No.

Department of Roads
Ministry of Physical Planning & Works
Federal Democratic Republic of Nepal

BASIC DESIGN STUDY REPORT
ON
THE PROJECT
FOR CONSTRUCTION OF SINDHULI ROAD
SECTION III
IN
FEDERAL DEMOCRATIC REPUBLIC OF NEPAL

December 2008

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.

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PREFACE

In response to a request from the Government of Federal Democratic Republic of Nepal, the Government of Japan decided to conduct a basic design study on the Project for the Construction of Sindhuli Road (Section III) in Federal Democratic Republic of Nepal and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Nepal a study team from March 9 to May 28, 2008.

The team held discussions with the officials concerned of the Government of Nepal, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Nepal in order to discuss a draft basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Federal Democratic Republic of Nepal for their close cooperation extended to the teams.

December 2008

Eiji Hashimoto

Vice-President

Japan International Cooperation Agency

December 2008

Letter of Transmittal

We are pleased to submit to you the basic design study report on the project for the Construction of Sindhuli Road (Section III) in Federal Democratic Republic of Nepal.

This study was conducted by Nippon Koei Co., Ltd., under a contract to JICA, during the period from March, 2008 to December, 2008. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Nepal and formulated the most appropriate basic design for the project under Japan's Grant Aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Hideo Katagiri
Project manager,
Basic design study team on
the project for the Construction of Sindhuli Road (Section III)
in Federal Democratic Republic of Nepal
Nippon Koei Co., Ltd.

SUMMARY

1. Outline of the Country

Federal Democratic Republic of Nepal with an area of approximately 147,000 square kilometers is a landlocked Himalayan country in South West Asia. It is bordered by China in the north and by India on the remaining three sides. The capital of Nepal is Kathmandu located in the Kathmandu Valley, the size of which is about 25km from east to west and about 20km from south to north. The total population of Nepal is about 25.3 million as of July 2004/05 according to the Central Bureau of Statistics (CBS), out of which the Kathmandu Valley has about 1.76 million. Terai Plain located along India border is a major farm production area.

According to the latest data from the Ministry of Finance (MOF), Nepal's nominal GDP for the year 2005/06 is around US$7.0 billion and per-capita nominal GDP is around US$318. Primary industry including agriculture is about 40% of the GDP and sustains about 80% of Nepal's population. Secondary industry including manufacturing accounts for about 20% of the GDP, and tertiary industry including the tourist business and services comprises about 40% of the GDP.

The road sub-sector has a leading role in the national transport system in Nepal. The development of road network started from the 1950s, and has expanded its network up to 15,905km in length by 2005. However, road network development in Nepal still has a long way to go as 12 districts among 75 districts of the entire nation have still no motorble roadway at all and 15 district headquarters are not linked to the road network as of December, 2005. Especially, since there is no all-weather road in Eastern Nepal where Sindhuli Road locates, population over one million do not receive benefits of social and economic development brought by road development. Moreover, the service level of the road is insufficient as about 70% of the network is unpaved and the road network is weak in sediment-related disasters. Therefore, in order to achieve the National Plan in which poverty reduction is primarily aimed and to reduce the traffic cost from the viewpoint of the national economy, the expansion of the road network and maintaining and improvement of the existing roads are one of the main subjects in Nepal.

2. Background and Outline of the Project

The Government of Nepal (GON) prepared the First Five-Year Plan in 1956, and since then, has completed ten periodic plans. Meanwhile, the Temporary Three-Year Plan (July 2007 to July 2010) is currently being implemented.

The road system in Nepal is divided into five classes: (1) national highways, (2) feeder roads, (3) urban roads, (4) district roads and (5) village roads. Among these, the nationwide road network constitutes national highways and feeder roads, which consist of fifteen routes and five routes, respectively. These are under the jurisdiction of the Ministry of Physical Planning & Works (MOPPW) and are managed by the Department of Roads (DOR). The DOR has prepared the Master Plan for Strategic Road Network (SRN) in December 2005 in order "to contribute toward the betterment of living conditions of the people through effective, efficient, safe and reliable strategic road connectivity" and identified prioritized projects.

The issues related to the road network of Nepal are mostly attributed to Prithivi Highway. This highway, which is the only significant commercial route connecting Kathmandu to Terai area and India, is constantly in danger of being damaged due to sediment-related disasters that occur every year. Kathmandu was previously isolated for twenty days due to a sediment-related disaster caused by heavy rains in July of 1993 and as the result of that, transport of goods indispensable for residents' life including oil and perishable foods was intercepted. Unstable transportation in monsoon season has caused uncertain supply of goods in the Capital and further, disturbances and political uncertainty.

Hence, the GON expects that Sindhuli Road, which is the second major trunk road connecting Kathmandu to the Terai area and Indian boundary, will contribute to security of the safety and economic growth of Nepal. Utilizing this road will consequently shorten the travel distance and travel time, which will benefit both agricultural production transport and long-distance bus trips. Furthermore, it is expected that the shortening of travel time to Sindhuli, Ramechhap and Kavrepalanchok districts will result in the reduction of travel cost and will contribute to stable transport and industrial promotion along the road. Therefore, it is foreseen that its implementation will stimulate social and economic activities, leading to the improvement of the quality of life of local residents. DOR listed up Sindhuli Road as one of specific road projects that correspond to important routes and identified it as the prioritized highway route connecting Eastern Terai area to the Capital Kathmandu with the route number H06.

Sindhuli Road, with its total length of 160km, connects Dhulikel on the Arniko Highway (31km eastward from Kathmandu) to Bardibas on the East-West Highway crossing the Terai Plain. The Feasibility Study for the Construction of Sindhuli Road (F/S) was conducted in 1986, and this road was divided into four sections, namely, Section I (37km Bardibas – Sindhuli Bazar), Section II (39km Sindhuli Bazar – Khurkot), Section III (32km Khurkot – Nepalthok) and Section IV (50km Nepalthok – Dhulikel).

After completion of the F/S, the Aftercare Study was carried out in 1993. Construction of Sections I and IV commenced in 1996 and 1998, respectively. Construction of Section II meanwhile was implemented in 2001, and remains in progress with a scheduled completion in March, 2009.

Section III (the Project) is the last section to be implemented. Its early commencement and the overall opening of the road are highly necessitated. Thus, the GON requested the Government of Japan (GOJ) in March 2001 for grant aid assistance to support the Project. In response to the request and prior to the Basic Design Study, GOJ dispatched experts to carry out Project Formulation Study for the Project, which aims to support the local consultant in conducting the EIA. In January 2005, the GOJ then assisted the related survey works and drawing preparation. The EIA, which DOR conducted from November 2004, was approved by GON in May 2006. Based on the review of the JICA Council on Environmental and Social Considerations (the JICA Council) reported in October 2006 regarding the result of EIA submitted by GON, GOJ dispatched a Preliminary Study Mission to Nepal in February 2007. Its purpose was to examine the scale of the project and environmental impacts, and to assist the DOR in building consensus with affected residents concerning the implementation of the Project and its related resettlement issues. Consequently a draft alignment was decided.

3. Outline of Basic Design and Main Feature of Project Facilities

JICA dispatched the Basic Design Study Team (the Study Team) to Nepal for the period from 10th March 2008 to 27th May 2008. The Study Team confirmed the contents of the requested assistance and held discussions with GON. In said study, site survey and relevant document collection were conducted while the proposed alignment was examined. The alignment was agreed through public consultation before it was finalized. Furthermore, the first and second environmental assistance for DOR's EIA update were conducted wherein the necessity, social and economic effects, and validity of the Project were confirmed. After returning to Japan, the Study Team examined the plan appropriate for the requested grant aid assistance. The third environmental assistance for DOR's EIA update was dispatched from 21st July 2008 to 2nd August 2008 and the Study Team obtained interim results. The updated EIA was reported to the JICA Council on 25th August 2008. Assistance to further update the DOR's EIA was not proposed by the JICA Council, which thus confirms that the already completed EIA update, is acceptable.

JICA consequently dispatched a Basic Design Explanation Team to Nepal from 24th September 2008 to 5th October 2008 while the Minutes of Discussions, which mainly covered the results of the basic design and the recipient country's obligations, were agreed by both sides.

The facilities designed in the Study are summarized below.

Category	Item	Contents / Scale
Road	Length	36.8km
	Width	4.75m
	Pavement	Standard: Double Bituminous Surface Treatment (DBST, Base 15cm, Sub-base 15cm) Hair-pin curves: Asphalt Concrete (Surface 5cm, Binder 2 x 5cm, Sub-base 15cm)
	Design Speed	30km/hr (except Hair-pin curves)
	Cross Drainage	Box culvert: 24 nos Pipe culvert: 283 nos (including irrigation)
	Bus stop	19 nos
	Passing Place	164 nos
	Guard block	Precast concrete wall type: installed only at dangerous locations
Causeway	Width	4.75m
	Structure	Continuous box culvert
	Length	No.3: 130m (remaining Section II) No.4: 30m (remaining Section II) No.5: 50m (remaining Section II) #1: 30m #2: 190m #3: 20m #4: 50m #5: 90m #6: 40m #7: 60m #8: 70m #9: 90m

4. Construction Period and Estimated Project Cost

The detailed design including tender document preparation will take about 9 months. The construction period will be about 53 months.

The cost to be borne by the Nepalese side, separate from Japan's Grant Aid, is estimated at about NRs 93.3 million, which includes compensation of private land and houses, relocation of electrical, communicational and water supply facilities, environmental mitigation measures, environmental monitoring, measures for local residents and traffic safety training, etc.

5. Project Evaluation and Recommendations

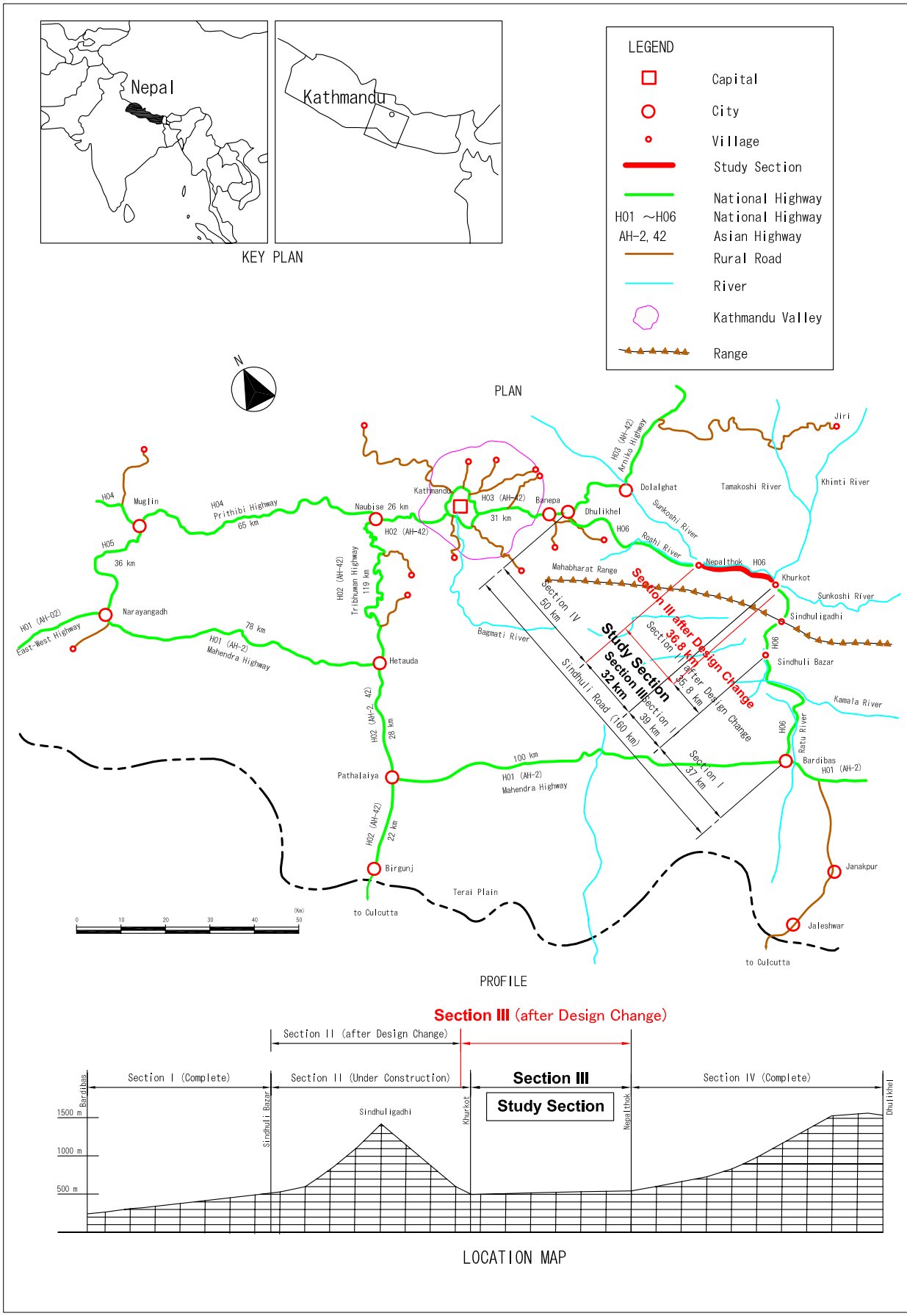
Population to receive the project benefit are estimated to be residents living along Sindhuli Road of 117 million, residents in Kathmandu Valley and Eastern Nepal of 544 million, users of bus and truck of 30 thousand per day and 10 million per year. The following benefits are expected.

Direct Impacts and Effects

- Running distance of traffic from Kathmandu to Terai Plain, will be reduced by about 140km and roundtrip of Kathmandu and Central Terai Area that requires 2 days will be able to be done in 1 day.
- Risks of interception of transportation to Kathmandu Valley will be reduced and stable supply of goods will be realized and thus, damage to capital functions will be avoided, life of 176 million citizens will become stable.
- Time for transport will be reduced and access to market and public facilities will be improved in the less developed area.

Indirect Impacts and Effects

- Farm villages will be connected to the market, and thus, cash crop farming will be promoted and regional economy will be activated along the road.
- By the opening of all-weather road in the area that has been less developed due to the civil war, the commerce, fabrication and housing industries will be developed and investment effects improved will contribute to regional development and poverty reduction.
- Travel time will be reduced, passengers will be able to enjoy safe traffic and safe getting on and off, and thus, stable supply of goods to the region will be realized. Improvement of access to public services and welfare facilities including hospital can be expected.


Nepal
Kathmandu
KEY PLAN
LEGEND
Capital
City
Village
Study Section
National Highway
H01 ～H06 National Highway
AH-2, 42 Asian Highway
Rural Road
River
Kathmandu Valley
Range
PLAN
N
Jiri
H03 (AH-42) Arniko Highway
Dolalghat
Tamakoshi River
Khimti River
Kathmandu
H03 (AH-42)
Banepa
Dhulikhel
Sunkoshi River
Roshi River
Naubise 26 km
31 km
H02 (AH-42)
H06
Nepalthok
Khurkot
Mahabharat Range
Section III after Design Change
36.8 km
Sunkoshi River
Sindhuligadhi
Section IV
50 km
Bagmati River
Study Section
Section III
32 km
Section II after Design Change
35.8 km
Sindhuli Road (160 km)
Section I
39 km
Sindhuli Bazar
Kamala River
Ratu River
Bardibas
H01 (AH-2)
Section I
37 km
100 km
H01 (AH-2)
Mahendra Highway
Pathalaiya
H02 (AH-42)
28 km
H02 (AH-42)
22 km
Birgunj
Terai Plain
to Culcutta
Janakpur
Jaleshwar
to Culcutta
H04
Muglin
H04
Prithibi Highway
65 km
H05
36 km
H01 (AH-02)
East-West Highway
Narayangadh
78 km
H01 (AH-2)
Mahendra Highway
H02 (AH-42)
Tribhuwan Highway
119 km
Hetauda
0 10 20 30 40 50 (Km)
PROFILE
Section III (after Design Change)
Section II (after Design Change)
Section I (Complete)
Section II (Under Construction)
Section III
Study Section
Section IV (Complete)
Bardibas
Sindhuli Bazar
Sindhuligadhi
Khurkot
Nepalthok
Dhulikhel
1500 m
1000 m
500 m
LOCATION MAP

Perspective View of the Sindhuli Road (Section III)

CONTENTS

Appendix

1. Member List of the Study Team
2. Study Schedule
3. List of Parties Concerned in the Recipient Country
4. Minutes of Discussions
5. Basic Design Drawings
6. Other Relevant Data

List of Figures

List of Tables

Abbreviation

AASHTO	:	American Association of State Highways and Transportation Officials
ADB	:	the Asian Development Bank
B/D	:	Basic Design
CFUG	:	Community Forest Users Group
DBST	:	Double Bituminous Surface Treatment
DDC	:	District Development Committee
DFID	:	Department for International Development
DFO	:	District Forest Office
DHM	:	Department of Hydrology and Meteorology
DOR	:	Department of Roads
DOLIDAR	:	Department of Local Infrastructure and Agricultural Roads
DWIDP	:	Department of Water Induced Disaster Prevention
EIA	:	Environmental Impact Assessment
E/N	:	Exchange of Notes
EMU	:	Environmental Management Unit
EPA	:	Environmental Protection Act
EPR	:	Environmental Protection Rules
FGD	:	Focus Group Discussion
G/A	:	Grant Agreement
GDP	:	Gross Domestic Products
GESU	:	Geo-Environment and Social Unit
GTZ	:	Deutsche Gesellschaft fur Technische Zusammenarbeit (German Technical Cooperation)
H01～H06	:	National Highway 01-06
hr	:	hour
IRC	:	Indian Road Congress
IUCN	:	International Union for Conservation of Nature and Natural Resources
JICA	:	Japan International Cooperation Agency
JIS	:	Japanese Industrial Standards
m	:	meter
m2	:	square meter
m3/s	:	cubic meter per second
MBT	:	Main Boundary Trust
MOPPW	:	Ministry of Physical Planning & Works
NRs	:	Nepal Rupee
ROW	:	Right of Way
RTO	:	Road Transportation Organization
Rs	:	India Rupee
SDC	:	Swiss Agency for Development and Cooperation
SHM	:	Stakeholders Meeting
SPAPs	:	Special Project Affected Persons
STA.	:	Station
SRN	:	Master Plan for Strategic Road Network
TCC	:	Track Construction Committee
US$	:	US Dollar
VDC	:	Village Development Committee
WHO	:	the World Health Organization

CHAPTER 1 BACKGROUND OF THE PROJECT

1.1 Background of the Project

Sindhuli Road, with its total length of 160km, connects Dhulikel on the Arniko Highway (31km eastward from Kathmandu) to Bardibas on the East-West Highway crossing the Terai Plain. The Feasibility Study for the Construction of Sindhuli Road (hereafter referred to as the F/S) was conducted in 1986, and this road was divided into four sections, namely, Section I (37km Bardibas – Sindhuli Bazar), Section II (39km Sindhuli Bazar – Khurkot), Section III (32km Khurkot – Nepalthok) and Section IV (50km Nepalthok – Dhulikel).

After completion of the F/S, the Aftercare Study was carried out in 1993. Construction of Sections I and IV commenced in 1996 and 1998, respectively. Construction of Section II meanwhile was implemented in 2001, and remains in progress with a scheduled completion in March, 2009.

The Department of Roads (hereafter referred to as the DOR) is implementing appropriate maintenance activities for nine bridges and 17 causeways of Section I, which were constructed through Japan's Grant Aid assistance, as well as for other road facilities. Thus, driving comfort and traffic volume of said section have increased. Furthermore, Section IV of which traffic volumes of motorcycles, buses and other transport vehicles for local products have also increased, has significantly contributed to the improvement of the local residents' life since its opening. As for the sections of Section II already opened to the public, bazaars have periodically been held and these have significantly stimulated the local economy.

Section III (hereafter referred to as the Project) is the last section to be implemented. Its early commencement and the overall opening of the road are highly necessitated. Thus, the Government of Federal Democratic Republic of Nepal (hereafter referred to as the GON) requested the Government of Japan (hereafter referred to as the GOJ) in March 2001 for grant aid assistance to support the Project. In response to the request and prior to the Basic Design Study, GOJ dispatched experts to carry out Project Formulation Study for the Project, which aims to support the local consultant in conducting the EIA. In January 2005, the GOJ then assisted the related survey works and drawing preparation. The EIA, which DOR conducted from November 2004, was approved by GON in May 2006. Based on the review of the JICA Council on Environmental and Social Considerations (hereafter referred to as the JICA Council) reported in October 2006 regarding the result of EIA submitted by GON, GOJ dispatched a Preliminary Study Mission to Nepal in February 2007. Its purpose was to examine the scale of the project and environmental impacts, and to assist the DOR in building consensus with affected residents concerning the implementation of the Project and its related resettlement issues. Consequently a draft alignment was decided.

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Nepal for the period from 10th March 2008 to 27th May 2008. The Study Team confirmed the contents of the requested assistance and held discussions with GON. In said study, site survey and relevant document collection were conducted while the proposed alignment was examined. The alignment was agreed through public consultation before it was finalized. Furthermore, the first and second environmental assistance for DOR's EIA update were conducted wherein the necessity, social and economic effects, and validity of the Project were confirmed. After returning to Japan, the Study Team examined the plan appropriate for the requested grant aid assistance. The third environmental assistance for DOR's EIA update was dispatched from 21st July 2008 to 2nd August 2008 and the Study Team obtained interim results. The updated EIA was reported to the JICA Council on 25th August 2008. Assistance to further update the DOR's EIA was not proposed by the JICA Council, which thus confirms that the already completed EIA update, is acceptable.

In addition, since it became clear during the site survey that a landslide zone exists, an additional survey team was dispatched from 17th August 2008 to 18th September 2008. Hence, the implementation plan, scope of the Project, and obligations of the Nepalese counterpart were then considered, and a corresponding draft report was prepared. JICA consequently dispatched a Basic Design Explanation Team to Nepal from 24th September 2008 to 5th October 2008 while the Minutes of Discussions, which mainly covered the results of the basic design and the recipient country's obligations, were agreed by both sides.

It was confirmed between GOJ and GON in March 2008 that the remaining 3.9km of Section II is to be included in the proposed project. Thus, the Project's road length was increased to 36.8km. (Total length of Section II was originally 39km, however, as a result of the sharp increase in market prices, it was anticipated that the tender price would exceed the ceiling price estimated 6 years before the tender. Thus, before the tender of Section II Phase 3, the 3.9km in length section from end point of Section II (STA.35+800 – STA.39+700) was removed from the scope of the project.)

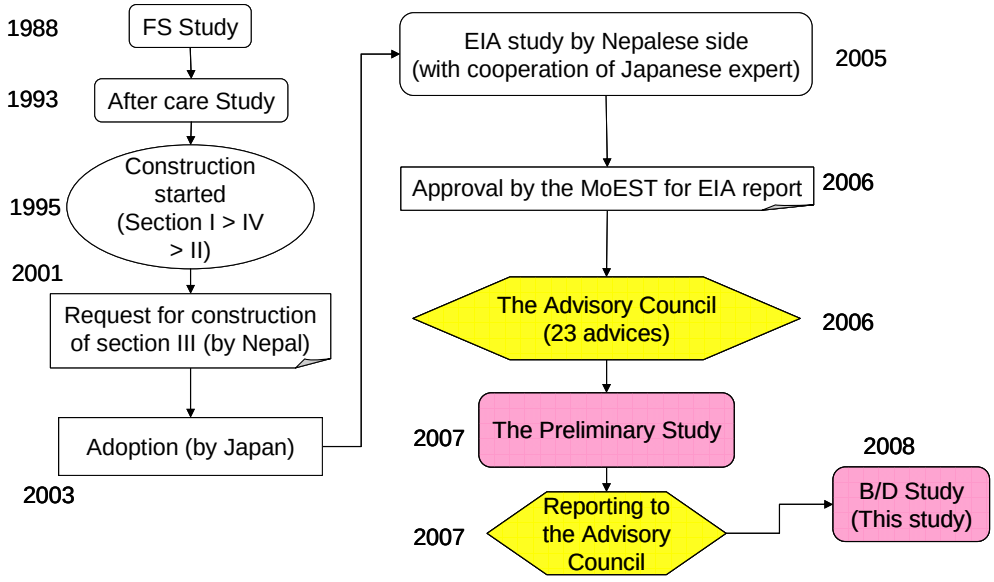
1.2 Social and Environmental Considerations

1.2.1 A Basis of Implementation of Environmental and Social Consideration Study (the system in Nepal, JICA guideline, and etc)

Sindhuli Road is classified as the National Highway; the preparation of the EIA report was required through the legal process (Environment Protection Rules, 1997). Thus, the Project was classified as category A by JICA Guideline for Environmental and Social Considerations. The reasons were; i) the EIA report through the legal process was required based on the law of Nepal, ii) a large scale resettlement and earth work were expected.

The EIA study for the Project by the Nepalese side, with the cooperation of a designated Japanese expert, was carried out in 2005. This report was approved by the Ministry of

Environment and Science Technology of the GON on May 2006. In October of 2006, JICA formed the JICA Council on Environmental and Social Considerations (the JICA Council). The JICA Council then submitted 23 advices to JICA related to the Project. Accordingly, JICA conducted the Preliminary Study in 2007, and reported its results in November and December to the JICA Council. The Preliminary Study Team and the GON agreed that the EIA report would be updated based on the final road alignment, which would be determined during the Study, while a complementary study would be carried out for updating the report. The background of this Study is shown in Figure 1-1.



