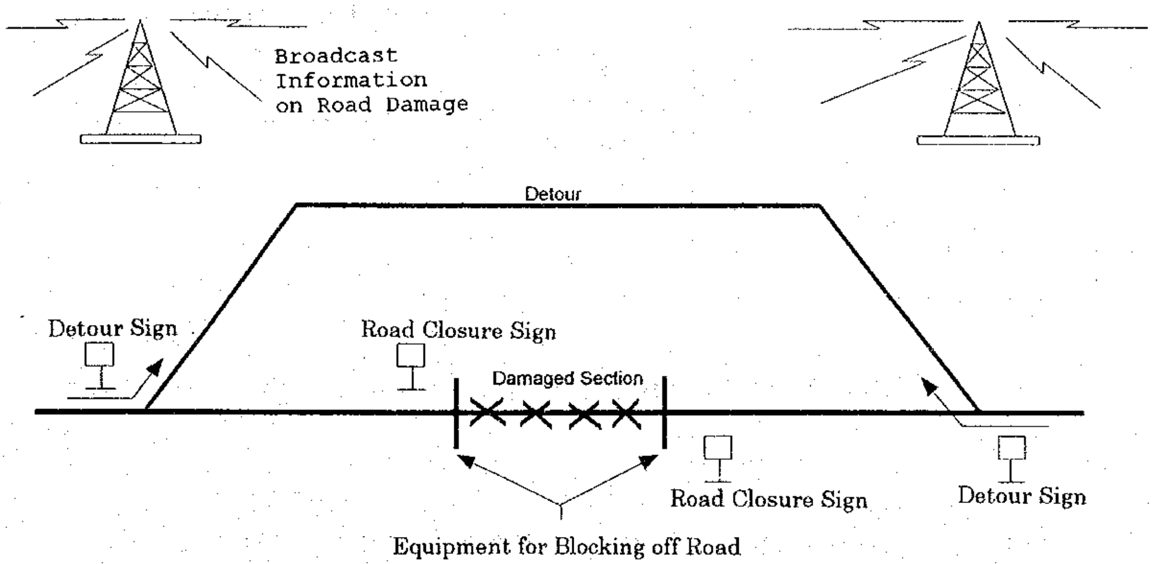

Fig.11.1.4 Traffic Control in a Disaster

The staff place the road closure sign just before the site of a road disaster, and prevent passage using a barricade. They also place a detour sign at the entrance to any detour road. Moreover, they transmit the information of the road closure to a radio station for road user convenience.

2. Transmission of Information to Other Agencies

When DOH closes a road, the information of the closure is transmitted to the local police department. Moreover, DOH transmits this information to the local radio station, as illustrated in Fig.11.1.5. When serious road damage extends over a wide area, the head office transmits this information to a national radio station.

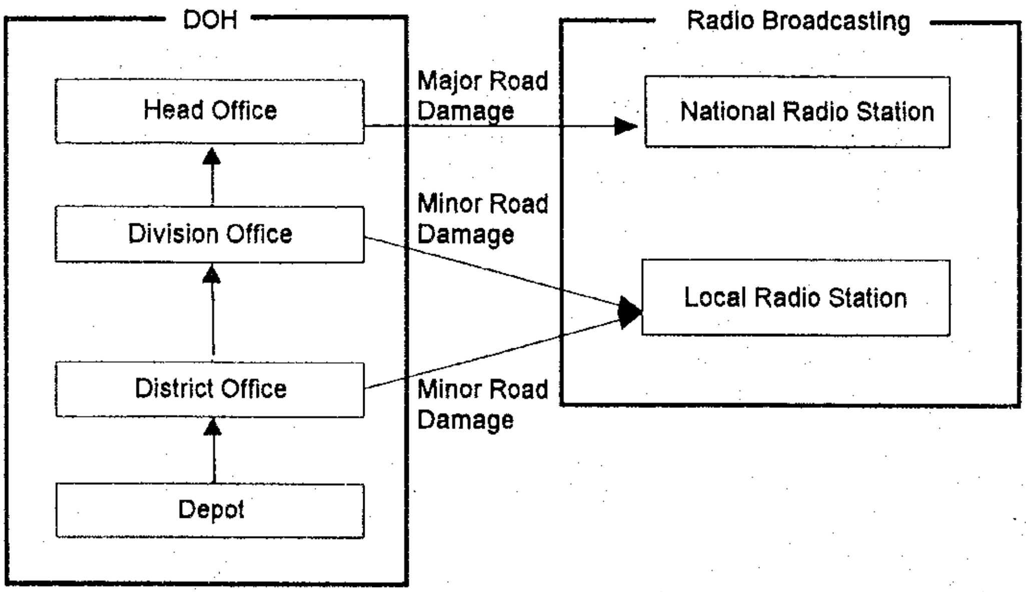

Fig.11.1.5 Transmission of Information to Radio Station

11.1.5 Urgent Repair Work

1. Organization Responsible for Urgent Repair Work

The action to be taken after damage is detected and those who are responsible for taking action are shown in Fig.11.1.6.