Source: Study Team

Figure 1-1 Background of the Study

The implementation of Environmental and Social Consideration Study was based on these laws of Nepal; i) Environmental Protection Act (EPA), ii) National Environmental Impact Assessment Guideline, 1993, iii) Environmental Protection Rules, 1997 (EPR).

In addition, the EIA study based on the laws of Nepal was conformity with the notes of JICA guideline (2004) referring the background mentioned above.

1.2.2 Results of the Preliminary Study, Main Points of the Study

(1) Results of the Preliminary Study

The Preliminary Study Team 1) conducted meetings/discussions with the GON, 2) considered the road alignment, 3) supported the Nepalese counterpart during stakeholders meetings/simple survey, 4) confirmed the basic agreement with the residents at the stakeholders meetings and opinions from those directly affected people by the project and 5) confirmed the compensation policy of the GON.

1) Considerations for the Road Alignment

The Preliminary Study Team modified the road alignment assumed during the initial EIA study. They recommended a proposed alignment with two to three alternatives at Sadhi River, Mulkot, and Ratmate. However, the recommended alignments at Mulkot and Ratmate were not accepted during the stakeholders meetings, while that for the Sadhi River have yet to be finalized by the Study Team. Thus, these matters were considered in the Study.

2) Stakeholders Meetings, Basic Agreement for the Road Project

The Preliminary Study Team supported its Nepalese counterpart in carrying out stakeholders meetings at the preparation stage. It aimed to seek participation of residents along Section III, and give special attention to the human rights of vulnerable social groups. The Nepalese counterpart explained the project plan by presenting the proposed alignment recommended by the Study Team. They eventually confirmed basic agreement with the residents for the project implementation. The Preliminary Study Team also assisted the Nepalese counterpart in carrying out a simple survey (visiting each PAP households, explaining the project). Based on the survey, they confirmed the residents' willingness to cooperate for the project, subject to amicable settlement of compensation claims.

3) Environmental and Social Considerations

The Preliminary Study Team reviewed Nepalese laws/regulations/guidelines/principles in relation to the environmental/social considerations and the compensation issue. They have also confirmed with the GON their intentions to update the EIA report. Moreover, the Study Team validated the current status of organizational structure for the monitoring of the environment management plan, and advised on related matters.

The Study Team explained the 23 advices given by the JICA Council, and discussed countermeasures with their Nepalese counterpart. The main agreements reached were as follows:

- The Nepalese counterpart will update the EIA report based on the final alignment which would be finalized during the Study.
- The updating and revising of the EIA report should be conducted in accordance with the advices of the JICA Council, and reflect the results of the complementary study.
- The updated/revised EIA report does not need approval from the GON.

(2) Main Points of The Study

The Study Team carried out the environmental and social consideration study, in view of the following points:

- To consider and finalize the alignment,
- To support the Nepalese counterpart in carrying out stakeholders meetings,
- To reply to the 23 advices received from the JICA Council,
- To assist the Nepalese counterpart in updating/revising the EIA report, and
- To confirm and assist in the formulation of the environmental management plan.

1.2.3 Results of Main Points of the Study

(1) To Consider and Finalize Alignment

1) Considerations, Design Standards and Principles

The Study Team finalized the alignment considering the proposed alignment and alternatives of the Preliminary Study Team, and assisted the Nepalese counterpart in explaining and forming agreement with the affected residents.

The Study Team established the road design standard (design speed, width, etc.) and design principles, with due consideration to the proposed alignment of the Preliminary Study Team. Principles of the road design are shown as follows:

- Design shall be based on established road design standards,
- Mitigate social and environmental impacts such as, setting up an alignment that will minimize effects on irrigated farm lands, houses and large scale earth works,
- Determine an alignment that will not pass along steep slopes/dangerous geological areas, eventually reducing road disasters risks, and
- Consider small retaining wall and slope protection structures to minimize environmental impact and to reduce construction costs.

The alignment was divided into 19 segments. The proposed alignment of the Preliminary Study was evaluated based on aspects such as engineering and environmental and social impacts, with due consideration to natural/social conditions. The final alignment was decided after comparing the results between the Preliminary Study and the Study. It was also realized that the common construction methods were adopted instead of the suggested tunnel and the one side pier method of construction. The final alignment was explained to the residents and agreed during the stakeholders meetings.

2) Environmental and Social Issues

Environmental and social issues to be considered in each segment divided into 19 include, 1) resettlement of houses, 2) loss of land, 3) noise and vibration, 4) safety on transportation, 5)

development of the area, 6) decoupling the area, 7) decoupling the farm land, 8) irrigation network, 9) convenience, 10) impact to natural environment, and 11) landscape. These issues were evaluated by categorizing the scale of impacts into three ranks, and the alignment was designed, as a whole, based on economic efficiency, construction efficiency, disaster prevention, driving comfort, and maintenance costs. Table 1-1 shows considered issues and corresponding measures.

Table 1-1 Considerations and Measures for Alignment Design

Item	Measures
1) Farm land with high harvest	Avoid such sites with due consideration to engineering aspects and consideration of residents concerns, or if not possible, minimize impact to loss of land and facilities.
2) Houses	
3) Forest	Avoid forest area as much as possible, or minimize cutting of slopes.
4) Bo trees (utilized as gathering places usually)	Avoid these trees as much as possible. Affected branches may be cut and transported to an agreed location.
5) Religious facilities	No such facilities exist along the road alignment except for traditional resting place known as "Pati." Alignment was modified to avoid said resting place.
6) Cultural facilities	

Source: Study Team

3) Measures for Slope Collapse

To prevent slope collapse, measures were considered such as, slight slope cutting and provision of a small berm on the cut slope for heights exceeding 7 m. Bioengineering slope stabilization for earth and soil or soft rock was also considered as an option. Where such a work was found unsuitable for the unstable slope, other types of slope protection structures were adopted.

4) Adopt Major Modifications to The Alignment

The alignment needed to be modified particularly at Sadhi River, Mulkot, Ratmate, and Ghumaune Chainpur. The required modification at Ghumaune Chainpur was realized during the Study, while those for the other locations were already identified during the Preliminary Study, which was then further considered in the Study.

These alignment modifications were explained during the stakeholders meetings and concurrence of participants was confirmed. The detail of consideration on these modifications is described in sub-clause 2.2.2, Basic Plan in Chapter 2.

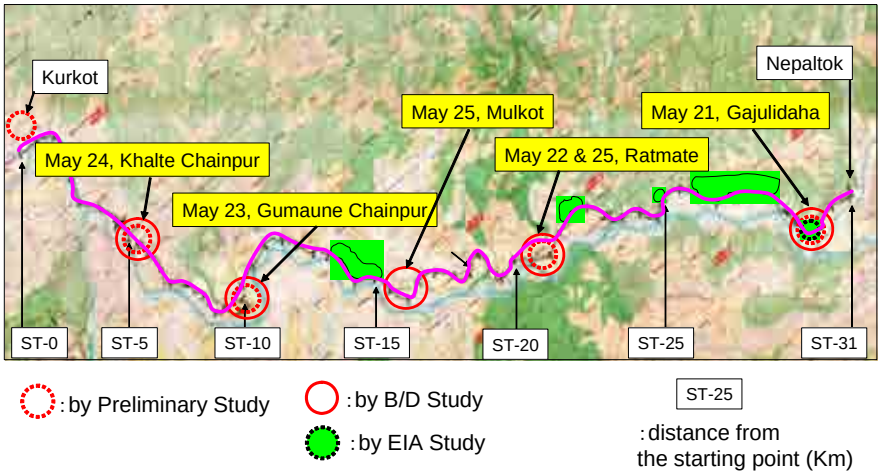
(2) To Support the Nepalese Counterpart to Carry out The Stakeholders Meetings

The Study Team has supported the Nepalese counterpart in carrying out stakeholders meetings since the preparation stage. DOR has obtained experience on this matter during the

Preliminary Study stage. The Study Team confirmed factors such as notice, venue, and agenda, for conducting the most effective meetings. Two members from the Study Team also accompanied and support them in said meetings.

1) Venue

One of the most important purposes of the stakeholders meeting was to reach mutual agreement with the residents. The selected venues were considered due to their proximity to the concerned residents situated along Section III. These venues include Gajulidaha, Ratmate, Ghumaune Chainpur, and Khalte Chainpur. The discussions during the meeting at Ratmate on 22nd of May were not completed due to bad weather condition that interrupted the sufficient explanation. The second meeting at Ratmate was held on 25th of May, simultaneous with another meeting at Mulkot. Venues of stakeholders meetings are shown in Figure 1-2.



Source: Study Team

Figure 1-2 Place and Date of Stakeholders Meetings

2) Preparation and Notice

The DOR and the Study Team discussed how to notify the residents regarding the meetings.

Notice letters for the meetings were distributed to related authorities two weeks before the scheduled dates. DOR sent letters to VDC, TCC and other related authorities, and posted announcements at major shops, gathering places, schools, etc. DOR members also personally visited the communities to verbally explain to the residents the significance of the meetings. The announcement presents the tentative alignment of Section III, the venue and the dates of the stakeholders meetings.

Source: Study Team

Figure 1-3 Sample of Sign Board to Notice the Stakeholders Meeting

The DOR initiated the following three methods of advertising the stakeholders meetings, which would appeal to women, social vulnerable groups and illiteracy people, motivating them to attend the meetings: i) oral communication with the people, ii) seek cooperation with authorities (VDC, TCC, etc), and iii) appeals of DOR for those situated along the RTO road. Oral communication is effective in Nepal, especially at Sindhuli, since the relationship between the people is very strong. The information of DOR's appeal was spread among the residents. Public notification was one of the advices from the JICA Council, where the oral communication for every village unit was seen to be most effective as information spread quickly and accurately. DOR took extensive efforts to advertise the stakeholders meetings to as many people as possible.

Letter of Notice to related authorities

The Project Manager of DOR sent letters to related authorities on 4th of May 2008. Table 1-2 shows the list of recipients.

Table 1-2 List of Receivers of Letter of Notice

Offices of Sindhuli District	VDCs	Community Authorities
- District Administration Office, Sindhuli	- Kuseswor Dumja V.D.C, Sindhuli	- Panchakanya Community Forest, Sindhuli
- District Development Committee, Sindhuli	- Jhagajholi Ratmate V.D.C, Sindhuli	- Sahasdhara Forest, Sindhuli
- District Forest Office, Sindhuli	- Purano Jhagajholi V.D.C, Sindhuli	- Sike Forest, Sindhuli
- District Land Registration Office, Sindhuli	- Sitalpati V.D.C, Sindhuli	
- District Survey Office, Sindhuli	- Majhuwa V.D.C, Sindhuli	
- District Health Office, Sindhuli	- Bhimeswor V.D.C, Sindhuli	
- District Agriculture Office, Sindhuli		
- District Water Supply Office, Sindhuli		
- Irrigation Division Office, Sindhuli		

Source: Study Team

Agenda

The DOR and the Study Team discussed the meeting agenda before the stakeholders meetings subsequently, DOR conducted the meetings in accordance with the agenda.

Meeting agenda are as follows:

i) Opening speech

Address from DOR to express gratitude to the participants; DOR's explanation of the purpose and main concerns of the meeting

ii) Explanation of the Sindhuli Road Project

DOR explained the current conditions of the project, the positive/negative impacts caused by the road construction at section III, and the corresponding mitigation measures.

iii) Background and details of the alignment design, principles of the project, design policy

The Study Team explained these items related to the road design. The explanation conducted by the expert who carried out the design was expected to provide the participants with deeper understanding.

iv) Interaction with participants

Participants voiced their opinions, while DOR responded accordingly. The Study Team assisted in explaining the engineering aspects, when necessary.

v) Participants confirmation of their concurrence to the alignment

Agreement of participants was confirmed after all programs above were completed.

vi) Focus group discussion

An interaction was initiated between the Study Team and some local groups (women's group at Gajulidaha / Ghumaune Chainpur / Khalte Chainpur, and low income group at Khalte Chainpur).

3) Results of Stakeholders Meetings

Participants

The number and ratio of the participants classified by gender, occupation, and caste (social status) are shown in Table 1-3.

The total number of participants was 623 (504 men and 119 women). About 20% of the participants were female while about 80% consist of farmers. About 47% of the participants belong to the high caste, 39% middle caste and 14% were from the low caste. The ratio of female participants during the initial EIA Study was only about 10%, which increased in this study judging from the ratio of females who participated in the meeting.

Table 1-3 Number of Participants of Stakeholders Meetings at Each Venue

Classification		Gajulidaha	Ratmate Bazar	Ghumaune Chainpur	Khalte Chainpur	Mulkot	Subtotal	Ratmate (Second)	Total
Sex	Male	48	123	59	105	71	406	98	504
	Female	21	15	30	31	20	117	2	119
	Total	69	138	89	136	91	523	100	623
Occupation	Farming	56	94	80	111	79	420	76	496
	Service + Farming	1	0	0	0	0	1	0	1
	Teacher	3	12	5	12	5	37	8	45
	Student	3	8	2	2	6	21	6	27
	Business	1	14	2	4	0	21	4	25
	Others	5	10	0	7	1	23	6	29
	Total	69	138	89	136	91	523	100	623
Caste	Upper	38	54	61	56	31	240	55	295
	Middle	24	77	22	35	52	210	33	243
	Low	7	7	6	45	8	73	12	85
	Total	69	138	89	136	91	523	100	623

Source: Study Team

Main opinions from the participants and replies from DOR

The major comments from the participants focused on compensation and requests for change of alignment to prevent loss of property. They also queried on employment opportunities (labor for construction) and the causeway structure. Furthermore, some people also queried on issues not related to the road project such as irrigation facilities, countermeasures for river disasters, and educational facilities.

The DOR proposed the consideration of the market price for compensation, special concerning on special PAPs (SPAPs), and a sub-committee system that would raise the people's concerns to the compensation fixation committee (main committee). The Study Team explained the consequences of alignment modifications based on engineering aspects.

Table 1-4 Major Opinions by the Participants and Answers by DOR and Study Team

Item	Opinions/requests by participants	Answers by DOR and Study Team
Compensation	- To have enough compensation, or compensation market price basis - To refer people's opinions to the compensation fixation committee	- Consideration of the market price and DOR's requests for certificate of real dealing. - Consideration SPAPs - To develop a sub-committee, forming a system to raise people's opinions to the main committee.
Alignment	- To change the alignment, and prevent the farm land or houses (individual opinion)	Study Team explained; - The alignment has been defined based on engineering considerations. - The reasons/details for changing the alignment from the previous one were explained.
Employment	- To increase the capacity employments of labors - Employment for women and old persons	- Consideration of PAPs regarding the employment of labors (but final decision depend on the contractor) - Consideration of prior employment of PAPs for maintenance of the road after construction (but the number of employment was limited)
Measure for flood	- Request of permanent bridge instead of temporary bridge where stones flow on it	Study Team explained; - The causeway structure design was planned as a permanent facility.
Others	- Irrigation facility, measures for flood by the big river, ie, Sunkoshi River, educational facility	- These requests were out of the scope of the road project. - The highly demanded need such as irrigation would be requested to the GON.

Source: Study Team

Focus Group Discussion

Focus group discussions were held at Gajulidaha, Ghumaune Chainpur, and Khalte Chainpur following interaction with the participants. The target groups include women's group (at three places) and low income group at Khalte Chainpur.

The concerns of the focus group discussion were social disharmony/other influences after the opening of the whole Sindhuli Road, women's rights for receiving compensation, etc.

The local residents at Sindhuli area have very strong family ties and relationships with their village. They have higher consciousness on equal rights for both sexes than what was earlier anticipated. In fact, most of them insisted on the need to discuss first with their family, matters concerning handling of compensation money and that every husband should never use it for himself alone.

Photo 1-1 Focus Group Discussion with Women Group at Gajulidaha

Photo 1-2 Focus Group Discussion with Women Group at Ghumaune Chainpur

Photo 1-3 Focus Group Discussion with Women Group at Khalte Chainpur

Photo 1-4 Focus Group Discussion with Low Income Group at Khalte Chainpur

(3) To Reply to The 23 Advices by The JICA Council

The main contents are:

1) Update/revise the EIA report (No.2)
2) Confirmation of influence on wildlife (No.3)
3) Compensation planting (No.4)
4) Items related to compensation (No.5, 11, and 12)
5) Environmental management plan (No.17, 21, 22, and 23)

1) Update/revise the EIA report (Advice No.2)

The EIA report which was carried out and approved by the Nepalese counterpart and the GON, respectively, was updated and revised based on the final alignment established during the stakeholders meetings. It was also updated considering the results of the complementary studies. The main points of updates/revisions are shown in Table 1-5.

Table 1-5 Updated/Revised Points and Contents of the EIA Report

Chapter	Updated/revised contents
Chapter. I Introduction	The background, purpose, and methodologies of update/revise work were added.
Chapter. II Project Description	-none
Chapter. III Policies, Legislation and Guidelines	- Additional descriptions into 3.1.2 and 3.2.3 - These chapters are added; 3.2.6 Land Acquisition Guidelines 1989 3.2.7 Land Reform Act 1964 3.2.8 Local Self-Governance Act 1988 and Local Self-Governance Rule 1999 3.2.9 Land Revenue Act 1977 3.2.10 Child-Related Act 1993 and Child Labour Act 2001 3.3 Environmental Standards
Chapter. IV Exising Environmental Condition	- Updating the data of Tables - Additional descriptions such as achievement of compensation plantation, prospect of planted trees for growing, results of sign survey (initial EIA Study), identification of the rare species, sensitive areas distribution (4.2.1.2, 4.2.1.3, 4.2.2.1, 4.2.3, 4.2.4) - Additional descriptions with regard to schools, hospitals, social features and cooperation with NGOs, position of religious/cultural facilities (4.3.1.14, 4.2.1.17, 4.3.1.19)
Chapter. V Consensus Building	- This new chapter was added to sort out the results of stakeholders meetings not only for this time but also previous meetings.
Chapter. VI Alternative Analysis	- The data of alignment by the Study was added into the comparison table (Table 6.1)
Chapter. VII Environmental Impacts and Mitigation Measures	- Re-evaluate all items, showing the evaluation clearly - Additional descriptions with regard to road construction impact on the forests, prospect of forest degradation triggered road construction (7.2.2.1 (i)、7.2.2.2 (iii)), land acquisition procedure, tenant farmer's right, sub-committee with regard to compensation fixation committee (7.2.3.1 (i)) - Update the data of amount of the land/houses, etc. - Update the calculation of Economic Valuation of the Impact - Additional description (due to Project implementation) on Table 7.17, (due to Project without mitigation measure) on Table 7.18 - Fixing discrepancy between description and Table 7.17, 7.18 - 7.5 Evaluation of mitigation measures (Table7.19) was added
Chapter. VIII Environmental Management Plan	- Criteria for sorting out the mitigation measures (8.2.1) - The items in Table 8.1 was sorted out - Responsibilities on monitoring implementation structure and budget were clarified, description of inter ministerial monitoring team was deleted
Chapter. IX Conclusion and Recommendation	- The project cost was referred

Source: Study Team

2) Confirmation of influences on wildlife (Advice No.3)

Methodology

The GON and the Study Team discussed the methodologies for the complementary studies. Both parties agreed that the studies would be carried out through examination of literatures and interviews of some specialists in Nepal.

Specified rare species

There are several lists that specify the rare species namely, National Parks and Wildlife Conservation Act 1973, CITES Appendices, and IUCN Red list. Rare species that are possibly in existence in the project site were identified in the EIA report based on these mentioned protected species lists.

Detailed check on the EIA report

The DOR set up a team to update the EIA report. The team consists of a leader (concurrent Project Manager of Sindhuli Road Project), a road engineer, a specialist for natural environment, and a specialist for social environment. The natural environment specialist covered the issues on wildlife.

The list of species in the initial EIA report was obtained through interaction with the local people. Simultaneously, field verification surveys were also conducted. Results of the detailed check of the initial EIA study revealed that no wildlife and nesting places exist in the project site, as verified during the field verification survey. Result of the field verification survey is presented in the methodologies chapter of the initial EIA report.

However, it was found that a plant called Sal (Scientific name: *Shore Robusta*) the only plant species identified as rare, still exists. Another plant scientifically known as *Acacia Catechu* was declared extinct in 2007 in Nepal, but remains in the IUCN Red List. Both species were verified commonly found in the project site particularly in the forest area. The contents in the updated EIA report were accordingly revised.

Thus, the impact of the road construction on the rare species was evaluated as insignificant.

3) Compensation planting (Advice No.4)

Prospect of planted trees for growing

The updated EIA report indicates that the planted trees could grow well due to local weather condition and the technical ability of the Community Forest Users Groups (CFUG) who have enough experiences in the forestry field. The Study Team also confirmed the background of the CFUG's planting techniques, potential of growing the trees in the field, the achievements of planting in Sections II and IV. The growth of the planted trees was generally evaluated as good.

Possibility of road improvement triggering further forest destruction

If anything, related forest destructions in Nepal due to road construction are caused by labors' destructive timber deforestation to collect fuel. Therefore, countermeasures for these issues, such as implementation of the accommodation of the labors, are included in the specifications of the road construction, including the incurred costs as per construction estimation. Hence, it is expected that the possibility of forest destruction caused by the Sindhuli Road construction project would be minimal.

Impact of the planting on the slopes on the natural environment of surrounding area

The species used in slope protection include native species in the project area, thatch grass,

silver grass, lawn grass, and shrub. The impact on the natural environment due to the planting on the slopes was evaluated as insignificant.

4) Items related to compensation (Advice No.5, 11, 12, and 13)

Reconfirmation of compensation process

The resettlement plan and procedure for compensation in Nepal were confirmed in the Preliminary Study, and further reconfirmed in this Study. The guideline "Environmental & Social Management Framework", which was approved by the GON in 26th of June 2007, shows details of the compensation procedure, responsible authorities, terms, and law basis, specifically in Chapter 3-9, Table 3.1, which was added to the updated EIA report.

Confirmation of the principles of the GON on compensation

The DOR proposed three points as measures for the compensation process as follows, and confirmed agreement with the residents at the stakeholders meetings.

- First point: Submission of the certification of land trade by the people, and it should be used for considering the market price for the compensation.
- Second point: Forming the sub-committee of the compensation fixing committee (main committee). The sub-committee would be formed by the representatives of Wards and project office members, and it would submit the opinions to the main committee.
- Third point: Substantial solution plan for the SPAPs.

Consideration of the PAPs who will lose most of their income

The DOR informed that the number of tenant farmers without own land was ten households or below. This number will be specified during the compensation procedure. The tenant farmers with official contract between the land owners can receive 50% compensation. This is provided by the Land Reform Act of Nepal. This management has been taken at the previous construction section; the number of tenant farmers in Section I was zero, one in Section II, and 12 in Section IV (by DOR).

The DOR proposed the countermeasures mentioned below for the SPAPs;

- The compensation for the SPAPs who would lose the most of income should be considered higher than the PAPs.
- The SPAPs will be given priority for employment as labors, although the final decision of the employment will be decided by the contractor.
- The SPAPs will be given priority for employment as staff members for the road maintenance after opening. However, the number is limited.

Women's opinions on right to compensation

The local residents in the project area have deep understanding of equal rights for both sexes. As a major opinion, they mentioned that they should first discuss the utilization of the compensation with family. It was evaluated that the risk of wasting the compensation money by a head of household would be low. The DOR explained this issue at the stakeholders meetings in the previous studies, and how their activities will seem to be effective. In addition, the DOR will take necessary effort to continue to request female residents to be present at the time of the payment.

Consideration of the absentee land owners

With regards to the results of the Preliminary Study, the number of absentee land owners on the tentative alignment was four households. They determined three absentee land owners and confirmed their opinions whether they could cooperate with the project under an appropriate compensation. The number of absentee land owners on the final alignment will be determined during the compensation procedure. If the absentee owners could not be determined, they would be sought through public announcements. Nevertheless, construction will commence even if it could not be determined. The owner identified during the construction will be able to receive the compensation.

5) Environmental and social management plan (No.17, 21, 22, and 23)

Sorting out the mitigation measures

The mitigation measures were sorted out according to three criteria as follows;

i) Measures to mitigate impact evaluated as significant or very significant
ii) Adoption of measures is mandatory by Law/Guidelines in Nepal
iii) Measures that are part of civil engineering and construction supervision

Implementation structure of monitoring

The Geo-Environment and Social Unit (GESU) of DOR carries out the environmental monitoring of the road projects. The discussion between GESU and the Sindhuli Road project office was held during this Study, and the monitoring implementation structure of Sindhuli Road project was confirmed as per Table 1-6.

Table 1-6 Classification of Implementation Structure of Monitoring by Each Stage

Stage	Project office	EMU	GEU	MoEST
During construction	Submission of the monitoring report to the GoN	Established in the project office, and have responsibilities for monitoring implementation	Taking site observation based on the monitoring report for 6 months each, and leads EMU if necessary.	-
One year within completion of construction	-	-	Implementation of the monitoring	-
Five years within completion of construction	-	-	Implementation of the monitoring, and evaluate if further monitoring would be necessary.	-
After two years from completion of construction	-	-	-	Implementation of auditing was defined by the Environmental Protection Rule

EMU: Environmental Management Unit, GEU: Geo-Environment and Social Unit, MoEST: Ministry of Environment, Science and Technology.
Source: Study Team

The budget issue was also confirmed during the discussion. The activity budget of EMU will be provided from the project budget, and GESU has its own budget with regard to the implementation of the monitoring.

Environmental standards

The environmental standards for air pollution have been established in Nepal. (This however remains tentative since it is still being revised at this time). Moreover, the environmental standards for drinking water are based on the standards of the World Health Organization (WHO). Aside from this, there are no other local standards in Nepal.