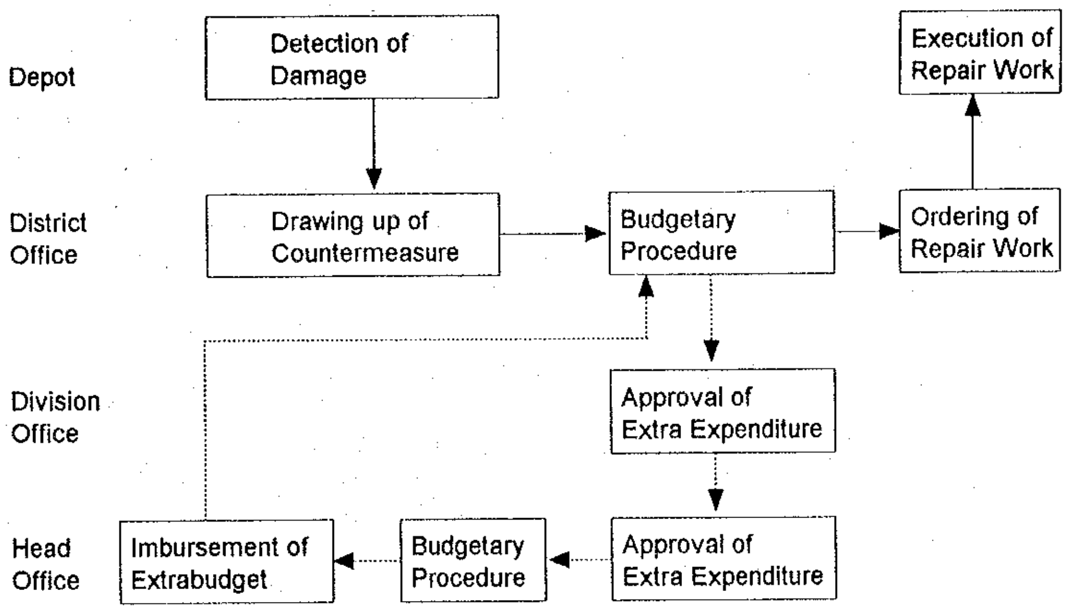

Fig.11.1.6 Action to be Taken for Urgent Repair Work

In the case of urgent repair work, both the action program and the budget for the repair work are usually decided by the district offices concerned so as not to waste time.

The main roles of each organization are as follows:

1) Depot
  - Detection of road damage via patrols
  - Execution of urgent repair work under the control of a district office

2) District Office
  - Collection of damage information from depots or citizens
  - Drawing up of countermeasures
  - Temporary procurement of budget for urgent repair work
  - Ordering depots to do repair work

3) Division Office
  - Approval of extra expenditure

4) Head Office
  - Approval of extra expenditure
  - Procurement of budget for urgent repair work
  - Disbursement of extra budget to district office

2. Materials and Equipment for Urgent Repair Work

Materials for urgent repair work are basically stored at the stockyards of district offices. A list of those materials are shown in Table 11.1.3.

Table 11.1.3 List of Major Materials to be Stored

MATERIAL NAME	TYPE / SIZE	MATERIAL NAME	TYPE / SIZE
Pipe for Culverts	Dia 0.40 - 1.00 m	Sacks for Sand Bags	
Cold Asphalt		Portland Cement	
Vinyl Sheeting		Sand	
Wire	# 8 - 10	Crushed Stone	
Rope		Gravel	

Equipment for urgent repair work are on standby at the workshop of district offices, except for Bailey bridge units. Bailey bridge girders are usually on standby at the workshop of a division office. A list of the major standby equipment is shown in Table 11.1.4.