The environmental standards for air pollution and drinking water were reported in the updated EIA report. In addition, the questions such as “how the items of air pollution and noise were considered?” and “If you considered them as important items” were raised. The Study Team replied to these questions as follows:

- The alignment was divided into 19 segments. Nine social environmental issues were considered namely, house resettlement, loss of land, noise and vibration, safety of traffic, development of the area, decoupling the farmlands, and resettlements of irrigation facilities, utilities.
- The proposed alignment was evaluated based on the considerations above. In case the issue is significant, the alignment will be studied again subject to some considerations including limitations in topographic properties (control points, alignment of ahead and follows), impact on the natural environment, economic efficiency, construction efficiency, safety against disasters, driving comfort, future maintenance of the road, and landscape

features.

- The mitigation measures during construction are: i) construction vehicles to operate on low speed, ii) utilization of the low noise/vibration-type generator, iii) initiate spraying of water to minimize induced air dust. These mitigation measures are included in the construction specifications, and cost estimates.

1.2.4 Overview of Environmental and Social Considerations of the Study

These points were evaluated for confirmation based on the results of the Study.

- Finalizing the road alignment
- Concurrence of the residents regarding the alignment and the procedure and principle of compensation
- Commencement of related works to determine the right of way (ROW) of the PAPs
- The directly affected people will cooperate in the project implementation, subject to acceptable compensation
- Completion of the update/revisions to the EIA report and its distribution to concerned authorities
- Sorting out the proper mitigation measures, efficiency of the measures, and implementation structure on monitoring

The necessary confirmations above were finally completed.

As a conclusion, the subsequent stage of the proposed Sindhuli Road Project can be initiated considering related environmental and social aspects.

1.3 Survey and Monitoring for Landslide in Mulkot Area

1.3.1 Objectives of the Survey and Monitoring

In the site survey of the Study, it was found that quite a number of landslides and collapses had occurred widely in the Mulkot area (STA.12 – STA.17+300). Since there is a possibility that this area could be a significant obstacle for the Project, detailed survey and monitoring, including installation of necessary equipment, was conducted in order to utilize information on the landslides in the detailed design, construction and maintenance stages of the Project.

(1) Scope of the Survey

Major scope of the survey was as follows:

- To understand the situation of the landslide distribution of bedrock;
- To know the thickness of colluvial deposits on the lower slopes;
- To know the movement of mass soil, groundwater level fluctuations and recorded results

of tiltmeter in the area.

Survey Items

- Topographic survey: prepare cross sections of large-scale collapse for landslide analysis
- Geological survey: conduct mechanical boring to grasp the geological situation and install equipment for estimation of sliding surface
- Monitoring: monitor continually the changes of results recorded by installed equipment

(2) Survey Works

Survey items conducted with corresponding quantities are shown in Table 1-7. Locations of the survey works are likewise shown in Figure 1-4.

Table 1-7 Survey Items and Quantity Conducted

Item	Category	Description	Unit	Quantity	Remarks
Topo. survey	Topo. survey	Cross-sectional survey	m	1,200	
		Drawing preparation	sections	3	
Geo. survey	Mechanical boring	Soil	m	43.85	total of 3 holes
		Rock	m	26.65	total of 3 holes
		Total	m	70.5	total of 3 holes
	Equipment installation	Pipe with strain gauge	m	65	total of 3 holes
Monitoring	Equipment installation	Moving pile	nos	20	
		Case for strain gauge	locations	3	
		Case for tiltmeter	locations	12	
		Monitoring hut	nos	1	
		Rainfall gauge	nos	1	
		Tiltmeter	nos	24	
		Foundation for tiltmeter	nos	12	
		Guard fence	nos	12	
	Monitoring	Moving pile	times	3	20 locations
		Strain gauge	times	21	3 holes x 7 times
		Tiltmeter	times	84	12 nos x 7 times
		Ground water level	times	21	3 holes x 7 times

Source: Study Team

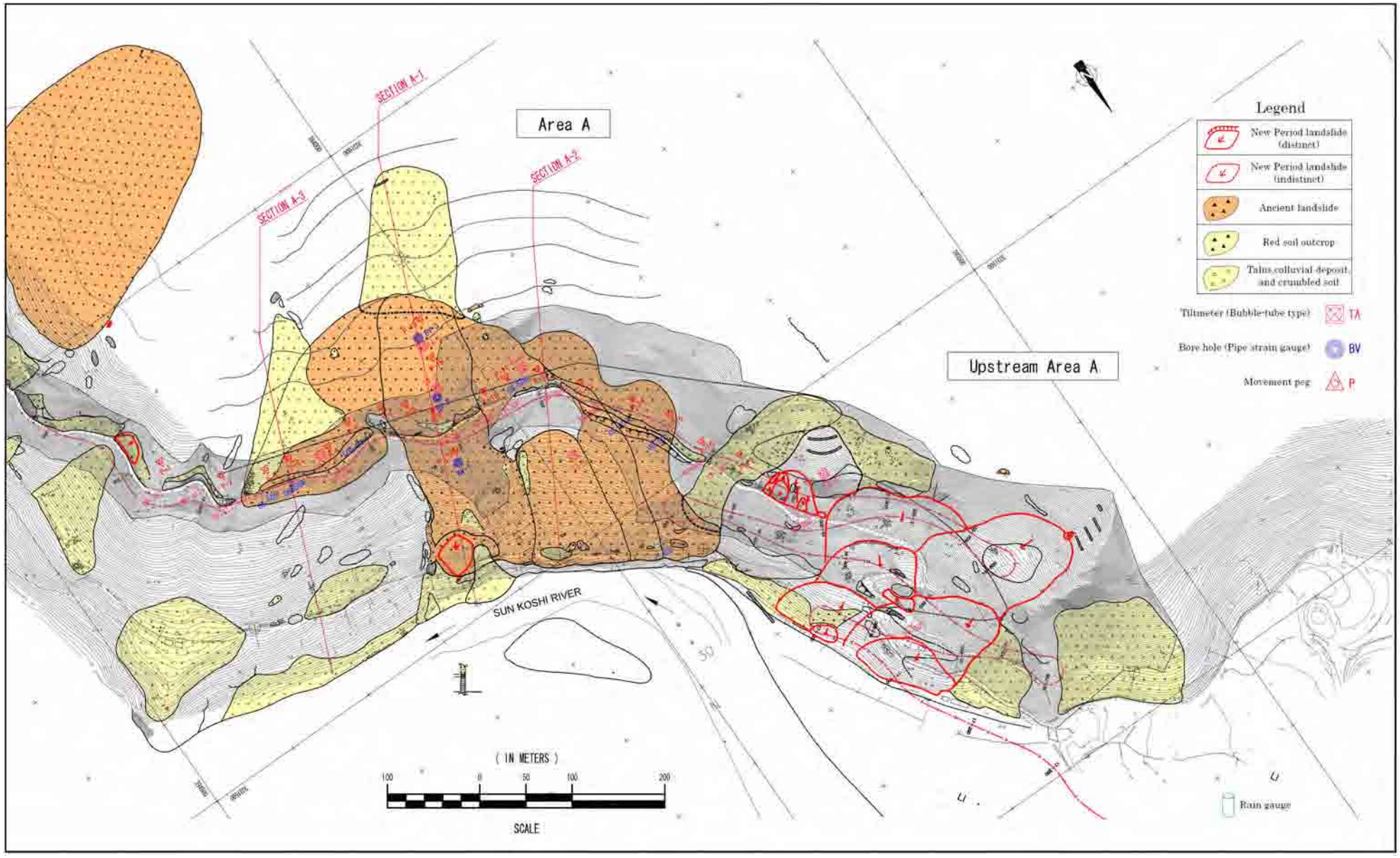


Figure 1-4 Location Map (1/2)

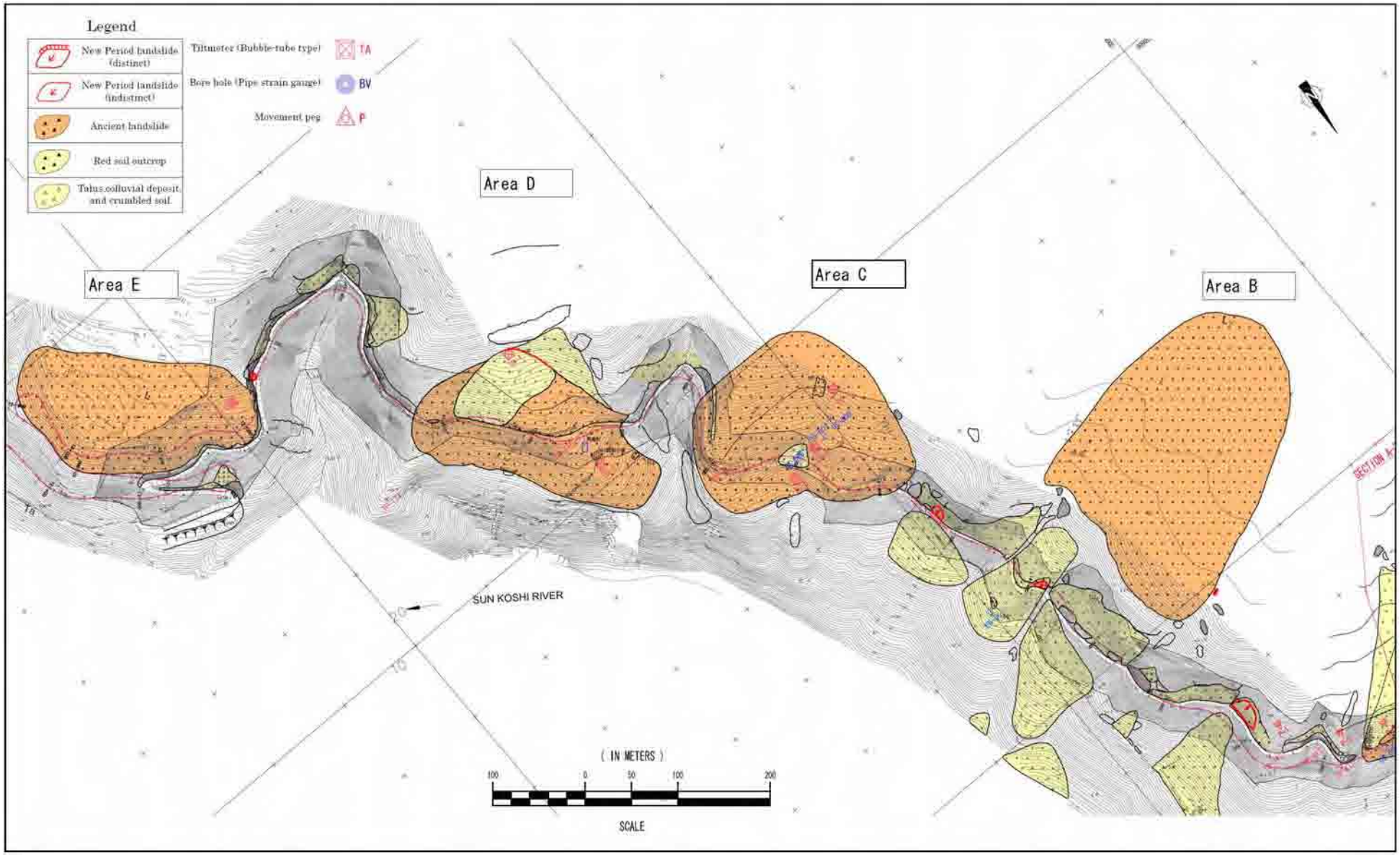


Figure 1-4 Location Map (2/2)

1.3.2 Results of the Study

(1) Description of the Areas

The following 6 areas were defined based on the distribution situation of unstable slopes, including landslide areas.

1) Upstream of Area A (STA.15+400 – STA.17+200)

Comparatively new landslides are distributed.

2) Area A (STA.14+800 – STA.15+400)

Old landslide deposits are distributed widely in the area with the road. Although any sign of complete landslide failure was not observed at present, a large-scale collapse occurred at the lower slope facing Sunkoshi River recently.

3) Area B (STA.14+300 – STA.14+600)

Old landslide deposits are distributed widely at the upper area of the road. Although no failure indication of a complete landslide was observed at present, the surface of the mountain side slope of the road that corresponds to a lower part of the landslide has become unstable.

4) Area C (STA.13+900 – STA.14+300)

Old landslide deposits are distributed in the area with the road. Although a sign of failure of a complete landslide was not observed at present, a part of secondary deposits has become unstable.

5) Area D (STA.13+500 – STA.13+900)

Old landslide deposits are distributed in the area with the road. There was no sign of failure of an entire landslide observed at present.

6) Area E (STA.12+400 – STA.13+300)

Old landslide deposits are distributed in the area along the road. Although there was not any sign of failure of landslide observed at present, some parts of the road slope for construction have collapsed.

(2) Geological Conditions of Base Rock

The base rock of the Project site consists of sedimentary rocks (sandstone and mudstone) of the Kuncha layer of lower Nawakot layers of Paleozoic Era. The rock has suffered weak metamorphism and takes on schistose.

The strike and the inclination of the schistosity plane are N10-30W - 20-40W in upstream

Area A and Area A and N10-55E – 40-50NW in Area B, C, D and E.

(3) Identification of Unstable Slopes and Distributing Situation

1) Ancient Landslide

Ancient landslide is a slope where soil and sand that originates from the landslide in the old times had piled up. The clod is distributed within the range from about 800m above sea level to the present riverbed +16m.

The deposit is fine-grained gravel including the matrix that consists of the silt or the sand of a reddish brown or a dark blue gray. There is a portion where the collapse has been generated on the riverside and on slopes. However, any sign that total landslide deposits widely distributed were made unstable was not seen. It is concluded that these ancient landslides had greatly moved in the past, but had stabilized after that.

2) New Period Landslide

New period landslides are distributed mainly in upstream area A. These are distributed within the range of 200m in width and 250m in depth. It is thought that the landslides consist of two or more movement units, and the scale of an individual unit is not large (About 100m in maximum width). The landslide still continues to slide slowly. The detritus having originated from the movement of landslide clod extends in the slope. Moreover, the cutting slope of the road for construction is unstable in several places, and small collapses and push-outs are seen.

3) Collapsed Area

One of the most typical natural failures is the collapsed ground found under the A-1 traverse line of Area A. The scale of the collapse reaches 80m in width and 50m in depth, and the soil piling up reaches to the Sunkoshi River riverbed widely. Additionally, slope collapse of various types has been generated along the cutting slope on the road for construction. These collapses were caused by artificial cutting and are small-scale excluding the collapse under the A-1 traverse line of Area A (Only about 2-3m in maximum depth).

4) Loosened Rock Slope

The bedrock loosens due to creep and toppling, etc., and are unstable. The end of such a part could be collapsed ground. In the road construction, there is a possibility to become unstable by cutting lower part of the slope.

5) Talus and Colluvial Deposit

The following soil is defined as a talus and a colluvial deposit in the Project.

- Soil that piled up in a heap under a steep rock slope. It is formed mainly by falling rocks and collapse.
- Soil that piled up in the vicinity of valley geographical features of exit (range where inclination becomes loose) in loose inclination. It is formed mainly by collapse and mud flow.
- Deposits by which original rock structures become indistinct because of the progressive loosening of bedrock.

The above-mentioned deposits are distributed everywhere, although small-scale and the distribution depths are often about 5m or less.

(4) Schematic Cross-Sections showing Geological Condition

Schematic cross-sections prepared based on the site investigation and boring survey are shown in Figure 1-5. The boring survey was conducted at A-1 section, and thus, A-2 section and A-3 section was prepared referring to A-1 section.

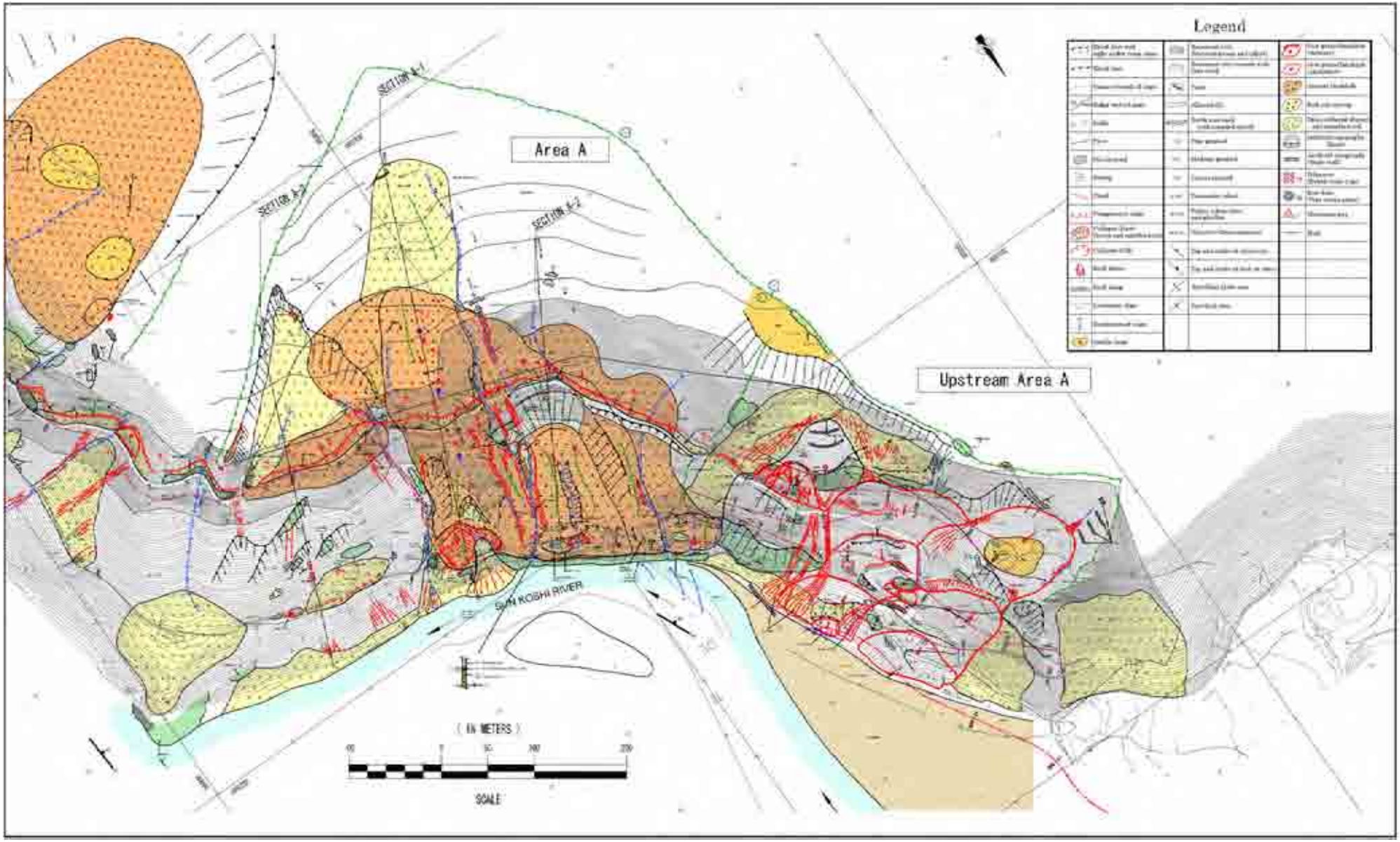


Figure 1-5 Geological Conditions of the Areas (1/2)

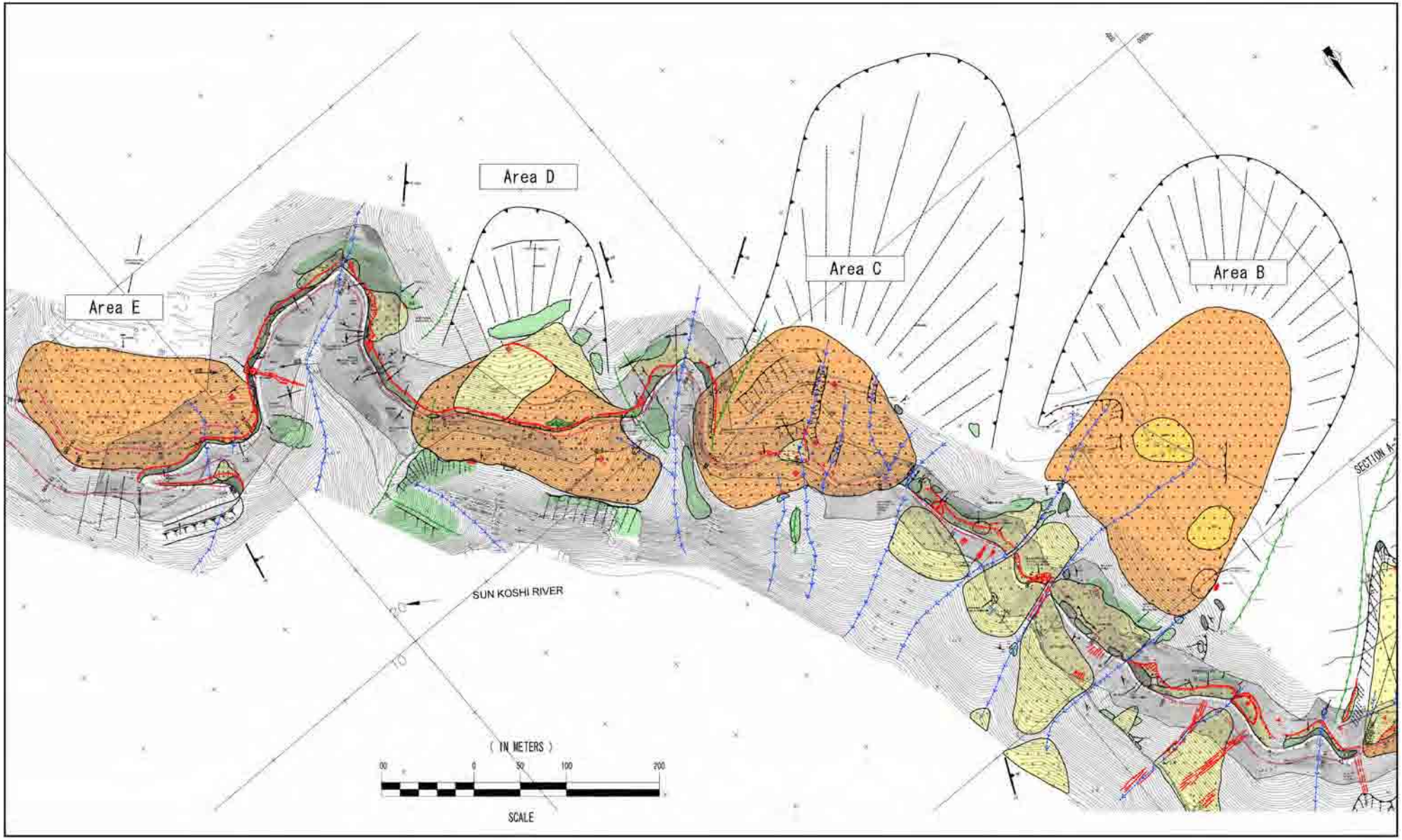


Figure 1-5 Geological Conditions of the Areas (2/2)

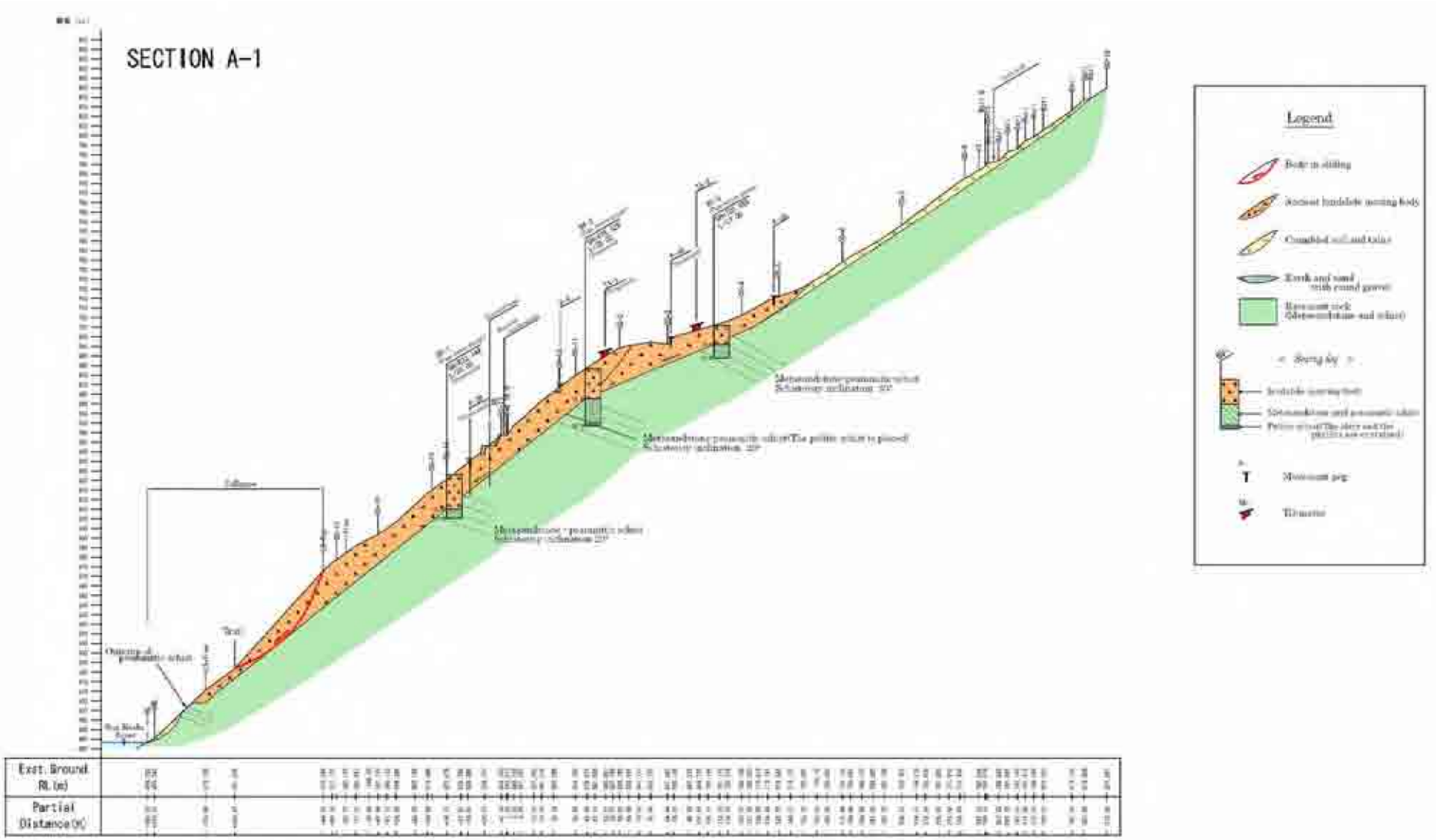


Figure 1-6 Schematic Cross-Section (1/3)

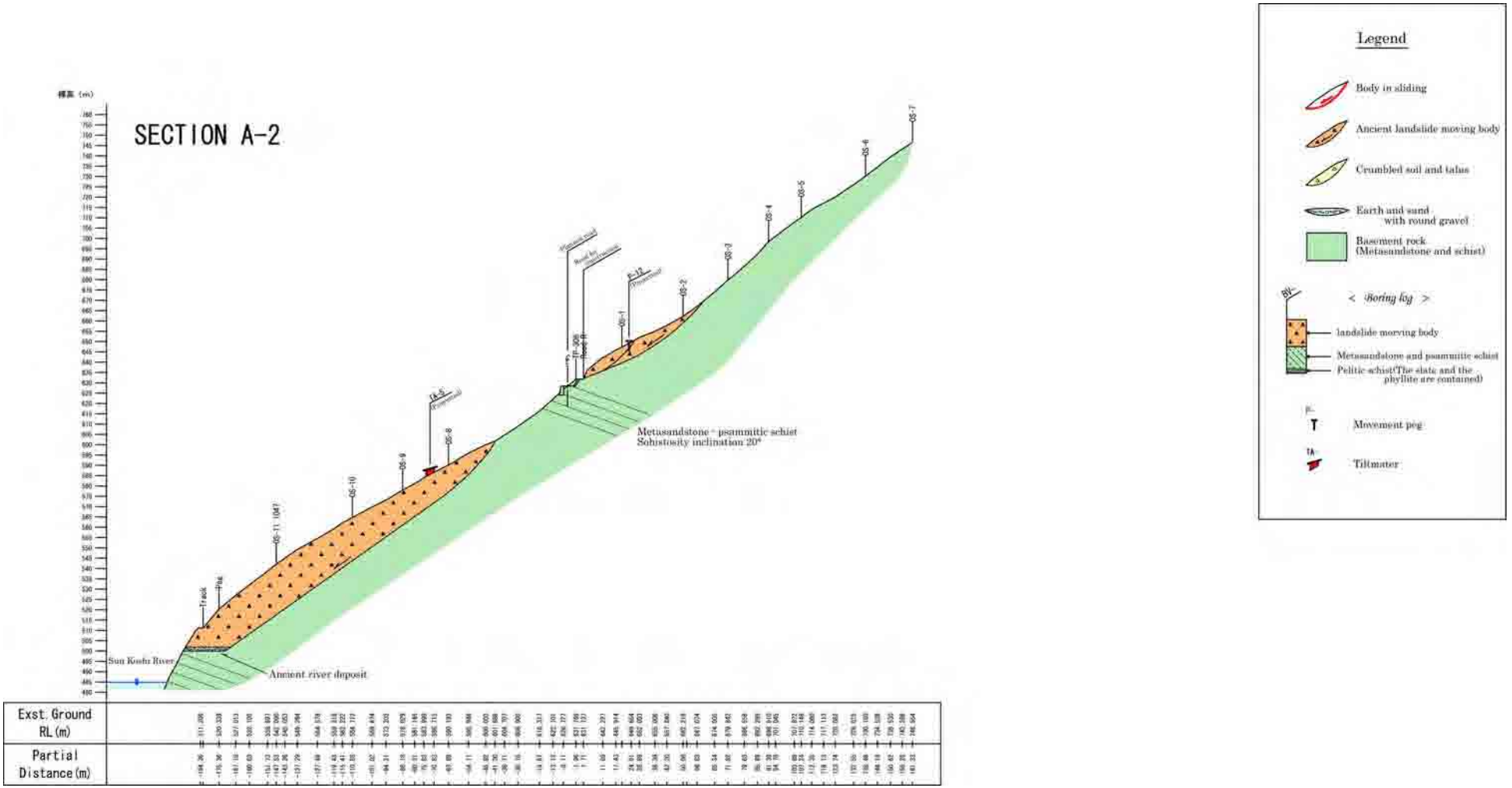
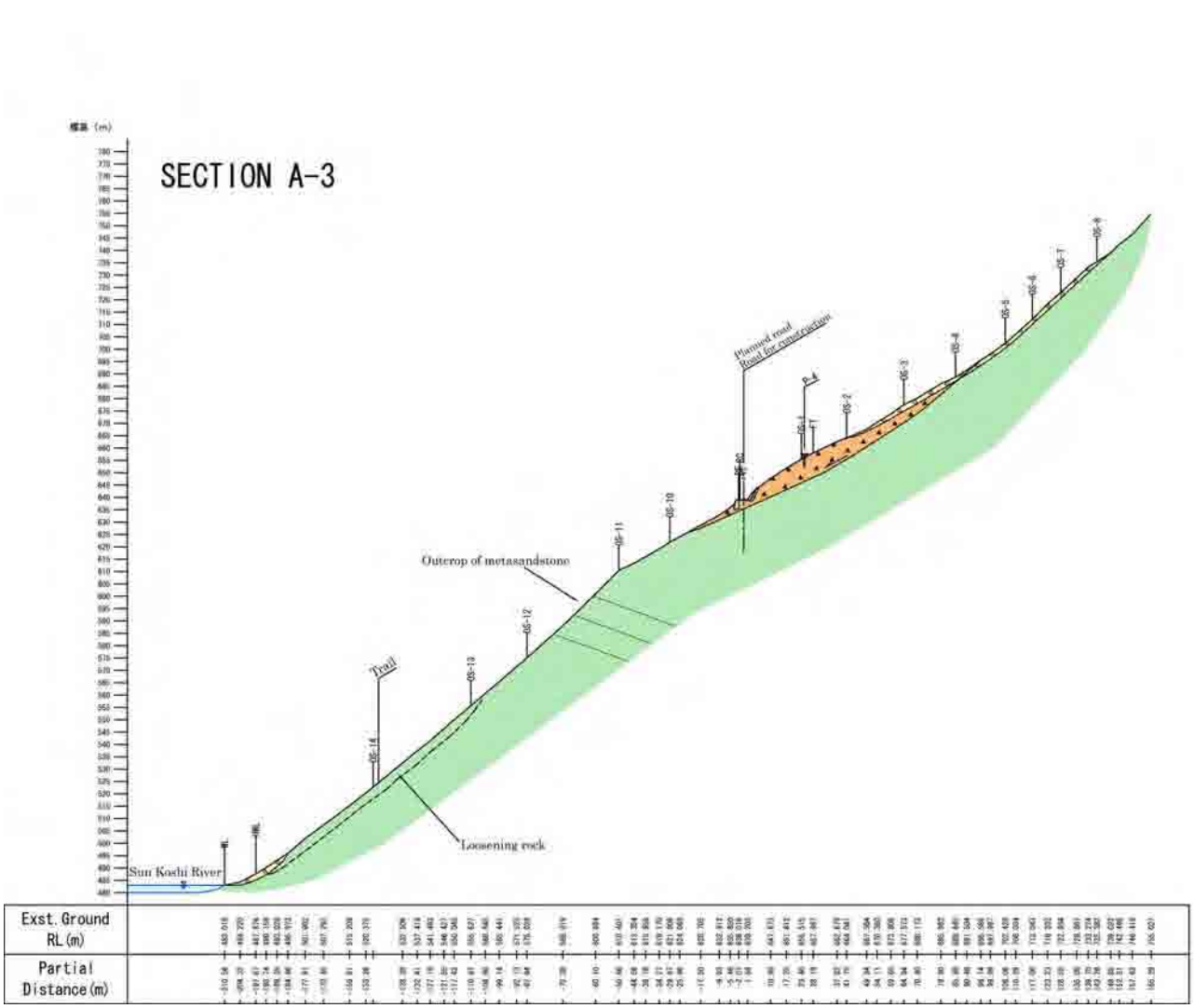


Figure 1-6 Schematic Cross-Section (2/3)



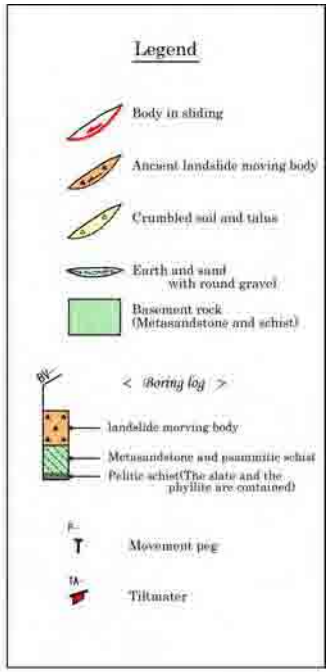


Figure 1-6 Schematic Cross-Section (3/3)

(5) Landslide Monitoring

1) Monitoring Period

In the Study, landslide monitoring was conducted for the period from September to October, 2008.

2) Equipment Installation

In order to monitor the movement of slopes taking on landslide, monitoring equipment were installed at 6 areas. Monitoring equipment, consisting of pipe strain meter, extensometer, tiltmeter and moving pile. Furthermore, to examine relationship between rainfall and movement of slopes, hyetometer was installed and groundwater levels were measured in bore holes.

3) Results and Actions

Moving pile

Displacements of 1 – 3 cm from the base were observed. Since it may include a measuring error, further monitoring was necessary to judge the trend of displacement based on the results.

Pipe strain meter

Although local displacements were observed at every gauge, cumulative displacements were not found. Consequently, it was not considered that they were caused by landslide.

Tiltmeter

Although displacements were observed at every gauge, cumulative displacements were not found and even if seen, these were not significant. Consequently, it was not believed that these were caused by landslide.

Groundwater level

The groundwater level of borehole BV-3 is declining, while water levels of the other boreholes were observed at the bottom of the hole and did not fluctuate during the period of monitoring.

1.3.3 Evaluation of Impacts and Countermeasures to be considered in Road Planning

In the road planning, impacts of unstable slopes were evaluated and recommended countermeasures were provided, as presented in Table 1-8.

Table 1-8 Impacts of Unstable Slope and Countermeasures

Station	Slope Type	Failure Type	Impact Evaluation	Countermeasure	Photo
STA.12+750-STA.13+240	Ancient landslide (Area E)	Collapse of cutting slope where landslide deposits are exposed	Stable against total landslide Possibly collapsed partially	Retaining wall at mountain side Continuous monitoring	
STA.13+250-STA.13+270	Loosened rock slope (Fracture zone)	Wedge-slip of loosened rock slope	Possibly collapsed partially	Retaining wall at mountain side	
STA.13+420-STA.13+470	Talus	Collapse of slope composed of talus	Possibly collapsed partially	Retaining wall at mountain side	
STA.13+470-STA.13+485	Loosened rock slope	Surface collapse of loosened rock slope	Possibly collapsed partially	Not necessary	
STA.13+570 STA.13+800	Ancient landslide (Area D)	Collapse of cutting slope where landslide deposits are exposed	Stable against total landslide	Retaining wall at mountain side Continuous monitoring	
STA.13+825-STA.13+850	Loosened rock slope	Slip of loosened rock slope	Possibly collapsed partially	Retaining wall at mountain side	
STA.13+920-STA.14+220	Ancient landslide (Area C)	Collapse of cutting slope where landslide deposits are exposed Pushed out of soil mass	Stable against total landslide Possibly collapse partially	Retaining wall at mountain side Continuous monitoring	
STA.14+240-STA.14+365	Talus and Colluvial deposit	Collapse of slope composed of talus and colluvial deposit	Possibly collapsed or with partial slip	Retaining wall at mountain side	
STA.14+365-STA.14+425	Talus	Collapse of slope composed of talus	Possibly collapsed or with partial slip	Retaining wall at mountain side	
STA.14+425-STA.14+540	Talus, Colluvial deposit, and Loosened rock slope	Collapse of slope composed of talus, colluvial deposit and loosened rock slope	Possibly collapsed partially	Retaining wall at mountain side Foundation of retaining wall at river side should be placed on rock	

Table 1-8 Impacts of Unstable Slope and Countermeasures

Station	Slope Type	Failure Type	Impact Evaluation	Countermeasure	Photo
STA.14+570-STA.14+600	Talus, and Loosened rock slope	Collapse of slope composed of talus and loosened rock slope	Possibly collapsed partially	Retaining wall at mountain side	
STA.14+810-STA.14+840	Loosened rock slope	Collapse of slope composed of loosened rock slope	Possibly collapse partially	Retaining wall at mountain side	
STA.14+840-STA.15+020	Ancient landslide (Area A-3)	Collapse of cutting slope where landslide deposits are exposed	Stable against complete landslide Possibly collapsed partially	Retaining wall at mountain side Continuous monitoring	
STA.15+030-STA.15+140	Ancient landslide (Area A-1)	Collapse of cutting slope where landslide deposits are exposed Slip of slope at valley side	Stable against complete landslide Possibly collapsed partially	Retaining wall at mountain side Continuous monitoring In case of slip, alignment should be shifted	
STA.15+140-STA.15+350	Ancient landslide (Area A-2)	Collapse of cutting slope where landslide deposits are exposed	Stable against complete landslide Possibly collapsed partially	Retaining wall at mountain side Continuous monitoring	
STA.15+400-STA.15+460	Talus and Colluvial deposit	Collapse of slope composed of talus and colluvial deposit	Possibly collapsed partially	Retaining wall at mountain side Foundation of retaining wall at river side should be placed on rock	
STA.15+460-STA.15+520	Ancient landslide (Upstream of Area A-2)	Collapse of cutting slope where landslide deposits are exposed Pushed out of soil mass	Possibly collapsed partially	Retaining wall at mountain side Foundation of retaining wall at river side should be placed on rock	
STA.15+540-STA.16+000	Ancient landslide (Upstream of Area A-2)	Movement of road surface and retaining wall due to slip and landslide	Possibly collapsed partially	Retaining wall at mountain side Foundation of retaining wall at river side should be placed on rock	
STA.16+380-STA.16+600	Ancient landslide (Upstream of Area A-2)	Movement of road surface and retaining wall due to slip and landslide	Possibly collapsed partially	Retaining wall at mountain side Foundation of retaining wall at river side should be placed on rock	
STA.16+760-STA.17+110	Ancient landslide (Upstream of Area A-2)	Movement of road surface and retaining wall due to slip and landslide	Possibly collapsed partially	Retaining wall at mountain side Foundation of retaining wall at river side should be placed on rock	

1.4 Seminar on Landslide Monitoring for Capacity Development

1.4.1 Objectives

In the Study, monitoring of unstable slopes was conducted only during the period of the dry season, i.e. from the installation of equipment to the end of October. Thus, the relationship between rainfall and the movement of unstable slopes was not fully understood. Furthermore, DOR did not have much experience in the monitoring of unstable slopes by using equipment. Therefore, taking this opportunity, a seminar on landslide monitoring was held for the purpose of capacity development of DOR staff on the continuous monitoring of unstable slopes using equipment.

1.4.2 Date

September 17 – September 19, 2008 (3 days)

1.4.3 Venue

September 17, 19: Hotel Everest
September 18: Site in Mulkot

1.4.4 Participants

* DOR:	18
* MOPPW:	1
* DWIDP:	9
* Embassy of Japan in Nepal:	2
* JICA Nepal Office:	1
* Study Team:	1
* Total:	32

1.4.5 Program

* Objective of the seminar
* General understanding of landslide
* Outline of landslide in Mulkot
* Explanation of monitoring equipments
* Training on site in Mulkot

Photo 1-5
Seminar in Room

Photo 1-6
Seminar on Site

1.4.6 Transfer of the Equipment

Moreover, DOR decided to continue the monitoring in the site and requested JICA to transfer the equipment used in the Study.

CHAPTER 2 CONTENTS OF THE PROJECT

2.1 Basic Concept of the Project

2.1.1 Overall Goal and Project Purpose

The GON prepared the First Five-Year Plan in 1956, and since then, has completed ten periodic plans. Meanwhile, the Temporary Three-Year Plan (July 2007 to July 2010) is currently being implemented.

The DOR has prepared the Master Plan for Strategic Road Network (SRN) in December 2005 in order "to contribute toward the betterment of living conditions of the people through effective, efficient, safe and reliable strategic road connectivity". The project for the construction of Sindhuli Road is recognized as one of the most important routes of the SRN and is prioritized as per the project list of the master plan. Furthermore, the road is part of National Highway No.6 (H06), which links the highly populated eastern Terai region with the capital, Kathmandu.

The issues related to the road network of Nepal are mostly attributed to Prithivi Highway. This highway, which is the only significant commercial route connecting Kathmandu to Terai area and India, is constantly in danger of being damaged due to sediment-related disasters that occur every year. It should also be realized that this road is a considerably long detour from the eastern Terai area, the major agricultural production area, to Kathmandu. Facts show that Kathmandu was previously isolated for twenty days due to a sediment-related disaster caused by heavy rains in July of 1993, and has been subjected to damages due to disaster that occurs almost every year.

Hence, the GON expects that Sindhuli Road, which is the second major trunk road connecting Kathmandu to the Terai area and Indian boundary, will contribute to security of the safety and economic growth of Nepal. Utilizing this road will consequently shorten the travel distance and travel time, which will benefit both agricultural production transport and long-distance bus trips. Furthermore, it is expected that the shortening of travel time to Sindhuli, Ramechhap and Kavrepalanchok districts will result in the reduction of travel cost and contribute to stable transport and industrial promotion along the road. Therefore, it is foreseen that its implementation will stimulate social and economic activities, leading to the improvement of the quality of life of local residents.

2.1.2 Outline of the Project

To achieve the abovementioned objectives, it was decided that the Sindhuli Road, which connects Bardibas and Dhulikel, is to be constructed. Consequently, the running distance and travel time is shortened while life of the local residents is improved. The Project, which required assistance, involves the construction of the remaining Section III (with total length of

36.8km and standard road width of 4.75 m) of the Sindhuli Road, including its ancillary facilities and 12 causeways. Table 2-1 shows the scope of the Project.

Table 2-1 Scope of the Project

Category	Item	Contents / Scale
Road	Length	36.8km
	Width	4.75m
	Pavement	Standard: Double Bituminous Surface Treatment (DBST, Base 15cm, Sub-base 15cm) Hair-pin curves: Asphalt Concrete (Surface 5cm, Binder 2 x 5cm, Sub-base 15cm)
	Design Speed	30km/hr (except Hair-pin curves)
	Cross Drainage	Box culvert: 24 nos Pipe culvert: 283 nos (including irrigation)
	Bus stop	19 nos
	Passing Place	164 nos
	Guard block	Precast conrete wall type: installed only at dangerous locations
Causeway	Width	4.75m
	Structure	Continous box culvert
	Length	No.3: 130m (remaining Section II) No.4: 30m (remaining Section II) No.5: 50m (remaining Section II) #1: 30m #2: 190m #3: 20m #4: 50m #5: 90m #6: 40m #7: 60m #8: 70m #9: 90m

Source: Study Team

2.2 Basic Design of the Requested Japanese Assistance

2.2.1 Design Policy

(1) Basic Policy

1) Requested Section

Requested section to be implemented under the Project is Section III with original road length of 32km and the remaining 3.9km of Section II, and consequently, it became 35.9km in total (Road length finally became 36.8km after further examination on the alignment.).

2) Design Concept

Since the Project is part of the Sindhuli Road Project, and is also one of the essential routes of SRN, the original design concept was not adopted. Instead, the development policy and design policy established in the Feasibility Study in 1986 was considered. However, as the detailed design of the remaining 3.9km of Section II has been completed, this design concept would be applied to Section III (32km).

3) Road Planning Policy

The project site consists of rocks with many cracks, vulnerable geological nature, river flood plain, erosion-prone hill and steep slopes. The proposed road is located on a site subjected to severe natural conditions with high risks of disaster. Therefore, road planning should be developed considering mitigation of environmental impacts and road disasters. However, such conditions would entail, voluminous cutting and embankments causing negative environmental impacts. Construction cost would then increase due to large-scale road structures and required disaster prevention countermeasures.

On the other hand, the Project would be implemented through grant aid assistance, and thus it is necessary to formulate a road development plan to comply with the fund restrictions. Moreover, the Project should achieve its objectives and should have sustainability. Therefore, securing traffic and connectivity with the completed sections are the primary aims of the Project, and under such fund restrictions and natural conditions, the service level of the road is expected to be improved. In addition to that, 23 review comments reported from the JICA Council would be considered in formulating road development plan.

Under such situation, construction costs would be reduced through a step-wise construction in accordance with the increase of traffic demands, consideration of causeways for river crossing, and others. Disaster-prone areas would be avoided as much as possible and disaster prevention works would be considered. Regarding environmental considerations, under the road planning policy “Environmentally-friendly Sindhuli Road Construction Project”, a road alignment that harmonizes with the geographical features considering minimal cutting and embankment would be achieved, by adopting a design speed of 30km/hr (except at hair-pin curves) and partially considering a running speed of 20km/hr.

4) Cost Reduction Measures

i) Step-wise Construction and Road Width

From the results of the traffic survey conducted in this Study, which is similar to that conducted in the study for Section IV and Section II, and the traffic demand forecast, it was found that the capacity of the road still will be sufficient to the future demand at the time of its opening, and a step-wise construction would be viable. In the first step, road with a width of 4.75m will be constructed and will be widened by capping the side-ditch in the second step. In the first step, construction of 4.75m road width would be the objective of the Project.

ii) Road Width and Number of Lane

Road width of 4.75m was adopted as the first step of step-wise construction as in Section II and Section IV, while two-lane road with road width of 5.5m was proposed in the F/S.

iii) Pavement Structure

DBST with base course of 15cm and sub-base course of 15cm was adopted, while asphalt concrete pavement (wearing course 5cm, base course 25cm, sub-base course 35cm, totally 65cm) was proposed in the F/S.

iv) Type and Total Length of River Crossing Structures

Causeways (box culvert type) with total length of 640m were adopted as river crossing structures, while bridges with total length of 1,000m were proposed in the F/S.

v) Slope Protection Works

The most common and economical slope protection method in Nepal is the vegetation system. This method would be adopted whenever possible to stabilize soil or soft rock. In cases where stable slope grade requires extensive cutting, other economical slope protection structures for disaster-prevention would be adopted. Furthermore, considering the natural environment, cutting slope height was basically limited to 7-10m.

5) Participation in Road Maintenance of Nepali side

Based on the above-mentioned development policy, countermeasures were planned as part of the Project to avoid many slope failures, large-scale landslides and scouring that could wash away the roads. However, participation of DOR in road maintenance, both during construction and after completion, would be still required.

6) Alignment of the Road

Alignment of the road was examined based on the draft alignment in the Preliminary Study. New information obtained through the site survey of the Study such as the existing road alignment, topographic and geological conditions, social and environmental conditions and others would be additionally examined. The alignment was finalized considering cost-saving measures, and social and natural environment impacts. The alignment was subject to the consensus at stakeholders meetings.

(2) Policy on Natural Condition

1) Climate Condition

Average climate data for the past ten years observed at Sindhuli Gadhi in Section II and Dhulikel and Nepalthok (only for rainfall data) in Section IV were studied. In Sindhuli Gadhi, the average highest temperature is 31.7 ºC in April while the average lowest is 7.2 ºC in January. Meanwhile in Dhulikel, the average highest temperature is 26.6 ºC in May while average lowest is 3.4 ºC in January. The project site is in a continental climate, which is warm with big temperature differences between day and night. As for the rainfall, Sindhuli

Gadhi has annual rainfall of 2,613mm with an average largest of 745.8mm in July and an average least of 7.4mm in January. Meanwhile, annual rainfall in Nepalthok is 887mm with average largest of 296.3mm in July, and average least of 9.0mm in November. The period between late May and early October is deemed as monsoon season. Pavement works (DBST and asphalt concrete pavement) and river-related works (causeway works and revetment works) should not be performed in monsoon season from the viewpoint of quality control and construction safety, respectively. A normal rate of operation was adopted for other works as there would be no large influence of rainfall.

2) River and Basin

Design flood flow and discharge for river crossing structures, revetment, ditches and cross drainage were calculated considering hydrological characteristics of the site in the monsoon season. For the calculation of rainfall intensity and flood discharge, rainfall and river discharge data observed in the vicinity of the site was used. Data from Sindhuli Gadhi rainfall station was used for river crossing structures; data from Nepalthok rainfall station was used for side ditches and cross drainage; and data from Pachuwar Ghat discharge station for the analysis of Sunkoshi River, and Panauti discharge station for the analysis of Rosi River.