Table 11.1.4 List of Major Standby Equipment

EQUIPMENT NAME	TYPE / SIZE	EQUIPMENT NAME	TYPE / SIZE
Motorized Grador		Truck Crane	
Tandom Roller		Back Hoe	10 - Wheel
Tyre Roller		Bulldozer	0.1 - 0.6 cum
Concrete Breaker		Pump / Hose	
Concrete Mixer		Tamper / Rammer	
Light Truck	4 - Wheel	Jack Hammer	
Medium Truck	6 - Wheel	Bailey Bridge	

In general, when some materials are not stored at the stock-yard, they are procured from other district offices or suppliers.

In the case when some equipment is not available within a particular jurisdiction, they are procured from other division offices, district offices or lease company.

3. Budgetary Procedure

The extra expenditure for urgent repair work is requested by the district office concerned and basically disbursed from the head office. However, at the time of urgent repair work, money is usually temporarily procured from the district's annual maintenance budget, in order to execute repair work rapidly. The head office then reimburses the district office later on.

11.1.6 Permanent Repair Work

The organization for permanent repair work is shown in Fig.11.1.7.

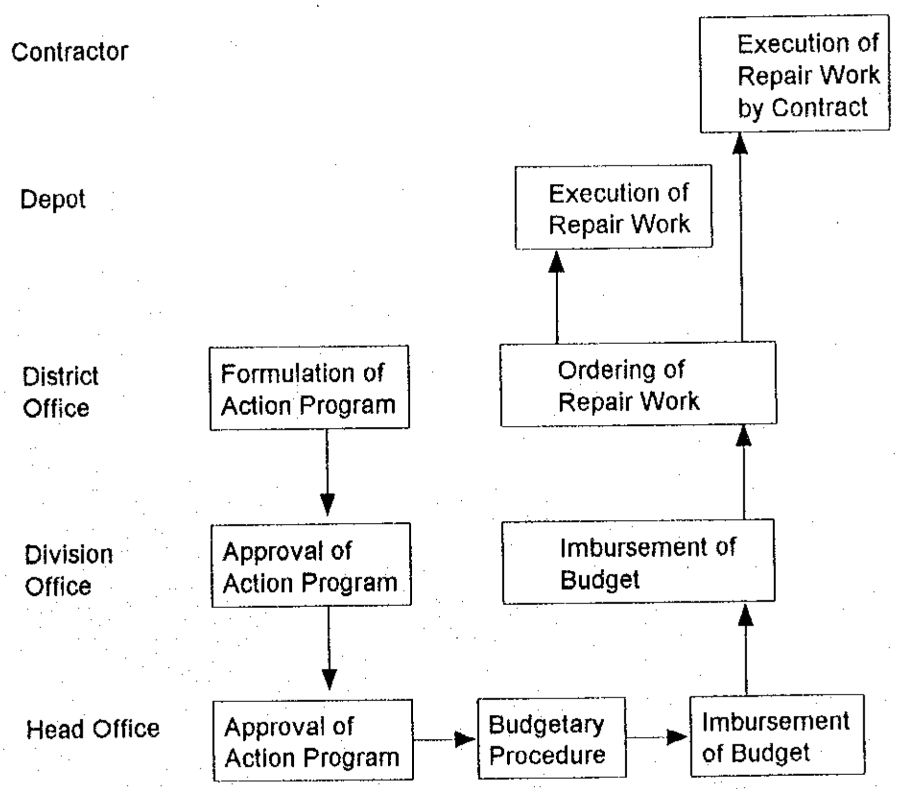

Fig.11.1.7 Organization for Permanent Repair Work

The main roles of each group are as follows:

1) Depot
   - Execution of repair work

2) District Office
   - Formulation of action program
   - Ordering depot to do repair work or arranging bids for repair work on a private basis

3) Division Office
   - Initial approval of action program
   - Disbursement of budget for repair work

4) Head Office
   - Final approval of action program
   - Procurement of budget for repair work
   - Disbursement of budget

11.2 Demands on DOH's Present Management and Operations System Restoration

11.2.1 Demands Concerning Data Collection

There were some opinion on the existing data collection system. They are summarized below.

1. Patrolling System

The number of patrol staff and cars are sufficient for daily maintenance. However, they are not sufficient in times of disaster, and thus can not grasp and inspect road damage promptly.

Moreover, patrol staff are sometimes put into a dangerous situation, and can not function efficiently as usual in a serious disaster.

2. Telecommunications Method

Telecommunications between a district office and depot patrol staff generally consists of a wireless telephone. However, in mountainous areas, wireless telephones can not function effectively. Thus, it is necessary to place a relay station in these areas.

3. Real-time Data Collection System

Real-time data collection facilities are quite effective for grasping meteorological conditions rapidly and anticipating the occurrence of road damage. Such facilities are necessary for a future management and operations system in DOH.