3) Topography and Geology

Topography of the site generally inclines in the northwest – southeast direction, influenced by tectonic line running nationwide. Tributaries of Sunkoshi River cross such a topography in the northeast – southwest direction, and developed delta at the inflow point to the river. Alignment of the road follows the topography of the ridges in order to limit the scale of construction. Continuous box culverts were planned at river crossings.

On the other hand, the site is at the northern section of the Main Boundary Thrust (MBT) that divides Nepal into two parts, namely, the northern and southern part. Ground of the site is constituted by a slate and phyllite affected by the metamorphism of Paleozoic Nawakhot layer. Strike inclinations vary throughout the site. Moreover, talus and colluvial deposits are widely distributed. In order to reduce risks of slope disaster, the alignment should firstly avoid as much as possible, the landslide prone areas. Secondly, slopes should have a stable gradient and should be minimal. Unstable sections that will remain are to be protected by retaining walls and crib works.

4) Forest and Trees

Since almost all areas along the road have been already cultivated, only a few well-developed forests remain with trees of varying heights. There are also many slopes with little vegetation. Large trees however are used as resting places of residents in many villages. From the viewpoint of conservation of natural environment, road alignment should avoid such

large trees, cut and embankment slope should be minimized and artificial slopes should be re-vegetated. In addition, tree cutting should be as limited as possible during the construction of road.

5) Earthquakes

As the site is designated as the highest-risk seismic zone V according to the Indian Standard Criteria for Earthquake Resistant Design of Structure, Third Revision, 1989, earthquakes were considered in the design of causeways and retaining walls.

6) Consideration of Natural Environment

Since the area along the Sunkoshi River, including the project site, is rich in natural environment, small slopes at the valley side should be kept flat as much as possible, so that road users can safely park to appreciate the beautiful scenery.

Provisions for special crossings intended for animals were not deemed necessary. This is recommended since no rare animals are found in the vicinity of the site. Furthermore, aside from the fact that the planned road width is narrow, the cut and embankment is minimized and many cross drainages will be provided.

(3) Policy on Social Condition

1) Consideration of Social Environment

There are many villages and valuable cultivated lands along the road. Stores and meeting places are also distributed. In setting the alignment, impacts including “relocation of houses and loss of lands”, “vibration, noise, exhaust gas, dust”, “traffic safety, interruption of regional society, fields and irrigation channel” would be considered and mitigated as much as possible. The number of relocated houses and area of affected land should be minimized. Affected irrigation facilities should be compensated.

2) Consideration of Future Needs for Facilities

Since the Project is located in the middle section of the Sindhuli Road, future needs for the facilities for travelers’ resting and facilities for regional development would be considered in order to promote effective utilization of open space that would be developed accompanying construction.

(4) Policy on Construction and Procurement

1) Procurement Condition of Labors

It is relatively easy to procure common labor services in the Project area. In fact, it was found during stakeholders meetings that many local residents are requesting to be employed.

On the other hand, many skilled laborers and heavy equipment operators in Nepal are working in neighboring countries like India as well as in the Middle East, where construction is booming. Therefore, the number of skilled labor for road and bridge construction has become limited in recent years.

It should be noted that laborers' wages in Nepal are rising as well as the prices of commodities.

2) Procurement Condition of Materials and Equipment

Natural materials (including sand, stone and timber), reinforcing bars and gabion wires are available in Nepal markets. Materials and goods for reinforced earth walls would be procured from Japan, since there are no equivalent goods in the local market.

3) Labor Laws and Construction Regulation

In case of labor employment, "Rule and Regulation for Workers and Employee to the Private Institution and Factory in Nepal, in 1991 and 1993" should be followed.

4) Procurement Condition of Goods for Daily Life

Considering the local residents' safety living and natural environment, migrant workers' quarters will be supplied with potable water and liquefied petroleum gas for cooking.

(5) Policy on Application of Local Contractor

1) Application of Local Contractor

Appropriate periods for negotiation between the main contractor and sub-contractor should be considered in the preparation of implementation schedule in the Study.

2) Use of Items Possibly Produced and Fabricated in Nepal

Some small and medium-sized enterprises can produce and fabricate items such as gabion wires, steel poles, etc. Items other than these would be procured from Japan and other countries.

3) Procurement of Equipment

Equipment for pavement would be procured through lease contract. Construction machineries other than machineries possibly produced and fabricated in Nepal, would be procured from Japan and other countries.

(6) Policy on Implementation Agency for Management and Maintenance

The DOR, the executing agency of the Project, has experienced implementation of Japan's Grant Aid projects. DOR's ability of management and O&M was fully proved in the past

projects especially in other sections of Sindhuli Road which started in 1986. However, since the length of the Project road is quite long and since minimum structures were adopted for pavement and slope protection, well-coordinated O&M and securing budget is expected.

(7) Policy on Grades of Facilities

1) Design Standards to be Adopted

Design standard for the Sindhuli Road Construction Project was established for the first time during the Aftercare Study in 1993. It refers to geometric standards of DOR and Japanese Road Structure Ordinance. It was partially modified for section II and section IV projects. For consistency purposes, the modified standard would also be followed for the Project.

2) Design and Running Speed

Japanese Road Structure Ordinance recommends adopting same design speed for a continuous 10 – 15km section with the similar route characteristics, importance of the section, traffic volume, topographic natures and regional natures. Even in case it is difficult to follow that, it is not desirable from the viewpoint of traffic safety to change design speed within a short length of less than 2km. Therefore, 30km/hr was adopted as design speed since most sections of the road follows a hilly and mountainous area except for hair-pin curves where design speed of 20km/hr was adopted.

However since vehicles would be running with various speeds in accordance with grades, radius and length of curvature, roadside conditions and others, actual running speed would be taken into consideration for the road design. Running speed of 20km/hr was considered for rolling sections while 40km/hr for flat sections of terraces.

3) Design and Grade Setting of Road Facilities

Nepali design and drawing standards was adopted basically for the road facilities. However, in cases where such standards are not applicable, Japanese standards was utilized.

A return period of 50-year was adopted for road structures along Rosi River and Sunkoshi River and causeways considering the return period adopted in other sections of Sindhuli Road that was set referring to Manual for River Works in Japan. Meanwhile, referring to the Highway Earthwork Series, Drainage Works Manual, Japan Road Association, a return period of 5 – 25-year were adopted for cross drainage in accordance with slopes and flow conditions, while return period of 3-year was adopted for side ditches for surface drainage.

Concrete blocks would be installed at locations where special attentions should be paid from the view point of traffic safety such as steep slopes and zigzag sections. In addition, structure types and products which are widely used and which can be manufactured in Nepal were adopted as much as possible for easy maintenance. Cutting slopes and embankment

slopes should be maintained by the Nepali side.

(8) Policy on Construction Methods and Construction Period

1) Maximum Utilization of Existing Road

DOR has constructed pilot tracks without slope treatment for widths of 3 to 4 m. This was provided to about 3km section of Khurkot and to about 26km of Nepalthok. These pilot tracks would be utilized as construction roads as much as possible and eventually, as part of the project road. With some improvements to be implemented, this would contribute to cost-saving measures as well as minimize land acquisition and resettlement.

2) Location of Start Point of Construction

Since the proposed project road can be accessed both from the Section II side and Section IV side, construction could simultaneously commence from both sides. This case requires the least construction cost. The intermediate locations of the project road could be accessed through the existing pilot tracks.

3) Construction Period

Considering construction period of 53 months, the Project would be implemented in 2 phases of 3 years, through grant aid assistance.

(9) Policy on Socio-Economy

1) Securing Road Function in National Road Network

One of the project objectives in constructing the road, which constitutes SRN as Highway No.6 (H06) and East-West Highway, is to achieve economic growth and industrial promotion through stimulating social and economic activities. In order to fulfill such objective, it is necessary to secure traffic throughout the year. Therefore, countermeasures against disaster, which is under restriction of construction costs, should be considered.

2) Role to Support Local Residents' Quality of Life

The road is not only intended to function as an arterial road but also to contribute in supporting the local residents' quality of life. Therefore, accessibility to the roadsides should be considered.

2.2.2 Basic Plan

(1) Overall Plan

1) Road Alignment

i) Examination of the Road Alignment

Considering the topographical and geological conditions, as well as the social and environmental conditions observed in the site survey, and taking into account some cost saving measures, the draft road alignment proposed in the Preliminary Study was revised in this Study. Revision of the alignment was made by dividing the road section of 32km into 19 sub-sections with similar characteristics of topography as shown in Figure 2-1.

Comparison of the alignment proposed in this Study and that proposed in the Preliminary Study, including the social and natural conditions of each sub-section .are shown in Table 2-2. Results of the detailed examination and coordination of routes are shown in Appendix 6-7. Major points for review of the route selection and items for comparison are as follows.

Major points for review of the route selection

1) Follow design standards presented in Table 2-5
2) Mitigate social and environmental impacts (Avoid large-scale earthwork, irrigated fields and houses)
3) Minimize risks of disaster as much as possible by avoiding steep topography and geologically unstable areas.
4) Minimize the scale of retaining walls and slope protection works, mitigate environmental impacts and economize construction costs

Items for comparison

1) Impact on social environment (relocation of houses, resettlement of land, noise and vibration, traffic safety, regional development, community segmentation, field segmentation, and impacts on irrigation, convenience of life)
2) Impact on natural environment
3) Economic aspect
4) Construction
5) Stability against disaster
6) Running comfort
7) Future maintenance
8) Scenery

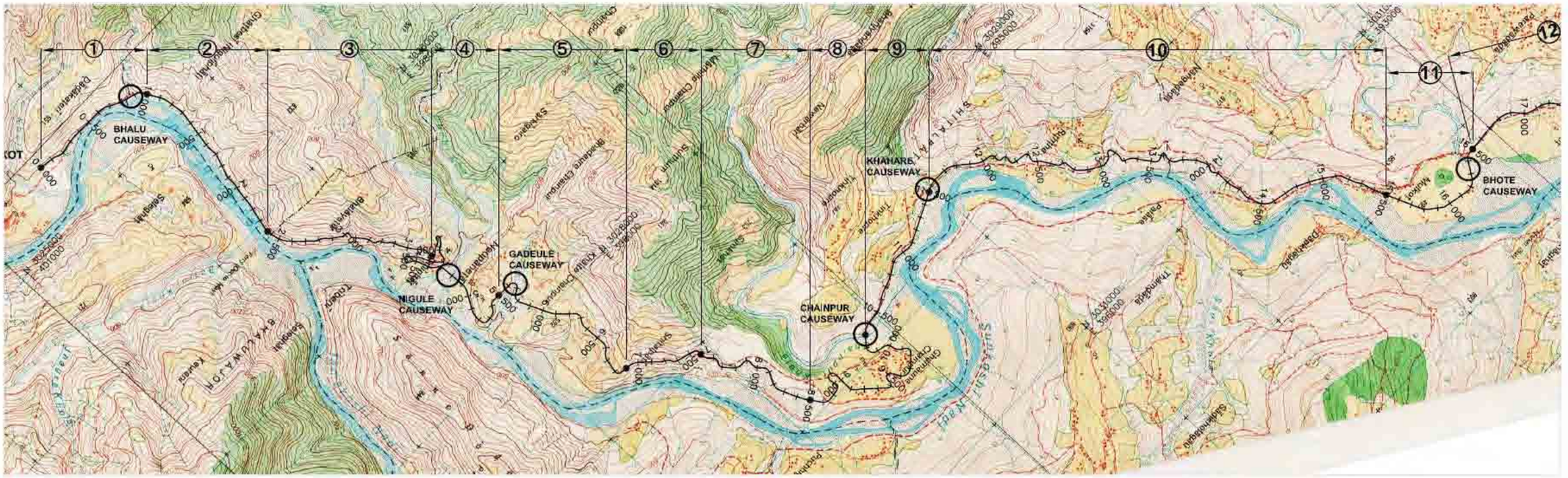


Figure 2-1 19 Sub-Sections of the Section III for Alignment Examination

Source: Study Team

Table 2-2 (1/2) Recommended Alignment Alternatives and Natural / Social Environment

No.	Section Name by Characteristics BP	Section Name by Characteristics EP	Natural / Social Environmental Situation	Recommended Route and Alternatives in Preliminary Study: Recommended Route	Recommended Route and Alternatives in Preliminary Study: Alternatives	Comments and Suggestions on Recommended Route and Alternatives in Preliminary Study made by Basic Design Study Team (Study Team's Recommendations)	Reason of Study Team's Recommendation	Remark
1	Section along Sunkoshi River 0+000 (Bhadaure Khola)	1+000 (Bhalu Khola)	・ Pilot Road of about 700m completed ・ Influenced by HWL of Sunkoshi River ・ Colluvial deposits and weathered schist distributed area (Partially hard rock) ・ Access of Bhalu Khola causeway is control point of profile	・ Follows Aftercare Study（AC）route	・ None	・ Set profile to be higher than HWL（STA.1+000: PH=470m）。 ・ Follow pilot road ・ Level of existing pass to be considered in designing the profile	・ Minimize cut and embankment ・ Reduce flood risks	Alignment Examination No.1
2	Section along Sunkoshi River 1+000	2+400	・ Stratification is vertical and partially boulder group ・ Vary from mild slope of deposits to steep slope of slate ・ Three tall trees	・ Follows AC route	・ None	・ Accommodate profile along the river bed grade gradually from No.1 section and set profile to be higher than HWL ・ Shift alignment to mountain side and suit design with natural topography	・ Reduce flood risks ・ Minimize cut and embankment ・ Utilize existing pass during construction ・ Avoid tall trees	Alignment Examination No.2
3	Section detouring Bhalayetar Failure 2+400	3+700	・ STA 3+300: Failure ・ Steep slope（Soft rock – medium hard rock of slate) ・ Scenery (Inflow point of Tamakoshi River to Sunkoshi River)	・ Avoids Bo-tree at causeway	・ None	・ Shift alignment to mountain side and suit design with natural topography ・ Secure parking space	・ Avoid failure ・ Avoid cutting of slopes with boulder ・ Consider scenery	Alignment Examination No.3
4	Dihiphat Zigzag and Village 3+700 (Dhobi, Niguli Khola)	5+500 (Gadaule Khola)	・ Houses / field ・ Causeways are control points of profile at BP and EP ・ Landslide / soil with boulder ・ Bo-tree	・ Follows AC route	・ None	・ Maintain stability against landslide (Avoid cutting lower edge of sliding) ・ Avoid fields as much as possible ・ Avoid raising elevation of causeway	・ Minimize cut and embankment ・ Mitigate impact on houses/field/trees	Alignment Examination No.4
5	Section in Khalte Chainpur RTO Road and Fields 5+500	6+900	・ Houses / hill / fields/ mild slopes ・ Wide RTO road ・ Old rest place（Shital-Pati）/ Bo-tree	・ Avoids houses ・ Avoidance of Shital-Pati is not enough	・ None	・ Utilize RTO road as much as possible ・ Avoid Shital-Pati	・ Social and environmental considerations ・ Mitigate erosion caused by construction of road	Avoid Shital-pati Alignment Examination No.5
6	Failed Section 6+900	7+500	・ Loose geology (colluvial deposits) and slate ・ Low trees ・ Scenery	・ Follows AC route	・ None	・ Implement mild climbing slope ・ Suit alignment with the topography	・ Reduce failure risks ・ Reduce earthworks scale and consider scenery	Alignment Examination No.6
7	Red Soil Eroded Terrace Section 7+500	8+500	・ Terrace covered with red soil ・ Heavily eroded red soil terrace ・ Poor vegetation ・ Dry and strong wind	・ Follows AC route ・ Passes edge of heavily eroded terrace	・ None	・ Shift alignment to mountain side and avoid eroded edge ・ Strengthen drainage outlet	・ Avoid erosion of soil ・ Mitigate erosion caused by construction of road	Alignment Examination No.7
8	Ghumaune Chainpur Village 8+500	10+300 (Chainpur Khola)	・ Hill with gully covered with red soil ・ Many houses and irrigated fields ・ Large-scale and complex irrigation facility in village ・ Many valuable tall trees including Bo-tree	・ Follows AC route ・ Passes irrigated fields	・ None	・ Avoid fields, houses and tall old tree by vast alignment change ・ Avoid destruction of irrigation system ・ Large-scale irrigation to be considered in designing the profile	・ Social and environmental considerations ・ Mitigate erosion caused by construction of road	Alternative route of Ghumaune Chainpur Alignment Examination No.8
9	Section along Fields on Foot of Mountains 10+300	11+500 (Khahare Khola)	・ Fields / houses / Bo-tree / low trees ・ Terrace deposits / colluvial cone / failure-prone rock ・ Irrigation	・ Avoids houses / fields	・ None	・ Avoid houses/fields as much as possible ・ Consider irrigation channel	・ Social and environmental considerations	Alignment Examination No.9
10	Section with High Risks of Failure in Mulkot 11+500	15+500	・ Large-scale failure ・ Forests / Tall Bo-tree ・ Pilot road completed ・ Steep area ・ Partially thick colluvial deposit	・ Follows AC route	・ None	・ Raise profile using maximum grade of up to the level of pilot road to avoid large-scale slope failure ・ Adopt zigzag section ・ Follow pilot road	・ Reduce slope failure risks ・ Avoid costly construction due to required slope protection works	Avoid Mulkot failures Alignment Examination No.10
11	Mulkot Village 15+500	16+500 (Bhote Khola)	・ Plane fields（Alluvial fan） ・ Pilot road passes fields along river ・ Bus stop (Final destination from Nepalthok) ・ Famous temple ・ Many valuable tall trees including Bo-tree	・ Follows pilot road that passes fields at river side ・ Partially passes dry riverbed of Bhote Khola that causes mud flow	・ AC route（passes field behind houses） ・ Local residents hope the alignment passing slope of mountain foot in front of houses	・ Follow pilot road that passes fields along the river ・ Minimize crossing distance of causeway and install revetment and avoid traversing dry riverbed of Bhote Khola ・ AC route should not be adopted as it traverses a series of houses	・ Improvement of market area by roadside station "Michi-no-eki" and gain advantage in improvement of safety against mud flow from the fields through revetment of road along Bhote Khola	Alternative route of Mulkot village Alignment Examination No.11

Source: Study Team

Table 2-2 (2/2) Recommended Alignment Alternatives and Natural / Social Environment

Section			Natural / Social Environmental Situation	Recommended Route and Alternatives in Preliminary Study		Comments and Suggestions on Recommended Route and Alternatives in Preliminary Study made by Basic Design Study Team (Study Team's Recommendations)	Reason of Study Team's Recommendation	Remark
No.	Section Name by Characteristics			Recommended Route	Alternatives			
	BP	EP						
12	Bhulkot・Ramtar Fields / Bus Route		・ Pilot road (bus route) completed at almost all the section ・ Many houses / fields ・ Boulders（Failure-prone slate） ・ Weathered soil (Red soil) ・ Large-scale colluvial clif（Old topography） ・ Many valuable tall trees including Bo-tree	・ Avoids fields / houses	・ None	・ Follow pilot road (bus route) ・ Candidate location of the roaside station "Michi- no-eki"	・ Social and environmental considerations ・ Reduce construction cost	Alignment Examination No.12
	16+500	18+500 (Gangate Khola)						
13	Katahare/Ratmate Village		・ Hill（Red soil） ・ Pilot road (Bus route) does not go to Ratmate from Kathare but go through mountain side of Ratmate ・ Route going through Kathare village to Ratmate passes irrigated fields, village and shops	・ Follows AC route ・ Passes irrigated fields, village and shops	・ Follows pilot road (bus route) that passes mountain side of Ratmate ・ Passes Ratmate market	・ Follow pilot road (bus route) that passes mountain side of Ratmate ・ Leave pilot road for RTO road before Ratmate market and avoid said market	・ Social and environmental considerations ・ Reduce construction cost	Alternative route of Ratmate village Alignment Examination No.13
	18+500	21+400 (Dhamile Khola)						
14	Khaharetol Village		・ Mountain – hill (colluvial deposits), partial failure, landslide / forests (at mild slopes) ・ Many houses / fields ・ Large-scale irrigation ・ Pilot road (bus route) completed at almost all the section	・ Avoids houses and passes fields under the houses	・ None	・ Utilize pilot road (bus route) as much as possible ・ Shift alignment to mountain side of house, and avoid houses/fields ・ Consider landslide and irrigation channel	・ Social and environmental considerations ・ Mitigate impact of landslide ・ Reduce construction cost	Khaharetol village Alignment Examination No.14
	21+400	24+100 (Sadhi Khola)						
15	Steep Slope with Large Boulders and Ridge of Rock		・ Large-size rocks（slate, phyllite） ・ Fracture zone at southern side ・ Bird propagation area（good forests） ・ Pilot road (bus route) constructed at upper side of the ridge and detouring largely	・ Follows existing pass along the river	・ Tunnel route	・ Adopt the route along the river since the route passing the peak with open cut causes large-scale cutting and vast soil surplus ・ Install special type of retaining wall at valley side to reduce hard rock excavation	・ Construction and economic aspect ・ Environment ・ Disaster prevention ・ Future maintenance	Alternative route of Sadhi Khola Add alternative of open cut of peak Alignment Examination No.15
	24+100	25+300						
16	Section Along Sunkoshi River		・ Pilot road (bus route) ・ Village ・ Forest	・ Avoids houses	・ None	・ Follow pilot road (bus route) ・ Avoid houses	・ Social and environmental considerations ・ Reduce construction cost	Along Sunkoshi River Alignment Examination No.16
	25+300	26+500						
17	Section in Sunkoshi River Bed		・ Influenced by HWL of Sunkoshi River ・ Exposed hard rocks on foot of mountains (failure-prone slate) ・ Pilot road (bus route) passes dry riverbed ・ Forest	・ Follows AC route（in the dry riverbed）	・ None	・ Adopt mountain side route and set the level of valley side retaining wall foundation to be higher than HWL	・ Disaster prevention（possibility of washing away of road and revetment constructed on fine sand due to deep scouring）	Alternative route of Sunkoshi dry riverbed Alignment Examination No.17
	26+500	28+000						
18	Gajulidaha Village		・ River terrace deposits（Red soil – soils with gravel） ・ Pilot road (bus route) passes market ・ Many houses	・ Avoids houses	・ None	・ Utilize pilot road (bus route) as much as possible ・ Avoid houses as much as possible in the vicinity of the village	・ Social and environmental considerations	Gajulidaha village Alignment Examination No.18
	28+000	29+800						
19	Section in Roashi River		・ Influenced by HWL of Rosi River ・ Landslide, failure ・ Failure-prone slate	・ Passes dry riverbed	・ None	・ Pass the dry riverbed using embankment with revetment ・ Avoid landslide and slope failure	・ Cutting mountain side is difficult due to fragile soil ・ River flow is slow since Rosi is a tributary of Sunkoshi and thus consider only scouring ・ Utilize frontedge of landslide as embankment (spoil bank) and stabilize sliding ・ Utilize spoil bank	Along Rosi River Alignment Examination No.19
	29+800	31+100 (Nepalthok)						

Source: Study Team

ii) Alignment Revisions

Resulting from the examination of the alignment mentioned above and based on newly obtained information, alignments proposed in the Preliminary Study were significantly revised for five sections, while one section was subjected to minor modification. Stations stated below are those from the Preliminary Study.

1) STA.8＋500－STA.10+300: Ghumaune Chainpur Village

Ghumaune Chainpur area is one of the richest settlements along Section III because of its existing rich farm lands with irrigation systems, where plural harvests are expected. The Study Team consequently realized that the proposed alignment by the Preliminary Study Team traverses these very rich/irrigated farm lands.

Alternatively, the road may pass along a very steep side slope, which could be possible judging from engineering considerations. Therefore, the Study Team considered and proposed the alignment (Route A) which would not have adverse impacts on the economic conditions of the local residents. The considerations were explained to the residents and their concurrence was obtained without difficulty.

Alignment examination is shown in No.8 of Appendix 6-7.

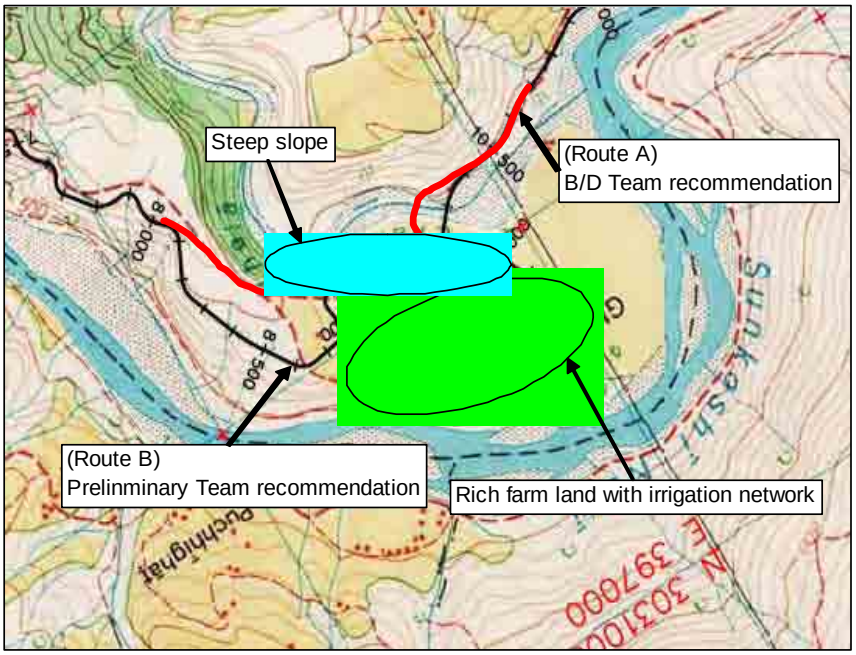


Figure 2-2 Alignment Alternatives Comparison at Ghumaune Chainpur

2) STA.11＋500－STA.15+500: Section with High Risks of Failure in Mulkot

Large-scale failure is observed on southern slope in Mulkot on the right bank of Sunkoshi River. Pilot road being constructed by Nepalese counterpart detours and traverses several 10m from the observed failure. The Study Team does not recommend the Preliminary Study

route that passes through failures, and instead recommends the route following the pilot road. Alignment examination is shown in No.10 of Appendix 6-7.