11.2.2 Demands Concerning Data Processing

There were some opinion on the existing data processing system. They are summarized below.

1. Internal Communication in DOH

Information on road damage should be reported promptly from a district or division office to the head office in a serious disaster. Thus, the head office can grasp the situation quickly, and indicate the appropriate countermeasures.

However, communications devices consist of only a telephone or facsimile at present. Thus, when a serious disaster affects a wide area, the head office is not able to receive information quickly due to jammed telephone circuits. Therefore, it is necessary to install an exclusive facsimile for disaster or to increase the capacity of the telephone circuits.

2. Guidelines for Countermeasure

There are occasions when patrol staff and district engineers can not promptly decide on countermeasures for road damage. Standards and a manual for small damage have been prepared by DOH. However, there is no standard or guidelines for countermeasures for serious damage. Therefore, it is necessary to prepare guideline promptly.

11.2.3 Demands Concerning Presentation of Information

Opinions on the existing presentation of information was only on information for road users.

At present, traffic signs and radio broadcasts are used to inform road users of road and traffic conditions. However, to ensure better transmission, it is necessary to develop other efficient information measures such as road information boards.

11.2.4 Demands Concerning Road Damage Restoration

The biggest issue concerning road damage repairs is budgetary restraints. The yearly budget for maintenance has been increasing year by year; however, most of that is for the routine maintenance work such as repaving, upgrading traffic facilities, etc., not for repair work.

Damages that involve the closing of a road usually require urgent repair work to reopen the road to traffic. However, most slope damage, such as slope erosion, rockfalls and small-scale landslides, tends to be left unrepaired.

11.3 Problems with the Present Management and Operations System

11.3.1 Essential Factors in the Management and Operations System

The basic objectives of the management and operations system in a disaster are:

1) to protect roads against extreme meteorological phenomena;

2) to protect road users against road damage; and

3) to maintain the smooth operation of transportation as much as possible.

The factors essential to achieve these objectives are summarized below.

1. Prompt Detection

In a disaster, late detection of unusual road and meteorological conditions can worsen road damage and increase the number of people injured. Therefore, prompt detection is an essential factor to protect the road and road users.

2. Prompt and Certain Transmission

When the data collection system detects unusual conditions promptly, the information should be transmitted to those who are responsible for deciding on countermeasures accurately and promptly.

3. Prompt and Appropriate Judgment

There are occasions when it is very difficult for information to get to the persons responsible for deciding countermeasures in the case of serious damage. The lateness of judgment can worsen existing damages. Therefore, prompt and appropriate judgment is an essential factor to protect the roads and road users.

4. Prompt and Appropriate Execution of Countermeasures

When countermeasures have been prepared for traffic control and repair work, they should be executed promptly and appropriately at the site. The lateness of execution can also worsen existing damage and result in more severe traffic restrictions. Therefore, prompt and appropriate execution of countermeasures is an essential factor to protect the roads, and road users and to maintain the transportation network.

11.3.2 Problems with the Existing Management and Operations System

1. Problems with the Organization in Charge of Management and Operations

The problem is when there is a serious disaster. As stated before, temporary organizations to cope with road damages are not considered in the ordinary organization. Therefore, when a serious disaster occurs, the execution of countermeasures, such as summoning depot staff and temporary labors and the execution of urgent repair work, is late.

2. Problems with Data Collection

There are some problems with existing data collection. They are shown below.

1) Problems with Collecting Meteorological Data

DOH has no facilities to collect the latest roadside meteorological data. DOH collects these data from the Meteorological Department after a disaster. Therefore, even if damage extends over a wide area, DOH is unable to grasp qualitatively and quantitatively real-time information on the weather.

2) Problem with the Patrol System

As stated before, the number of patrol staff and cars are not sufficient for a disaster.

In addition, patrol staff can not arrive at the site of a damaged road in a timely fashion because of the traffic confusion due to the damage. Therefore, they can not grasp the condition of road damages in general. This results in countermeasures being executed late. In addition, the patrol staff may be involved in secondary disasters.

3) Problems with Telecommunications

When there is road damages in a distant area in the mountains, it is impossible for district offices and patrol staff to communicate by wireless telephone. Therefore, district engineers are late in grasping the status of road damage and deciding on countermeasures.

3. Problems with Data Processing

There are some problems with existing data processing. They are described below.