3) STA .15＋500－STA.16＋500: Mulkot Village

The residents in Mulkot did not agree with the alignment recommended by the Preliminary Study Team (Route A), since they prefer a route that will lead to the RTO road (Route B). However, it was realized that Route B is not feasible as it will involve resettlements and affect many farm lands. The route will also pass through a market, aggravating resettlement issues.

The Study Team further considered another alternative alignment which will pass over the hillside (Route C). This route seems suitable as traffic road, but was not accepted by the residents since it is far from Mulkot. The residents prefer the new road to be located near the settlements in order for them to reap benefits.

The width of Sindhuli Road, which is supposed to be similar to that of a national highway, is considerably wider than the existing track road, with limited curves and grades. Initially, the residents objected since it appears that the route could traverse existing settlements. The Study Team further discussed the engineering aspects of the route and explained the difference between the Sindhuli Road and the existing track road to be utilized.

A few residents still realized that they would lose most of their own farm lands. However, they finally agreed with Route A, subject to amicable compensation claims.

Related alignment examination is shown in No.11 of Appendix 6-7.

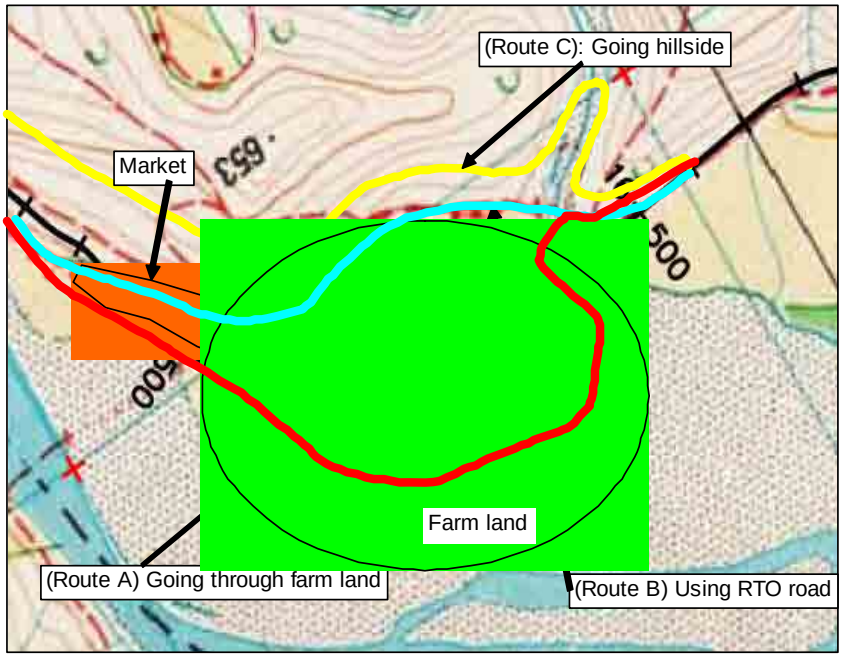


Figure 2-3 Alignment Alternatives Comparison at Mulkot Village

4) STA.18＋500－STA.21＋400: Ratmate Village (Alignment Examination No.13)

The proposed alignment in the Preliminary Study (Route-B) was not acceptable to the residents. This was then further considered in the Study.

While Route A was considered to avoid many resettlement requirements, it traverses rich farm lands where plural harvests are expected. Meanwhile, some residents prefer the road that goes through the market area (Route C). There were also some who doubted if the Study Team actually considered the affected local people and thought that the alignment recommended during the Preliminary Study was already deemed as final. The Study Team resolved these concerns with DOR, and explained the reasons why it is not feasible for the alignment to go through the market area.

Eventually, the residents have agreed with the proposed alignment Route A.

Alignment examination is shown in No.13 of Appendix 6-7.

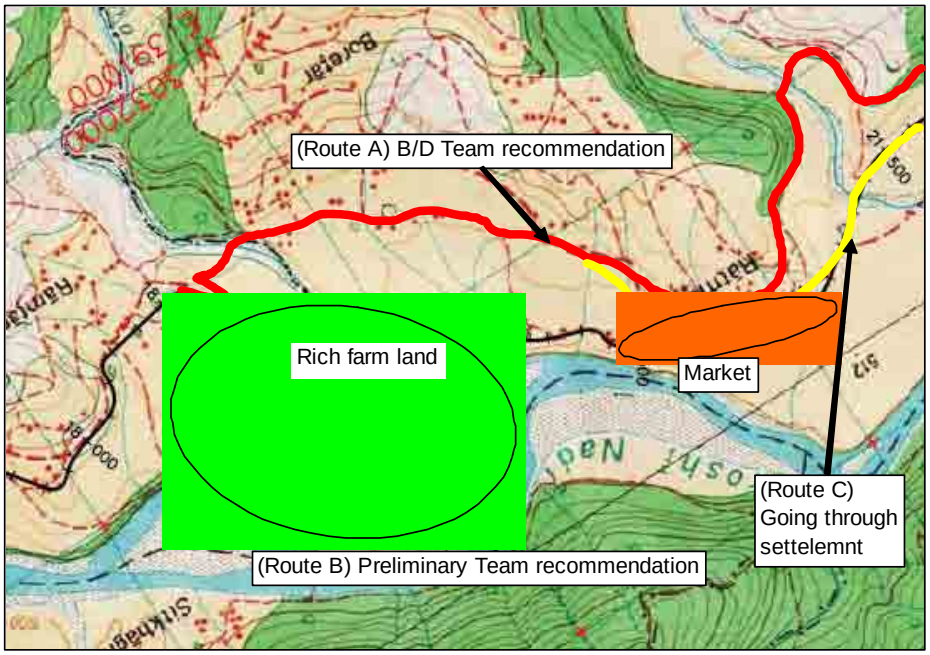


Figure 2-4 Alignment Alternatives Comparison at Ratmate Village

5) STA.21＋400－STA.25＋300: Steep Slope with Large Boulders and Ridge of Rock

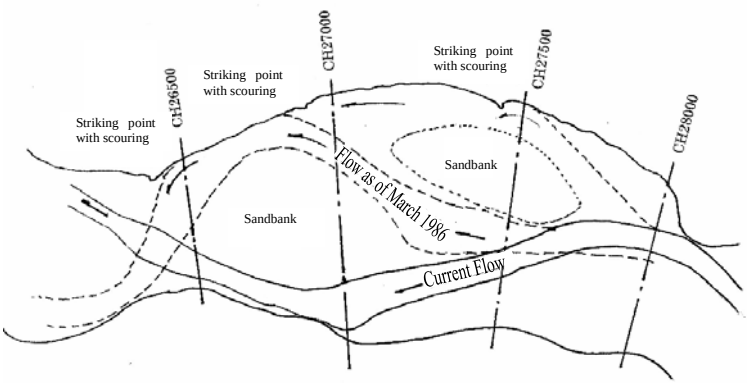
Three alternatives are proposed in the Preliminary Study, including the tunnel route, and the route passing a steep slope along the river. The Study Team added an alternative route passing the same peak as the tunnel route but with an open cut. The Study Team finally recommended the alignment passing a steep slope along the river, with some revisions. Alignment examination is shown in No.15 of Appendix 6-7.

6) STA.26+500－STA.28＋100: Section in Sunkoshi River Bed

In the Preliminary Study, embankment in the dry riverbed was recommended. However, the Study Team judged that the road is subjected to flooding when the water level is higher than 2m, consequently causing scouring of 3-5m deep. Moreover, since the waterway is unstable and riverbed material is sand, the embankment road is expected to be washed away. Therefore, after conducting a review from the viewpoint of disaster prevention, the alignment was rerouted to the mountain side and the road level is proposed to be raised higher than the elevation of the flood level. Alignment examination is shown in No.16 of Appendix 6-7. Examination of the case of embankment on the riverbed of Sunkoshi River is shown below.

River Flow

Based on the aerial photo taken in March 1986, the Sunkoshi River water currently flowing away from the right bank appeared previously striking the right bank. It was assumed that the behavior of water flow changes whenever flood occurs and while main stream flows at different directions. Therefore, in this evaluation, it is considered that the lowest elevation of the riverbed continues to change its location. A conceptual image of the change of water flow is shown in Figure 2-5.



Source: Study Team

Figure 2-5 Conceptual Image of the Change of Water Flow (Past and Present)

Hydrological Analysis and Relation between Water and Road Levels

Hydrological analysis with 50-year return period was conducted using surveyed river cross sections. The present situation was realized based on local reports on past flood levels, and measurements of current scouring depths. Its results are presented in Table 2-3, Figure 2-6, Photo 2-1, Photo 2-2 and Figure 2-7. Riverbed material was judged to be fine sand considering its typical particle size of 1-28mm.

Table 2-3 Hydrological Analysis Results and Present Situation

Station	HWL (m)			Lowest Riverbed Elevation (m)	Existing Scouring Depth (m)	Velocity (m/s)
	From Analysis	From Reports	Adopted			
CH26500	516.94	517.11	517.11	509.09	5.0	5.00
CH27000	519.32	518.31	519.32	514.37	3.0	3.06
CH27500	519.88	519.49	519.88	514.04	4.0	4.26
CH28000	521.64	521.96	521.96	516.18	-	5.09
CH28500	523.18	523.10	523.18	515.98	-	5.38

Source: Study Team

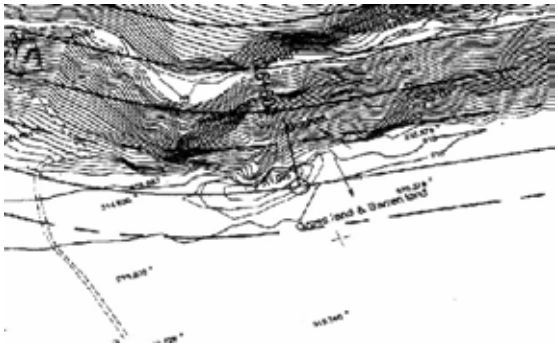


Figure 2-6 Scouring at CH26500 (5m)

Photo 2-1 Scoring at CH27000 (3m)

Photo 2-2 Scouring at CH27500 (4m)

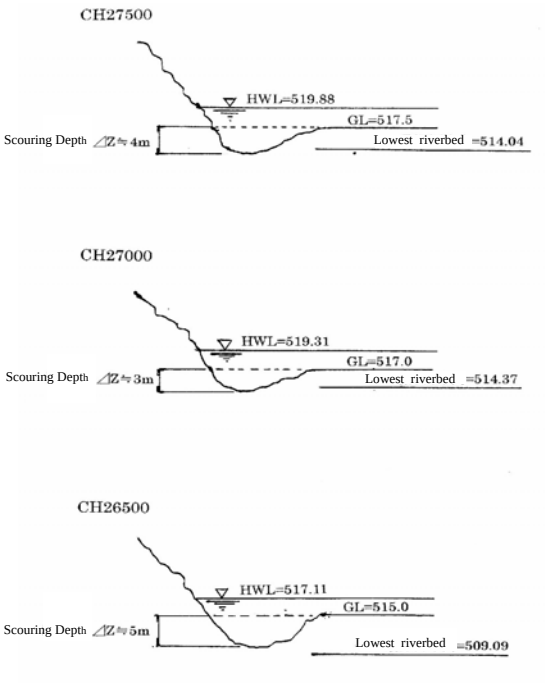


Figure 2-7 Riverbed Cross Sections Showing Relationship Between Flood Level, Scouring Depth and the Lowest Level

Examination on the Foot Protection Size of Revetment

In cases where revetment type is adopted for the road structure, concrete block (thickness = 0.9m or 0.6m) will be selected as foot protection, based on flow velocity determined from the Project for Urgent Rehabilitation of Section IV. Installation width was calculated as 12m, using the following formula.

$Bc = Ln + \Delta Z / \sin\theta$ (Source: page 106, Mechanical Design of Revetment)

Where,	*Bc:*	Installation width of foot protection (m)
	Ln:	Surface width (surface width of 1 block is 2m)
	ΔZ*:*	Scouring depth (5m)
	θ*:*	Slope grade of scouring (angle of repose of sand, 30°)

$Bc = 2.0 + 5.0 / \sin 30^{\circ} = 12\text{m}$

Alternatives and Comparison Study

Comparison of results between embankment on riverbed (proposed in the Preliminary Study) and embankment at elevation higher than flood level (alternative presented in this Study) is shown in Table 2-4.

Table 2-4 Comparison of Results

Item	Riverbed (Preliminary Study)	Alternative
Disaster prevention	Unstable against future flood as embankment is planned on sand.	More stable
Cost	Costly	Economical
Construction	Significant volume of cast-in-place concrete for revetment and foot protection	Almost all works comprised simple retaining wall
Maintenance	Close monitoring is necessary and in case of disaster, repair work is difficult.	Normal maintenance
Indefinite elements	Many, especially in the hydraulic aspect	Minimal
Overall evaluation	Not recommended	Recommended

Source: Study Team

Optimum Alternative

Based on the above comparison, the alternative considering embankment at elevation higher than flood level should be adopted, as it exhibits advantages in terms of stability against flood and economic aspects.

iii) Road Length

Original road length of 32km increased to 32.917km as a result of road development plan formulated based on previously mentioned policies and consensus obtained at stakeholders meetings.

2) Design Parameter and Standards to be Adopted

Table 2-5 shows the design standards established for the Project, based on the standards of Sections II and IV which was set basically based on Nepalese standard and partially Japanese standard.

Table 2-5 Summary of Design Parameter and Standards for Road Design

Item		Unit	Section IV		Section II		Section III	
Design Speed ( ): Running Speed		km/hr	40	2-lane section on Dhulikel side	-		(40)	Flat section
		km/hr	30	Hilly area	-		30	Hilly/ mountainous section and existing road improvement section
		km/hr	20	Existing road improvement section	20	Mountainous section	20	Hair-pin curve
							(20)	Steep sections
Road Width		m	4.75	Exceptionally 4m	4.75	Exceptionally 4m	4.75	Exceptionally 4m
Cross-fall (Earth Surface)		%	4		-	no	-	no
(DBST)		%	2.5		2.5		2.5	Follow Sec.II/ IV
Max. Super-elevation		%	-		6		6	Follow Sec.II
Min. Radius of Horizontal Curvature	(40km/hr)	m	45		-		45	Follow Sec.IV
	(30km/hr)	m	25		-		25	Follow Sec.IV
	(20km/hr)	m	15		15		15	Follow Sec.II/ IV
Vehicle for Computation of Widening at Curvature			Semi-trailer		Semi-trailer		Semi-trailer	
Min. Radius of Vertical Curve		m	300		300		300	Follow Sec.II/ IV
Av. Vertical Grade	(40km/hr)	%	5		-		5	Follow Sec.IV
	(30km/hr)	%	7		-		7	Follow Sec.IV
	(20km/hr)	%	7		7		7	Follow Sec.II/ IV
Max. Vertical Grade		%	9		10		10	Follow Sec.II
Max. Applied Length of Max. Vertical Grade Length		m	300	Before & After the section: 4%, 150m	300	Before & After the section: 4%, 150m	300	Follow Sec.II/ IV
Av. Interval of Passing Place		m	200		200		200	Follow Sec.II/ IV
Min. Stopping Distance		m	-		40	Min. 20m	40	Min. 30m

Source: Study Team

3) Design and Running Speed

Based on the policies stated in sub-section of this report "2.2.1 (7) Policy on Grades of Facilities, 2) Design and Running Speed", design and running speed were set as shown in Figure 2-8.

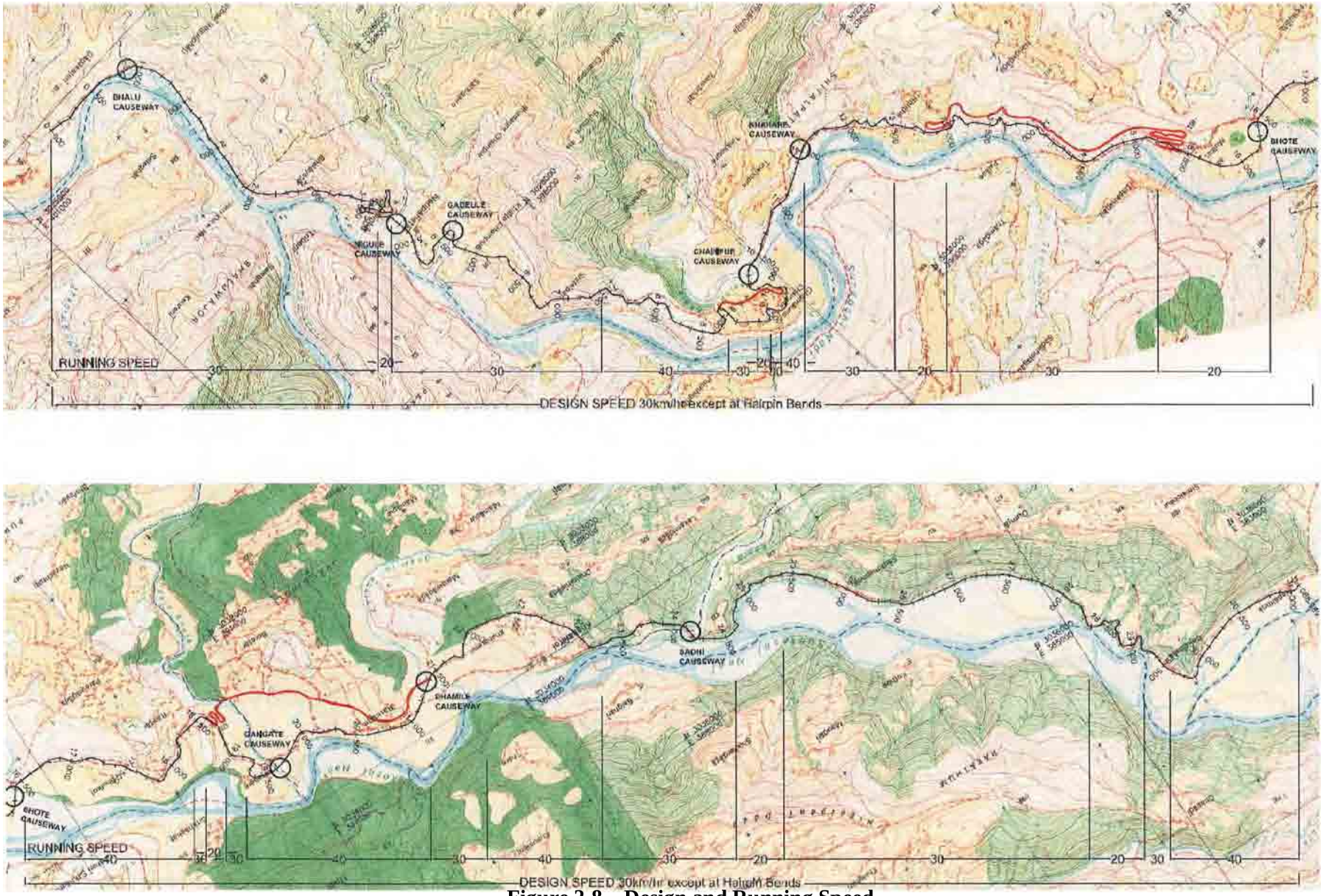
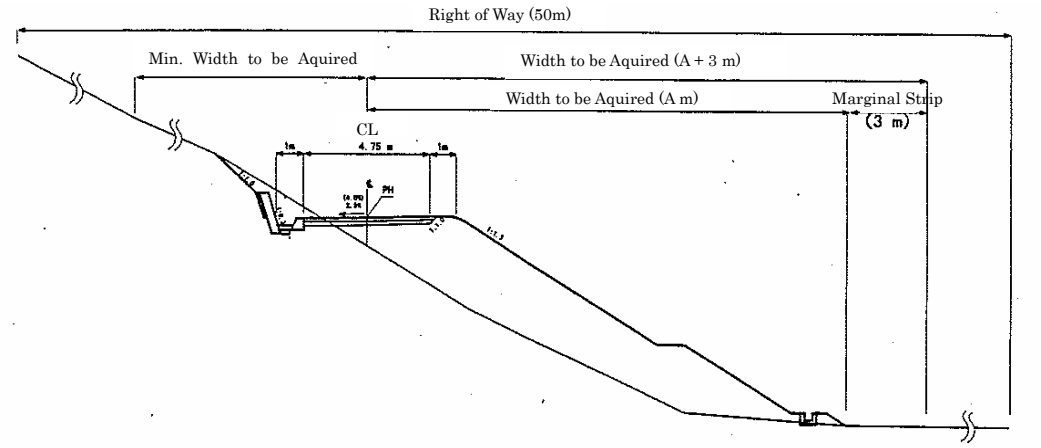


Figure 2-8 Design and Running Speed

4) Right of Way

Right of way for the road is 50m wide. However, land to be acquired is 15m on both sides from the centerline, or the width necessary for the construction with a marginal strip of 3m, as shown in Figure 2-9.



Source: Study Team

Figure 2-9 Right of Way and Land to be Acquired

(2) Road Facility Plan

1) Geometric Design

i) Points for Alignment Setting

The following are points where special attention should be paid in setting the alignment, in terms of traffic safety, maintenance of road surface and smoothness of traveling. These were realized based on experiences in Section II and Section IV.

1) Combination of Tangent and Radius of Horizontal Curve (in case actual running speed would exceed set speed)
   - For the section subject to a design speed of 30km/hr, minimum radius of horizontal curve connected to tangent, which is longer than 40m and with descending grade of greater than 8%, should be 45m. (adopt the minimum radius for running speed of 40km/hr)
   - For the section subject to a running speed of 20km/hr, minimum radius of horizontal curve connected to tangent, which is longer than 40m, should be 25m. (adopt a minimum radius of design speed of 30km/hr, except for hair-pin curves)
   - For the section subject to a running speed of 20km/hr, minimum radius of horizontal curve connected to tangent, which is longer than 40m and with descending grade greater than 8%, should be 45m. (adopt the minimum radius for running speed of 40km/hr)

2) S-Curve

Ratio of large and small circle radii (R1 : R2) should be less than 1 : 2.0.

3) Compound Curve

Compound curves should not be adopted as much as possible. In case this could not be avoided, radius of larger circle, R1, should be equal or less than twice the radius of smaller circle, R2.

ii) Widening of Curve

Inside part of the curve has to be widened so that semi-trailers could pass within the road width. Widening can be calculated based on the formula for widening for semi-trailer, as per Japanese Road Structure Ordinance. Volumes of widening by radius of curve are shown in Table 2-6.

Table 2-6 Widening of Curve

Radius of Curve (m)	Widening (m)
25	0.50
20	1.00
15	2.25

Source: Study Team

iii) Securing Sight Distance

Sight distance should be secured properly especially in mountainous roads. Since the road has only one lane, it needs twice the sight distance of two-lane roads. However, due to topographical conditions and environmental considerations, sight distance in some sections would have to be shorter than necessary. In the Project, therefore, a minimum 30m sight distance was secured, and 40m at locations where vehicles are allowed to travel with a higher speed. Additional widening to secure such sight distance was set as shown in Table 2-7.

$$E=D^2/(8R)$$

where, E = Necessary Width (m)
D = Sight Distance (m)
R = Radius (m)

Table 2-7 Additional Widening for Sight Distance (m)

Radius (m)	Carriageway Width (m)	Running Speed 30km/hr		Running Speed 40km/hr	
		Min. 30m		40m	
		Necessary Width	Additional Widening	Necessary Width	Additional Widening
25	3.875	4.50	1.0	-	-
30	3.375	3.75	0.5		-
45	3.375	-	-	4.45	1.5
50	3.375	-	-	4.00	1.0
55	3.375	-	-	3.64	0.5

Source: Study Team

iv) Super-elevation of Curve and Minimum Curve Length

Since the running speed on the road could be high due to its open roadside view and its alignment having less curves, and since the rainfall is minimal at site, super-elevation for DBST could be set to 2.5%, considering traffic safety and ease of road surface maintenance. In other case, the super-elevation could be set in accordance with design (running) speed and horizontal curve radius as shown in Table 2-4. To minimize slope failures on the valley side, super-elevation should be inclined to the mountain side (if parabola opens to the valley side, this becomes reverse super-elevation), at curves with radius larger than a certain defined value. Minimum length of curve should be set as shown in Table 2-8, considering the balance of running comfort and drivability.

1) Super-elevation

$$e = \frac{V^2}{127R} - f$$

where, e = Super-elevation (%)

V = Design speed (km/hr)

R = Radius (m)

f = Coefficient of friction (= 0.15)

Table 2-8 Super-elevation at Curves

Design (Running) Speed V (km/hr)	Radius (m)	Super-elevation (%)			Remarks
		Calculated value	Integral number	Design value	
30	50 -	-0.82	-1	-2.5% to mountain side	Reverse super-elevation if parabola opens to the valley side.
	45	0.75	1	2.5	
	40	2.72	3	4	
	35	5.25	5	4	
	30	8.62	6	6	Max. 6%
	25	13.35	6	6	Max. 6%
（20）	25 -	-2.40	-2	-2.5% to mountain side	Reverse super-elevation if parabola opens to the valley side.
	15・20	6.00	6	6	Max. 6%

Source: Study Team

2) Minimum Length of Curve

$$L_c = \frac{Vt}{3600}$$

where, Lc= Minimum length of curve (m)

V = Design speed

t= Running time（3 seconds）

Table 2-9 Minimum Length of Curve

Design (Running) Speed V (km/hr)	Lc (m)
（40）	35 [30]
30	25 [20]
（20）	20

[ ] shows minimum values from topographical or existing road conditions.
Source: Study Team

v) Run-off Length for Super-elevation, Widening and Sight Distance

1) Super-elevation

$$Ls = 0.01(S2 - S1) \times n1 \times (W/2 + We)$$

where, Ls: Run-off length for super-elevation (m)

S: Super-elevation (%)

n1: Run-off ratio (Japanese Road Structure Ordinance)
Design speed 40km/hr: n1=100
30km/hr: n1=75
20km/hr: n1=50

W: Standard road width (m)

We: Widening (m)

Larger value is to be adopted after the comparison with run-off length for widening.