1) Problems with Real-time Information

As stated before, meteorological data and data on river conditions, such as rainfall and water levels are collected after a disaster. Therefore, it is impossible to anticipate the worsening of a disaster. Thus, it is impossible to draw up appropriate countermeasures in a timely fashion.

2) Problems with Internal Communications

A telephone or a facsimile is used to report on disaster conditions and relay countermeasures within DOH. In a serious disaster, congested telephone circuits delay the transmission of vital information. Therefore, persons in charge are late in grasping the actual conditions of a damaged site. In addition, they are unable to create a system of support quickly enough to deal with the disaster.

4. Problems with Presentation of Information

As stated before, the number of depot staff and cars are not sufficient for a disaster. Therefore, the necessary working staff for traffic control are late in arriving at a damaged site and executing the appropriate countermeasures. This results in road users becoming confused and the situation becoming worse.

5. Problems with Road Repair Work

At present, DOH has no standards for repair work. Consequetly, it appears that there is some confusion and misunderstandings in applying restoration measures due to a lack of appropriate information. For this reason, standards or a manual for repair work is essential.

At present, when a road is damaged, each district office carries out an action program of repair work. However, there are cases when sufficient repair measures cannot be selected because of the inadequacy of the process of selection for repair measures.

11.4 Recommendations on the Improvement of the Management and Operations System

11.4.1 Organization of Management and Operations

Improvements for the existing organization are recommended below:

1. Improvement of Organization to Cope with Road Damages

In a serious disaster, lateness in organizing to cope with the disaster results in the worsening of road damage. Therefore, it is essential to organize quickly, when a serious disaster is anticipated due to severe weather conditions. From this standpoint, improvements in organization to cope with road disasters are:

1) the establishment of emergency organizations and systems by level;

2) the preparation of a manual that includes a communications network chart, those in charge, etc., so staff can communicate and execute orders accurately and promptly;

3) the execution of training for disasters based on the manual; and

4) the organization of a division or section to manage real-time information and to decide on countermeasures (see Fig. 11.4.1.).

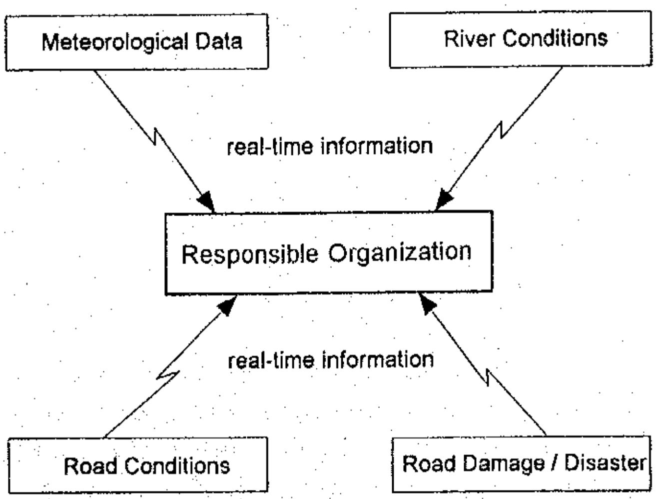

Fig.11.4.1. Flow of Real-Time Information

11.4.2 Data Collection

Recommendations to improve existing data collection methods are as follows:

1. Improvement in Meteorological Data Collections

In a disaster, DOH can not obtain up-to-date meteorological data. Therefore, it is essential to have facilities or procedures to collect meteorological data on a real-time basis. From this standpoint, improvements in collecting meteorological data are:

1)the development of a data collection system inside DOH composed of data collection facilities such as rain gauges and private telecommunications circuits; and

2)the development of a communications procedure to collect meteorological data on a real-time from the Meteorological Department.

2. Improvement in Patrolling System

The number of patrol staff and cars are not sufficient for a disaster. Therefore, it is essential to develop other systems that can detect road damage and inform it of DOH instead of patrol staff. From this standpoint, improvements would consist of:

1)formulation of a road information monitoring system that monitors roadside service, with truck drivers informing DOH of road conditions in disasters as well (see Appendix 6-2); and

2)installation of emergency telephones or signboards that indicate the section and telephone number in charge of collecting road-disaster information.

3. Improvement of Telecommunications

When patrol staff are far from a district office, it is very difficult for them to communicate with the district engineer. Therefore, it is essential to develop telecommunication measures that ensure the accurate and certain transmission of information. From this standpoint, improvements in telecommunications are:

1)the installation of relay stations for wireless telephones; and

2)the development of a private telecommunications circuit via microwaves, satellite communications, etc.