2) Widening

$$Ln = We \times n2$$

where, *Ln:* Run-off length for widening (m)

We: Widening (m)

n2: Run-off ratio (Japanese Road Structure Ordinance)
Design speed 40km/hr: n2=20
30km/hr: n2=15
20km/hr: n2=10

Calculation results are shown in Table 2-10.

Table 2-10 Run-off Length for Widening (Calculated Value)

Widening (m)	Run-off Length (m)		
	20km/hr	30km/hr	40km/hr
0.50	5.0	7.5	10.0
1.00	10.0	15.0	20.0
1.50	15.0	22.5	30.0
2.25	25.0	-	-

Source: Study Team

3) Standard Length of Run-off

Standard run-off length for widening is longer than that of super-elevation. The Japanese Road Structure Ordinance stipulates that run-off length for a design speed of 30km/hr is 25m. Thus, 25m was adopted as the run-off length.

vi) Vertical Grade at Hair-pin Curves

Vertical grade at hair-pin curves with radius of 15m/20m should not exceed 5% similar to the other sections, where, Japanese Road Structure Ordinance stipulates combined grade of 8% considering rolling of vehicles at curves, sliding and movement of cargo.

2) Slope Works

Cut and embankment slopes were designed considering standard slope grades stipulated in the

Highway Earthwork Series, Slope Protection Manual, Japan Road Association and adopted grades in preceding road sections. Standard works was set in accordance with the geological condition and height of the slope.

i) Concepts for Slope Works

Plan of slope works was formulated based on following concepts which are also responses to the review comments from the JICA Council.

1) Apply vegetation to stable rock and/or soil slopes as much as possible
2) Adopt other slope protection works for slopes with unstable surface
3) In case cutting with stable slope cause large-scale cutting, grade should be steeper and adopt slope protection works by structure
4) Adopt slope protection works which are applied widely in Nepal as much as possible
5) No protection works would be applied to small-scale stable rock slopes from the viewpoint of cost saving

ii) Slope Grades to be Adopted

1) Standard Slope Grades

Based on the Slope Protection Manual, standard grades for the Project was set as shown in Table 2-11 and Table 2-12.

Table 2-11 Standard Slope Grades for Cutting

Type of Slopes		Grade
Rock		1:0.3 - 1:0.8
Soft Rock		1:0.5 - 1:1.2
Sandy Soil	Dense	1:0.8 - 1:1.0
	Loose	1:1.0 - 1:1.2
Gravel, Soil	Dense	1:0.8 - 1:1.0
	Loose	1:1.0 - 1:1.2

Source: Slope Protection Manual, Japan Road Association
Note: Except for special cases, such as failure prone slopes and large slopes.

Table 2-12 Standard Slope Grades for Embankment

Embankment Material	Height（m）	Grade
Good Grading Sand, Gravel	< 5m	1:1.5 - 1:1.8
	5 - 15m	1:1.8 - 1:2.0
Crushed Rock	< 10m	1:1.5 - 1:1.8
	10 - 20m	1:1.8 - 1:2.0
Sandy Soil	< 5m	1:1.5 - 1:1.8
	5 - 10m	1:1.8 - 1:2.0

Source: Slope Protection Manual, Japan Road Association
Note: Except for special cases, such as large slopes.

2) Slope Grades and Geological Conditions for Cutting Slope

Slope grades for cutting slope was set based on the standard slope grade shown in Table 2-11. However, it is more practical to classify grades based on geological conditions. Table 2-13 shows slope grades for cutting slope classified based on topographic map reading, and observed information on the exposed rock and deposit situation during the site survey.

Table 2-13 Slope Grades and Geological Conditions for Cutting Slope

Mark	Geological Classification		Classified Slope Grade
	Major	Minor Classification	
A	Soil	Colluviums (Gravel)	1:0.8 - 1:1.2
B	Soil	Colluviums (Soil)	1:1.0 - 1:1.5
C	Soil	Terrace deposit (Red soil)	1:1.0 - 1:1.5
D	Soil	Terrace deposit (Rock, Gravel)	1:0.6 - 1:1.0
E	Soft Rock	Hardly weathered Slate	1:0.6 - 1:1.2
F	Soft Rock	Weathered and joint developed Slate	1:0.5 - 1:0.8
G	Rock	Slate	1:0.3 - 1:0.5
H	Soft Rock	Hardly weathered Schist, Phyllite	1:0.8 - 1:1.2
I	Soft Rock	Weathered and joint developed Schist,	1:0.5 - 1:1.0
J	Rock	Schist, Phyllite	1:0.3 - 1:0.5

Source: Study Team

iii) Slope Protection Works be Adopted

1) Slope Protection Works by Vegetation

Protection works by vegetation will be adopted since these provide advantages to the intended harmonizing of road with its surrounding environment and scenery. However, slopes of stable rock will not be vegetated since plants are expected to invade the slopes from adjacent areas. Vegetation works are not sufficient in terms of slope stability for unstable slopes, in such case, cutting at stable grade or slope protection by structures are considered.

Vegetation targets for each classification of area where vegetation will be executed are set as shown in Table 2-14, considering local vegetation situation and constructed slopes in the other sections.

Table 2-14 Classified Areas and Vegetation Target

Classification of Area	Vegetation Target
Cultivated area	To establish plant community consisting of grasses with shrubs expecting assimilating surrounding environment, without care in selecting suitable kind of plants for the slope grade and geology on sites.
Shrub area	To establish plant community consisting of grasses with trees and shrubs expecting assimilating surrounding environment, without care in selecting suitable kind of plants for the slope grade and geology on sites.
Forest area	To establish plant community consisting of trees, shrubs and grasses almost same as the surrounding revegetation within several years, without care in selecting suitable kinds of plants for the slope grade and geology on sites.
Dried Area	To establish plant community consisting of grasses with shrubs with resistance to dryness and strong wind, expecting assimilating surrounding environment without care in selecting suitable kind of plants for the slope grade and geology on sites.

Source: Study Team

2) Slope Protection Works by Structure

Protection works by vegetation are not enough in terms of stability for sections where steeper than standard grades shown in Table 2-13 has to be adopted due to topographic conditions, etc. In such cases, protection works using structures such as cribwork, retaining wall, and others would be considered.

3) Types of Slope Protection Works and Slope Category and Characteristics

Selection of the type of slope protection works was done based on slope category and characteristics, and the need for vegetation. Furthermore, works which have been adopted in other sections of Sindhuli Road, and other works widely used in Nepal, were adopted considering construction cost and ease of maintenance.

Types of slope protection works, slope category and characteristics are shown in Table 2-15.

Table 2-15 Vegetation Objectives and Land Use

Slope Classification		Embankment		Cutting					
				Soil		Soft Rock		Rock	
Slope Characteristics		Easy to be eroded	Stable to an erosion	Easy to be eroded	Stable to an erosion	Easy to be eroded and weathered	Stable to an erosion and weathering	Many Cracks and possible rock fall	Stable rock or keeped stable slope
Geology		B,C	A,D	B,C	A,D	E,F,H,I		G,J	
No Protection Work									◎
Vegetation	Sodding	○	○	○	○	○	○		
	Stepped sodding			○	○	○	○		
	Grass striping	○	◎	○	◎	○	◎		
	Sodding with straw	○	○	○	○				
	Tree planting	○	◎	○	◎	○	◎		
	Planting tree cuttings	○	◎	○	◎	○	◎		
	Earthbags with sodding	○	○	○	○				
Structure	Wet masonry	◎		◎	○	◎	○	○	
	Cast-in-place concrete crib (earth-filled)	◎		◎	○	◎	○		
	Cast-in-place concrete crib (stone-filled)	◎		◎	○	◎	○		
	Shotcrete					○		◎	
	Earth reinforcing					○		◎	
	Gabion	◎	○	◎	○	◎			
	fencing	○	○	○	○	○			

Legend) ◎:Use ○:Occasional use

Note)

①In case it is impossible to secure stable slope by vegetation only, structure will be adopted.

②In case of possible rock-fall, rock-fall prevention work will be considered.

③In case of topographical restriction, geotexitle reinforced earth wall will be considered.

Source) Study Team

4) Types of Slope Protection Works and Slope Grade and Height

Types of slope protection were selected considering construction in preceding sections of Sindhuli Road and their stability. Table 2-16 shows types of slope protection works classified according to slope grade and height.

Table 2-16 Slope Protection Types and Slope Grade and Slope Height

Slope Classification	Geology	Slope Protection Work	Grade	Height
Cutting	Rock	No Protection Work	1:0.5	≦7 m (*1)
		No Protection Work	1:0.3	≦5 m
		Wet Masonry	1:0.5	≦7 m
		Shotcrete	1:0.3	≦7 m (*1)
	Soft Rock	Vegetation	1:0.8	≦7 m (*1)
		Wet Masonry	1:0.5	≦7 m
		Cast-in-place Concrete Cribwork + Rebar Reinforced Earth Wall	1:0.8	≦7 m (*1)
	Soil (w/ Gravel)	Vegetation	1:1.0	≦7 m (*1)
		Wet Masonry	1:0.5	≦7 m
		Cast-in-place Concrete Cribwork	1:1.0	≦7 m (*1)
	Soil (Red soil)	Vegetation	1:1.5	≦7 m (*1)
		Wet Masonry	1:0.5	≦7 m
		Cast-in-place Concrete Cribwork	1:1.2	≦7 m (*1)
Embankment	Sandy Soil with Gravel	Vegetation	1:1.5	≦5 m
			1:1.8	5～10 m
		Gravity Wall	1:0.02	≦3 m
			1:0.5	≦3 m
		Wet Masonry	1:0.5	≦5 m
		Compound Wall	1:0.5	≦15 m
		Gabion Wall	1:0.1	≦7 m
			1:0.3	≦7 m
			1:0.5	≦7 m
		Geotextile Reinforced Earth Wall（w/o anchor）	1:0.1	around 12 m
		Geotextile Reinforced Earth Wall（w/ anchor）	1:0.1	around 20 m

Note（*1）Maximum height would be 8m for the top step.
Source: Study Team

3) Pavement

Base course will be 30cm (two layers), composed of 15cm river gravel and 15cm crushed stone. DBST will be provided from the viewpoint of traffic safety, environmental consideration and protection of road structure.

Furthermore, as carried out in Section II, a 15cm-thick asphalt concrete pavement (surface course 5cm, intermediate course 5cm and binder course 5cm) will be provided to avoid transformation of road surface due to lateral force in curves with running speed of 20km/hr

and with radius of less than 20m including hair-pin curves. It will also be provided in curves with running speed of 20km/hr and with radius of 25m and with length of 25m (running time is more than 4 seconds).

4) Slope Protection and Landslide

Avoidance of risky areas referring to hazard map prepared in this Study was considered primarily as countermeasures against slope failure (mainly, surface failure) and landslide (or large slope failure). In case it was impossible to avoid such areas, where large-scale countermeasures including anchoring and piling can not be adopted, the following countermeasures were planned.

i) Slope Failure

1) Avoidance of large-scale cutting and adopting a cutting slope height within 7 – 10m.
2) Installation of retaining wall (wet-stone masonry, gabion) at the toe of the slope.
3) Installation of cribwork in cases where it is impossible to secure stable grade above the toe.
4) Adoption of earth reinforcement using re-bars on rock slope, in cases where the stable grade may cause large-scale cutting.

ii) Landslide

1) Avoidance of areas where large-scale countermeasures will be necessary.
2) To increase stability, a loading berm will be adopted when alignment will pass the bottom of the landslide, and cutting when it passes the top of the landslide.
3) Pocket will be secured between road and mountain side slopes in case of small-scale failures.

iii) Specific Risky Area

It was confirmed that special attention should be paid to following three areas shown in Figures 2-10 to 2-12 in term of road planning. Countermeasures for each area are proposed as shown below.

1) Collapse Area at Bhalayetar (STA.3+400)

[Topographical and Geological Conditions]

Collapsed soils piled at about 10m away from Sunkoshi River and rocks existing 60-70m above riverbed form a steep slope with grade of 45 degrees. Slate formed from hard and medium-hard rocks are exposed at steep slope surface.

[Countermeasures]

It is thought that the collapse was caused by stream water and will possibly be expanded. However, as the collapse is not expected to infect to upper potion of the slope considering

current situations, the alignment should detour collapsed area and traverse rock area at mountainous side.

Source: Study Team

Figure 2-10 Collapse Area at Bhalayetar (STA.3+400)

2) Collapse Area at Mulkot (STA.15+200)

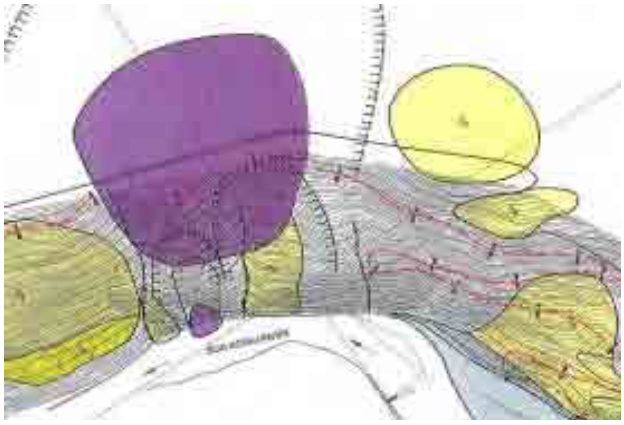
[Topographical and Geological Conditions]

This is currently being collapsed area located at steep slopes where Sunkoshi River strikes. This collapse locates at lower potion of a large landslide behind the collapse. It can be unstable in case the failure of lower slope expands. Weathered slate is distributed at surface and is mostly loosened.

[Countermeasures]

It is thought that the collapse was caused by strikes of Sunkoshi River. As the collapse is located at lower potion of a large-scale landslide, in case the collapse expands, it will possibly affect to the upper potion of the slope. The landslide behind the collapse does not look active, however due to its large scale, countermeasures against the sliding becomes costly. Therefore, it would be cost-effective that the alignment to traverse mountainous side detouring collapse areas as much as possible. However, the landslide block is too large to avoid completely, continuous monitoring displacement and/or deformation of the landslide block would be necessary.

The monitoring is conducted up to October by Study Team, and GON would take over it at the completion of this Study. Therefore, a technology transfer seminar on the landslide monitoring was held and monitoring equipments composed of 24 tiltmeters (for 12 locations), pvc pipes with strain gauge of 65m (for 3 holes), extensometer of 130m (for 3 holes) and one hyetometer would be granted at the completion of this Study.



Source: Study Team

Figure 2-11 Collapse Area at Mulkot (STA.15+200)

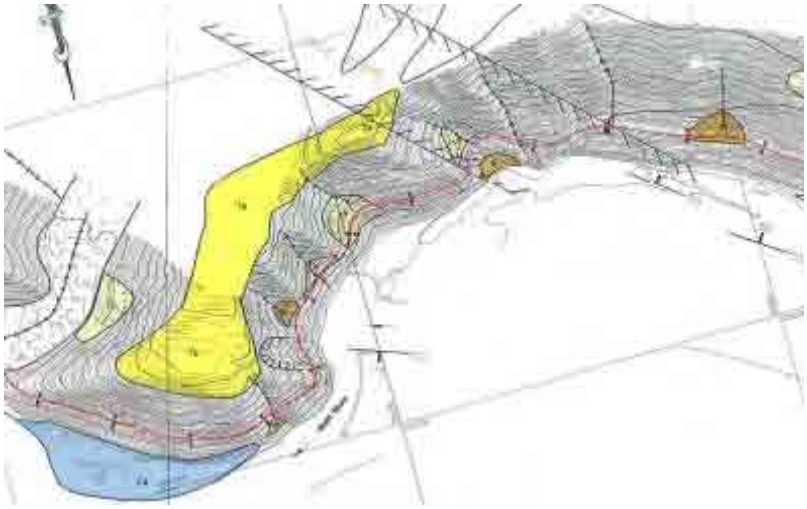
3) Steep Rock Area and Fault at Sadhi (STA.26+700)

[Topographical and Geological Conditions]

This is a large-scale steep slope between Sunkoshi River and Sadhi River. Slate is exposed and the rock at fracture zone has formed to phyllite.

[Countermeasures]

As rock exposed at surface is partially loosened at upper potion, cutting slopes it should be as limited as possible and should be protected using re-bar reinforcement and shotcrete.



Source: Study Team

Figure 2-12 Steep Rock Area and Fault at Sadhi (STA.26+700)

5) Drainage

i) Return Period of Rainfall

Return period of rainfall for the design of drainage facilities and river crossing structures will

be set as shown in Table 2-17.

Table 2-17 Return Period for Drainage Facilities

Facility	Application Condition	Return period (Year)
Side ditch	for road surface and small-scale slopes	3
Cross drain (Culvert) A	for large natural slopes	5
Cross drain (Culvert) B	for important large natural slopes	10
Channel works A	for important drainage in terms of road management	25
Channel works B	for important drainage on the large-scale embankment	50
Causeway	for mud flow	50

Source: Study Team

ii) Frequency Analysis of Rainfall

The frequencies of annual maximum daily rainfall of stations near the Project area, were analyzed. Annual maximum daily rainfall time series of Melung, Hariharpur Gadhi, Nepalthok and Sindhuli Gadhi stations were analyzed for the period shown below.

Sindhuli Gadhi: 1956-2007
Nepalthok: 1948-2004
Hariharpur Gadhi: 1978-2002
Melung: 1959-1999

Results of Lognormal (LN) distribution fitting of maximum rainfalls for four stations are shown below.

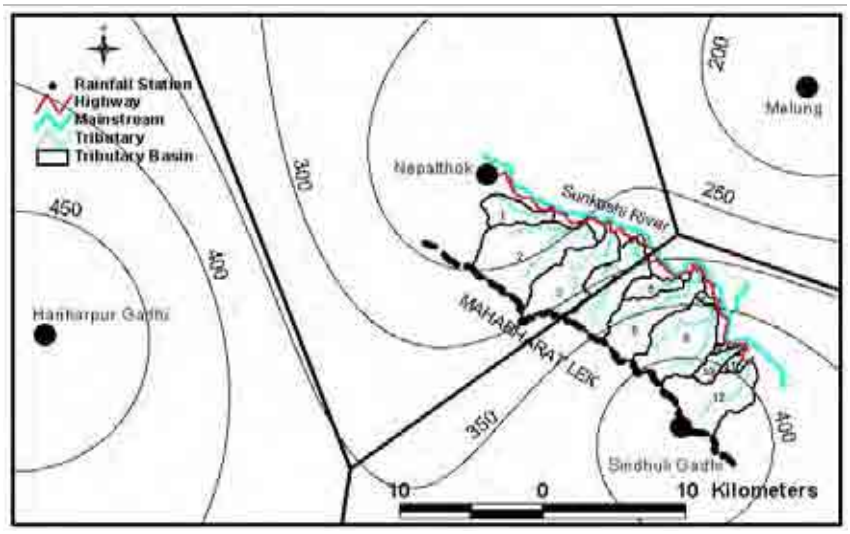
Table 2-18 Design Daily Rainfall in the Project Area

Station	Design Daily Rainfall in the Project Area (mm/day)					
	2 Year	3 Year	5 Year	10 Year	25 Year	50 Year
Sindhuli Gadhi	169	206	245	300	368	423
Nepalthok	86	106	126	154	190	218
Hariharpur Gadhi	173	215	261	325	407	475
Melung	72	86	102	124	151	172

Source: Study Team

iii) Basin Rain Determination

In the Project area, basins of 12 tributaries of Sunkoshi River have to be considered for the rainfall-runoff process analysis. The basin rainfall for the analysis in tributaries were determined by developing the Thiessen Polygons. The Thiessen Polygons developed from rainfall data of Sindhuli Gadhi, Nepalthok, Hariharpur Gadhi and Melung stations is shown below.



Source: Study Team

Figure 2-13 Thiessen Polygons for Return Period of 50-Year

Since the Melung and Hariharpur Gadhi stations are quite far, the Project area is substantially controlled by the Sindhuli Gadhi and Nepalthok stations. Furthermore, since the Nepalthok station is located at a lower elevation compared to most parts of basins, it was considered that rainfall of Nepalthok may not properly represent the basin rainfall. Therefore, the Sindhuli Gadhi's rainfall data shown in Table 2-19 was used for runoff analysis of causeways which are important structures, and Nepalthok's rainfall data shown in Table 2-20 was used for other drainage facilities including side ditches and cross drainage.

Table 2-19 Rainfall for Causeway Design (Sindhuli Gadhi data)

Return Period	2	3	5	10	25	50
Rainfall (mm/day)	169	206	245	300	368	423

Source: Study Team

Table 2-20 Rainfall for Drainage Facilities Design (Nepalthok data)

Return Period	2	3	5	10	25	50
Rainfall (mm/day)	86	106	126	154	190	218

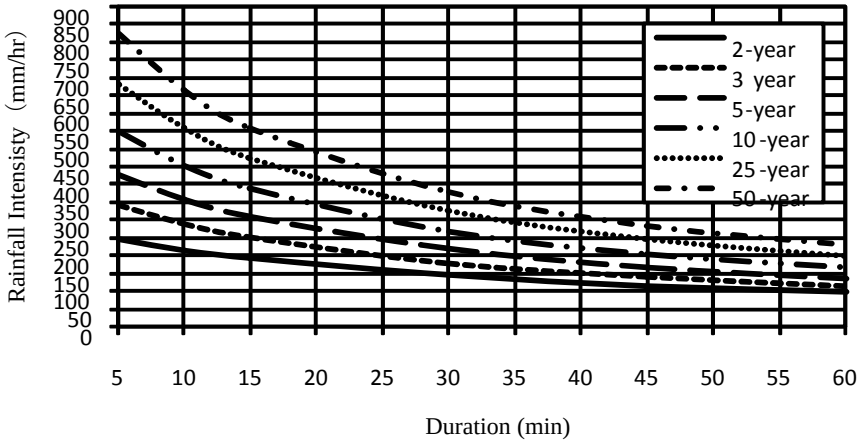
Source: Study Team

iv) Rainfall Intensity Analysis

Since the rainfall intensity analysis of Section II was conducted in the Study by using rainfall data of the Kathmandu Airport station, the result of that analysis was utilized for the rainfall intensity analysis of the Project. That is, the rainfall intensities of Sindhuli Gadhi and Nepalthok were calculated by using the 24-hour rainfall data of Sindhuli Gadhi and Nepalthok, and the ratio of short duration rainfall depths and 24-hour rainfall of Kathmandu Airport.

Rainfall intensity curves for Sindhuli Gadhi and Nepalthok calculated in the above-mentioned

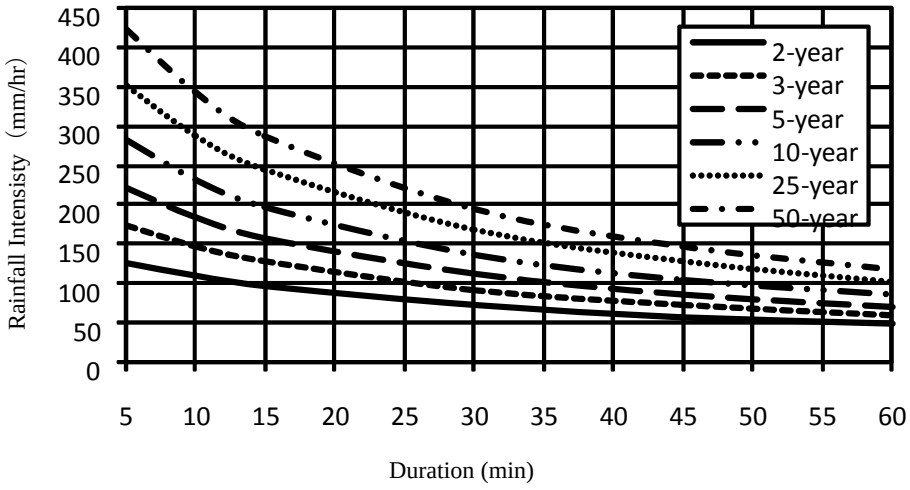
manner are shown in Figures 2-12 and 2-13.



Source: Study Team

Figure 2-14 Rainfall Intensity Curve for Sindhuli Gadhi

Based on Figure 2-12, the rainfall intensity for causeway design, at a duration of 60 min and a return period of 50 years is 228mm/hr.