11.4.3 Data Processing

Recommendations to improve existing data processing are as follows:

1. Improvements for Processing Real-time Information

At present, meteorological data and river condition data are processed after a disaster. However, it is essential to obtain these data promptly via real-time data processing. In addition, it is essential to anticipate a future disaster so that DOH can prepare countermeasures to prevent the disaster. From this standpoint, improvements in processing real-time information are:

1)the development of a data processing system that manages real-time data and indicates the present conditions of the weather and rivers, etc.;

2)The analysis of past records on road damage for the items below in order to identify hazardous DOH road sections

- distribution of the road damage;
- relationship between road damage and meteorology; and
- potential of road damage

3)the development of a system to forecast road damage based on past meteorological and road damage records.

2.Improvement of Internal Communication Measures

In a serious disaster, congested telephone circuits delay the transmission of information. It is essential to ensure the accurate and prompt transmission of internal communications. From this standpoint, improvement in internal communications are:

1)the installation of an exclusive facsimile or telephone for disasters;

2)increasing the capacity of telephone circuits; and

3)the development of private telecommunications circuits via microwaves, satellite communications, etc.

11.4.4 Presentation of Information

Recommendations to improve the existing methods for presenting information are as follows:

1. Improvement of traffic control at a damaged site

The number of depot staff and cars are not sufficient for a disaster. Therefore, it is essential to develop other systems to deal with a damaged site promptly, so traffic control can be executed by other entities instead of depot staff. In addition, it is essential to prepare appropriate traffic control methods by damage level, as this determines the number of staff needed at a site. From this standpoint, improvements in traffic control at a damaged site are:

1)the formulation of a road information monitoring system and execution of said monitoring by having a contractor set up and take down related traffic sign;

2)entrusting a contractor with traffic management at a damaged site, by having him set up and remove traffic signs, enforce road closures, etc.;

3)preparation of a detour to have road users avoid damaged road sections; and

4)execution of road closures on hazardous road sections before road damage actually occurs, so road users will not be injured or inconvenienced.

11.4.5 Repair Work

Repair work shall be carried out step by step to alleviate budgetary restraints; namely, urgent repair work shall be executed first then temporary or permanent repair work will follow.

1) Urgent Repair Work

Urgent repair work focuses on reopening as soon as possible a road section closed to traffic due to the occurrence of road damage. Emphasis is placed on how quickly the damaged spot is passable for traffic and not on the quality of the repair work itself.

2) Temporary Repair Work

If permanent repair work is considered to be an over investment at present, temporary repair work with a lifetime of 5 or more years shall be carried out as a makeshift measure.

3) Permanent Repair Work

Permanent repair work shall be applied hen the lifetime of a temporary job is about to expire or the damaged spot is located in an important part of the road network that will produce adverse socioeconomic consequences if not permanently repaired.

11.4.6 Preventive Work

If the problem with budgetary restraints for maintenance work is solved, road damage preventive work is extremely effective for road maintenance.

Road damage prevention shall be executed in line with the two flows as shown in Fig.11.4.2. The first flow is based on the findings of route inspection, while the other flow is based on the results of a damage potential evaluation.

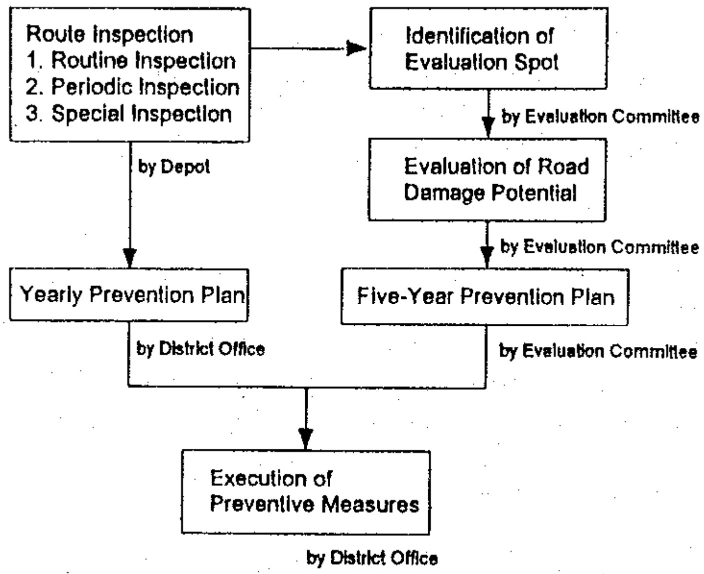

Fig.11.4.2 Flow for Road Damage Prevention

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