Source: Study Team

Figure 2-15 Rainfall Intensity Curve for Nepalthok

Based on Figure 2-13, the rainfall intensity for drainage facilities design at a duration of 10 min is 150mm/hr, 230mm/hr, 290mm/hr and 350mm/hr for the return periods of 3 years, 10 years, 25 years and 50 years, respectively.

v) Runoff Calculation

Runoff calculation was made using the rational formula given below. Velocity was calculated using Manning's formula. Since the Highway Earthwork Series, Drainage Manual, Japan Road Association stipulates run-off coefficient for steep mountainous to be 0.75 – 0.90, a coefficient of 0.8 was adopted for important drainage and 0.4 for ordinary drainage and small-scale drainage.

$$Q = 1/3.6 \times C \times I \times A$$

where, Q= Peak discharge (m^3/sec)

C= Runoff coefficient

I= Rainfall intensity (mm/hr)

A= Catchment area (km^2)

vi) Side Ditch

According to the recommendation from "Road Safety Note 2, Designing Safe Side Drains, Traffic Engineering and Safety Unit, Design Branch, Department of Roads, November 1996", for traffic safety, side ditches were designed with a depth of 45cm or shallower and with a bottom width of more than 40cm. Types and cross sectional shapes are the same as those along the Section II road. However, as the outlets of drains should be planned at safe locations considering possible slope disaster, there are exceptional cases where side ditches need to be long, with large cross sections. Furthermore, in cases where the super-elevation inclines to the valley side and rainfall flowing as well towards the valley side, concrete blocks will be installed to guide water to appropriate locations, considering running comfort and reduction of surface damage.

vii) Cross Drain

Minimum diameter size of cross drain pipes is 60cm following the design guideline in the Classification and Design Standards for Feeder Roads (Second Revision), 1994, DOR.

Where the land within the right of way is not geologically stable, drainage structures should be extended and the outlet facilitated at appropriate locations. Types and shapes are similar to those adopted in Section II.

viii) Channel Works

In cases where the same stream crosses the road at several locations, on a zigzag pattern and/or where the bed soil condition is in danger of erosion at the outlet of discharge, appropriate channel works should be planned.

ix) Irrigation Channel

Irrigation channels located along the alignment and affected by the Project will be replaced with same scale channels or cross drain pipes with minimum diameter of 45cm. Locations and radius of cross-section of irrigation channel in the Section III is shown in Table 2-21.

Table 2-21 Location and Radius of Irrigation Channel

Location (STA)	Radius (mm)	Location (STA)	Radius (mm)	Location (STA)	Radius (mm)
4+350	600	18+535	600	24+100	450
4+390	600	18+565	450	24+120	450
4+480	600	18+660	1,200	24+140	450
5+740	600	19+070	600	24+200	600
8+650	1,200	19+240	600	24+265	450
9+610	900	19+360	600	24+285	450
9+940	900	19+580	450	24+340	450
17+140	1,200	19+665	600	24+370	450
17+360	900	19+720	600	24+380	900
17+470	600	19+840	600	31+330	600
17+530	600	20+780	600	31+390	600
17+550	600	21+140	1,200	31+490	600
17+650	600	21+980	600	31+780	600
17+740	600	22+180	600	32+160	600
17+840	600	23+280	600	32+620	600
17+925	600	24+000	600	32+920	600
18+000	600	24+020	450	-	-
18+460	600	24+065	450	-	-

Source: Study Team

6) Retaining Wall

In cases where retaining walls are necessary to be installed, suitable type should be selected in accordance with Table 2-22.

Table 2-22 Selection Criteria for Retaining Wall Type

Type	Height	Geology	Conditions
Boulder mixed Concrete Gravity Wall	less than or equal to 3m	Sandy soil or more stable	* Steep (45°) at valley side, but wall height can be low * Concrete can be provided easily.
Wet Stone Masonry Wall	less than or equal to 5m (Embankment) less than or equal to 7m (Cutting)	Sandy soil or more stable	* Moderate slope at embankment side (30 - 35°) including revetment. * To hold unstable mass at surface of fracture zone at cutting side. * Concrete can be provided easily
Compound Wall (Wet Stone Masonry + Gravity Wall)	less than or equal to 15m (Embankment)	Sand/Gravel or more stable	* Wall higher than 5m at valley side * Gravity foundation is adopted for the wall higher than 5m * Concrete can be provided easily
Gabion Wall (t=1.0m or 0.5m)	less than or equal to 5m (Embankment) less than or equal to 7m (Cutting)	Sandy soil or more stable	* Embankment and/or collapsed section and/or landslide block with much seepage water. * Concrete materials need not be procured, and thus all works have to be done by labor manpower.
Gabion Wall (Special Type) (t=0.5m)	range from 5m to 7m or under (Embankment)	Soft rock or more stable	* Wall height exceeding 5m, and due to steep topography, concrete can not be placed and all works have to be done by labor manpower. * Boulder materials are available.
Geotextile Reinforced Earth Wall (without anchor)	Exceeding 7m	Sandy soil or more stable	* In cases where concrete wall and/or gabion wall is (are) not appropriate.
Geotextile Reinforced Earth Wall (with anchor)		Hard/Medium rock or more stable	* Narrow working space; there should be an existing hard rock that can be used for anchoring
Wet Stone Pitching	less than or equal to 10m (Embankment)	Sand/Gravel or more stable	* Revetment protection works with a slope grade of 1:1.0 or milder
Concrete Leaning Wall	less than or equal to 7m (Cutting)	Soft rock or more stable	* Collapsed sections with loose original ground without seepage water * For foot protection of unstable rock at upper side of slope * For protection against comparably large rock-fall from upper side of slope
Replacing Concrete	—	Soft rock or more stable	* Supporting layer for foundation is inclined and/or in no good condition

Source: Study Team

7) Revetment, Countermeasures against Scouring and Outflow of Back-fill Material

i) Basic Policy

Where the road is to be constructed inside the river flood plain, the road surface level was designed at a height considering margin for flood level and margin for rising of water level at curved flows as shown below. Compound wet-stone masonry wall with foot protection of cast-in-place concrete as revetment was adopted based on the project for Urgent Rehabilitation of Sindhuli Road (Section IV). To avoid outflow of back-fill, stable materials such as gravel will be used as back-fill materials up to the flood level and geotextile will be installed above the gravel layer.

- Road proposed height ≥ Design flood level (50 years) + rising at curved flow +

margin

- Structure of revetment: Wet-stone masonry compound wall
- Countermeasures against scouring: considering maximum souring depth, concrete foot protection that is effective to movement and outflow of soils
- Thickness of foot protection: 1.2 – 0.9m considering flow velocity
- Length of foot protection: 6m from design scouring depth

ii) High Water Level estimated at Return Period of 50-Year

1) Hydraulic Analysis

Hydraulic analysis was conducted using HEC-RAS developed by the Hydrologic Engineering Center, US Army Corps of Engineers. The unsteady flow simulation module of HEC-RAS solves the Saint Venant equations intended for determining the conservation of continuity and momentum.

Equation for conservation of continuity:

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = q$$

Equation for conservation of momentum:

$$\frac{\partial Q}{\partial t} + \frac{\partial (Q^2 / A)}{\partial x} + gA(\frac{\partial h}{dx} + S_f) = 0$$

The friction slope S_f is estimated using Manning's equation given as:

$$S_f = \frac{n^2 \mid Q \mid Q}{A^2 R^{4/3}}$$

Where,

Q	=	River flow (m^3/s)
A	=	Cross-sectional area of flow (m^2)
q	=	Lateral inflow per unit distance ($m^3/s/m$)
X	=	Longitudinal distance (m)
t	=	Time elapsed (s)
S_f	=	Friction slope
h	=	Water surface elevation (m)
R	=	Hydraulic radius (m)
n	=	Manning's friction coefficient

g = Acceleration due to gravity (m/s^2)

2) High Water Level

High water levels estimated at a return period of 50-year for tributaries of Sunkoshi River and main stream of Rosi and Sunkoshi River are shown in Table 2-23. Hydraulic calculation is presented in Appendix 6-1.

Table 2-23 HWL of Each Tributary at Return Period of 50-Year

Tributary/River (at crossing point)	H.W.L (m)	River (at sectional point)	H.W.L (m)
Bhalu Khola	464.07	Rosi CH31+000	546.40
Niguli Khola	481.46	Rosi CH30+800	544.85
Gadaule Khola	509.86	Rosi CH30+600	542.18
Chainpur Khola	492.50	Rosi CH30+400	540.05
Khahare Khola	485.41	Rosi CH30+200	537.73
Bhote Khola	503.17	Rosi CH30+000	536.40
Gangate Khola	534.78	Sunkoshi CH28+500	523.18
Dhamile Khola	522.76	Sunkoshi CH28+000	521.64
Sadhi Khola	529.76	Sunkoshi CH27+500	519.88
Andheri Khola	502.24	Sunkoshi CH27+000	519.31
Jagire Khola	501.90	Sunkoshi CH26+500	516.94
Bhadaure Khola	485.71	-	-

Source: Study Team

iii) Margin for the Rise in Water Level due to River Curve

1) Rise in Water Level

Road profile was defined based on the rise in water level due to river curve, in addition to the ordinary high water level. Rise in water level was estimated using the following formula. Estimated results at every point of Sunkoshi and Rosi Rivers are shown in Table 2-24 while those for Bhote Khola are shown in Table 2-25. Calculations of river flow and velocity at every point are presented in Appendix 6-1.

$$\Delta h = B \cdot U^2 / (2 \cdot g \cdot rc)$$

Where, Δh: Rise in water level outside the curved river (m)
B: River width (m)
U: Sectional average velocity (m/s)
G: Acceleration due to gravity (m/s2)
Rc: Curvature of river

Source: page 123, Draft Technical Standard for River Training and Sabo, Ministry of Construction, Japan

Table 2-24 Rise in Water Level at Curve Section of Sunkoshi and Rosi Rivers

River/Flow	Station	River width (m)	Velocity (m/s)	Curvature (m)	WL rise Δh/2 (m)
Sunkoshi 4,749m3/s	28+600	414	5.00	1,000	0.53
	29+100	768	3.06	1,000	0.37
	29+600	687	4.26	1,000	0.64
	30+080	431	5.09	1,000	0.57
	30+500	357	5.38	1,000	0.53
	Design				0.60
Rosi 1,080m3/s	31+880	280	2.30	500	0.15
	32+100	180	4.82	600	0.36
	32+320	230	4.33	400	0.55
	32+500	110	4.06	200	0.46
	Design				0.50

Source: Study Team

Table 2-25 Rise in Water Level at Curve Section of Bhote River

River/Flow	Station	River width (m)	Velocity (m/s)	Curvature (m)	WL rise Δh/2 (m)
Bhote 916m3/s	18+200	40	8.76	110	1.42
	18+155	50	7.74	200	0.76
	18+085	81	5.08	400	0.27
	Design				1.50

Source: Study Team

2) Margin

Since the profile of the road section along Sunkoshi River is located at a much higher elevation than the water level of the river, enough margins should be secured to mitigate impact of cutting of the natural environment. However, the top of the foundation of retaining wall should be set at a high elevation to minimize the effects caused by the river flow. The regulation for the structures of river facilities of Japan stipulates that the margin for the flow of 2000m3/s - 5000m3/s should be more than 1.2m. However, since the foundation will be made of concrete, a value of 0.6m (half of the stipulated standard) was adopted from the viewpoint of cost saving, without compromising structural suitability.

On the other hand, since the profile of the road section along Rosi River is controlled by the water level of the river, and since its flow is 500m3/s – 2000m3/s, a 1.0m margin is required as per the above mentioned regulation. However, since the hydraulic condition of the river is influenced by the topographic features and meander is extremely unique, the higher value 1.2m was adopted from the safety aspect. For Bhote River, which has lesser problems, a 1.0m margin was adopted.

3) Countermeasures against Scouring of Revetment Foundation

Maximum scouring depth was estimated to grasp the scale of scouring which is assumed to be the major cause of road subsidence and retaining wall collapses. Penetration depth of the revetment foundation and installation of foot protection was considered based on the estimated maximum scouring depth. Governing maximum scouring depth was determined from the following:

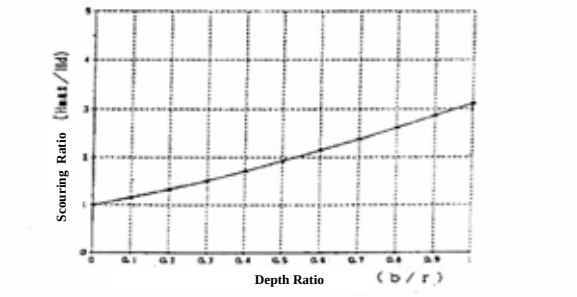
- Maximum scouring depth estimated based on hydraulic analysis
- Existing maximum scouring depth

Maximum scouring depth estimated based on hydraulic analysis

Estimated maximum scouring depth based on the hydraulic analysis at curved section, without installation of foot protection, was calculated using the following formula.

$Hmax = C \times Hd$

Where, *Hmax*: Estimated maximum scouring depth (m)
Hd: Design water depth (m) = H.W.L – Riverbed elevation
C: Depth ratio (based on *b*/*r* defined from Figure 2-14)
b: River mainstream width (m)
r: Curvature at revetment (m)



Source: page .I-15 Reference, Disaster Rehabilitation Policy for Preservation of Beautiful Nature

Figure 2-16 Chart for Determining Depth Ratio

Estimated maximum scouring depth was calculated using the following formula.

$\Delta Zs = Hmax - Hd$

Estimated maximum scouring depth of Rosi and Bhote River are shown in Tables 2-26 and 2-27, respectively.

Table 2-26 Estimated Depth of Rosi River (Without Foot Protection)

Station	H.W.L	Riverbed El.	Water Depth (m)	b (m)	r (m)	C	Hmax	ΔZs
31+880	536.50	532.99	3.51	80	500	1.3	4.56	1.06
32+100	538.56	535.73	2.83	50	Straight	1.0	-	-
32+320	540.58	538.00	2.58	80	400	1.4	2.83	1.04
32+500	542.24	540.03	2.21	110	200	2.0	4.42	2.21
Max.								2.3

Source: Study Team

Table 2-27 Estimated Depth of Bhote River (Without Foot Protection)

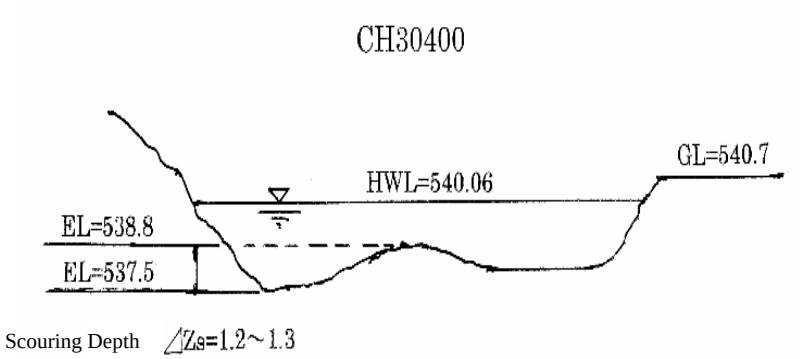
Station	H.W.L	Riverbed El.	Water Depth (m)	b (m)	r (m)	C	Hmax	ΔZs
18+200	503.17	499.49	3.68	40	110	1.6	5.89	2.21
18+155	501.97	498.00	3.97	50	200	1.4	5.56	1.59
18+085	500.23	497.17	3.06	81	400	1.3	3.98	0.92
Max.								2.3

Source: Study Team

Since the road section along Andheli River is straight, existing scouring depth was taken as the maximum scouring depth.

Existing Maximum Scouring Depth of Rosi River

Existing maximum scouring depth of Rosi River was estimated to be 1.2-1.3m based on existing topographic map and results of site survey, as shown in Figure 2-17.



Source: Study Team

Figure 2-17 Scouring Depth at Cross Section of Rosi River

Setting of Design Maximum Scouring Depth

From above, the maximum scouring depth varies from 1.0-2.2m. Thus, 2.5m was considered as the design maximum scouring depth for foundation of retaining wall.

Penetration of Retaining Wall Foundation and Foot Protection

Two methods are available in determining the penetration depth of retaining wall foundation.

These are i) adopt the maximum scouring depth without the installation of foot protection and ii) reduce the maximum scouring depth by installing foot protection.

In case of method i), although design scouring depth is 2.5m, excavation of 3m is required including the thickness to accommodate the base slab of foundation. Secondly, the construction site is near the river, thus, pump drain is necessary. Moreover, backfill material in front of the foundation toe is at risk of being washed away due to flood, significantly affecting the stability of stone masonry wall in the same manner as that for section IV.

On the other hand, in case of method ii), since the backfill material in front of the foundation toe is protected by a foot protection, scouring and outflow of material is not anticipated. Furthermore, since excavation depth can be limited, it becomes advantageous from the viewpoint of maintenance.

Therefore, foot protection was adopted with a 2m penetration depth from the lowest riverbed elevation.

4) Scale of Foot Protection

Design Velocity (Typical Velocity)

Design velocity for foot protection was estimated by multiplying the average velocity calculated from hydraulic analysis with a correction factor. Design velocity at every station of each river is shown in Table 2-28.

For outside correction factor at moving floor (α), correction for flow ($\alpha 1$) and correction for foot protection ($\alpha 2$) are used under the relationship $\alpha = \alpha 1 \times \alpha 2$. (Source: page.I-16 Reference, Disaster Rehabilitation Policy for Preservation of Beautiful Nature)

$$\alpha 1 = 1 + b/2R + \Delta Z/2Hd$$

$\alpha 2 = 0.9$ (in case of $Bw / H > 1$)

where,
- Hd: Design water depth
- b: Width of low cannal
- R: Curvature
- ΔZ: Existing maximum scouring depth
- Bw: Width of foot protection (6m)
- $H1$: Water depth above foot protection

Table 2-28 Design Velocity of Each River

River	Station	b	R	ΔZ	Hd	α1	α2	α	Av.Velocity	Design Velocity	Adopted value
Rosi	31+880	80	500	1.3	3.51	1.27	0.9	1.14	2.30	2.62	6
	32+100	50	600	1.3	2.83	1.27	0.9	1.14	4.82	5.49	
	32+320	80	400	1.3	2.58	1.35	0.9	1.22	4.33	5.28	
	32+500	110	200	1.3	2.21	1.57	0.9	1.41	4.06	5.72	
Andheli	37+290	150	∞	1.5	3.10	1.24	0.9	1.12	4.69	5.25	7 (*1)
	37+400	100	∞	1.5	2.84	1.26	0.9	1.13	6.18	6.98	
	37+500	145	∞	1.5	2.48	1.30	0.9	1.17	4.99	5.84	
Bhote	18+200	40	∞	1.0	3.68	1.14	0.9	1.02	8.76	8.93	7 (*2)
	18+155	50	∞	1.0	3.97	1.13	0.9	1.02	7.74	7.89	
	18+085	81	∞	1.0	3.06	1.16	0.9	1.04	5.08	5.28	

Source: Study Team

(*1)：Since the flow center of Andheli River changes depending on its flow and water level, STA.37+400 was adopted as the typical section and related value is set.

(*2)：Based on the existing scouring situation, the velocity of the lower Bhote River appears less than the estimated velocity due to the effect of causeway, and thus, maximum velocity of 7m/s was set.

Shape of Foot Protection

Since the design velocity in this project is high, the required foot protection becomes extensive. Therefore, from the viewpoint of constructability, foot protection shall be cast-in-place.

Shape of foot protection was determined in reference to the Project for Urgent Rehabilitation of Section IV, as shown in Table 2-29.

Table 2-29 Scale of Velocity and Foot Protection

Item	Type-A	Type-B
Design Velocity	7 m/s	6m/s
Width of 1 block	2.0 m	2.0m
Length of 1 block	2.5 m	2.5m
Thickness	1.2 m	0.9m
Weight	13.8 ton	10.3ton

Source: Study Team

Installation width of foot protection was calculated using following formula.

$$Bc = Ln + \Delta Z / \sin\theta$$

Where, *Bc*: Installation width of foot protection (m)

Ln: surface width (surface width of 1 block is 2m)

ΔZ: scouring depth

θ: slope grade of scouring (angle of repose of sand, 30°)

(Source: page 106, Mechanical Design of Revetment)

Foot protection will be installed at every section, with a 2m penetration depth deemed to mitigate the anticipated scouring depth. Required installation width was calculated using the following formula.

$$Bc = 2.0 + 2.0 / \sin 30^{\circ} = 6\text{m}$$

Therefore, installation width is 6m.

5) Policy on Countermeasures against Outflow of Backfill Material

It is realized that outflow of backfill material can be avoided by securing enough depth of penetration and installation of foot protection. Furthermore, to minimize outflow of retained materials due to varying water levels, backfill materials will be composed of boulders and gravels with a few fine graded particles.

8) Causeway

i) Basic Concept

In reference to the report of Aftercare Study for the Construction of Sindhuli Road, a causeway was adopted as fording structure for purposes of minimizing the initial investment.

The key concepts of adopting a causeway structure are to allow for some non-fatal damages caused by avalanche and sediment flow, to allow for frequent maintenance during the rainy season, with consolidation of the framework of maintenance and to tolerate road closure during peak of rainfall.

Based on the river characteristics, the options proposed as causeway structure include overflow type, box culvert type and submerged bridge type. The overflow type was finally chosen for the causeways of Sections I and IV.

However, during the service stage, problems were realized with regards to the maintenance on the wearing surface on top of the slab, due to debris flow and accumulation of debris above the road. Hence, the box culvert type was adopted as causeway structure for Section II, instead of the overflow type. The same concept was considered in the design of causeways for Section III.

ii) Design Conditions

1) Design Standards

The box culvert type causeways were designed in accordance with the standards below:

- Specifications for Highway Bridges, 2002, Japan Road Association
- Earth Works for the Road Facilities (Culvert), 2001, Japan Road Association
- Earth Works for the Road Facilities (Slope protection), 1986, Japan Road Association
- Regulation for the Structures of River Facilities, 1978, Japan River Association
- The Study for the design criteria on the transit road over devastated river, 1982, Technical Center for Sediment Control and Landslide
- Basic policy for the disaster rehabilitation with keeping the beautiful scenery, 2002, Japan Association for Disaster Prevention
- Hydraulic formula, Japan Society for Civil Engineers (JSCE)
- Classification and Design Standards for Feeder Roads (Second Revision), 1994, Department of Roads, Nepal
- Indian Road Congress (IRC) Standard

2) Characteristics of the Rivers where Causeways are Located

Causeways will be constructed at nine rivers as shown in Table 2-30. Planned road heights were determined based on the high water level, with margin provided based on flood discharge calculated from hydrological analysis.

Table 2-30 Characteristics of the Rivers

#	River Name	Station	Catchment Area (km^2)	Flow Type	Crossing Point	Flood Discharge (m^3/s)	Planning Height (m)	Max. Size of Boulder (m)
1	Bhalu Khola	STA.0+850	0.58	Sand/Gravel Flow	Sediment area	29	464.07	1.0
2	Niguli Khola	STA.4+800	21.70	Mud flow		1101	481.46	2.0
3	Gadaule Khola	STA.5+500	0.73	Sand/Gravel Flow	Sediment area	37	509.86	-
4	Chainpur Khola	STA.10+240	18.16	Mud flow		922	492.50	1.5
5	Khahare Khola	STA.11+600	4.53	Mud flow		230	485.41	0.75
6	Bhote Khola	STA.15+800	18.04	Mud flow		916	503.17	0.75
7	Gangate Khola	STA.19+600	19.03	Mud flow		966	534.78	0.70
8	Dhamile Khola	STA.21+350	28.35	Mud flow		1439	522.76	1.5
9	Sadhi Khola	STA.24+200	7.21	Mud flow		366	529.76	0.3

Source: Study Team

3) Planned Road Heights at Causeways

Planned road heights for each causeway were determined based on the calculated high water level with margin provided due to flooding.

The margin due to flood is defined as:

Margin = maximum wave height of the avalanche (sediment) (h) + margin for the avalanche (sediment) (dh) + margin for freeboard (causeway) (h_0)

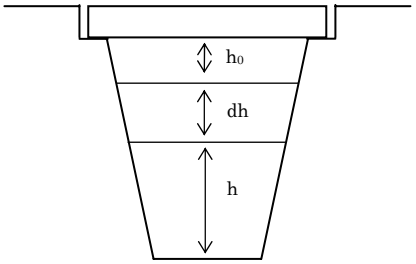


Figure 2-18 Margin for the Fording Structures

Using the same concept of Section II, the parameters are considered below:

h: calculated high water level based on hydrological analysis

dh: margin for the flood defined by 0.4*h, but not exceeding 0.8 (meter)

h_0: margin for freeboard is determined based on the table below

Table 2-31 Margins for Freeboard h0

planned high water level (m^3/s)	less than 200	from 200 to 500	from 500 to 2,000
margin for freeboard (m)	0.6	0.8	1.0

Source: Regulation for the Structures of River Facilities

Since Bhote Khola and Sadhi Khola have sharp curves at crossing points, the difference of elevation between the inside and outside of the flow, based on centrifugal movement, should be considered. The difference can be calculated using the formula given below (" Hydraulic formula" by JSCE):

$$\Delta h = m\frac{b \cdot v^2}{g \cdot r_c}$$

where,

Δh: difference of elevation

b : width of the flow

rc : curvature radius at the center of the flow

v : average velocity of the section

m : coefficient (=1)

For the purpose of minimizing the initial investment considering allowance on risks of damage, margin of passage and sedimentation of avalanche was not determined in this Study.

4) Determination of Planned Height

The planned heights determined from the conditions above are shown in Table 2-32. In this table, three causeways in the remaining section of Section II are shown as well, since their planned heights were also revised.

Table 2-32 Planning Height of Causeway in Section II

No.	river name	gradient river bed (%)	water volume (m^3/s)	H.W.L. (m)	depth (m)	LRBL (m)	gradient (%) surface (%)	⊿HWL (m)	⊿h (m)	h_0 mergin (m)	Curve flow (m)	sum of mergin (m)	height of lower surface	thickness of slab (m)	Calculated road height (m)	Planning road height (m)
1	Andheri Khola	3.36	987	502.24	2.48	499.76	3.29	0.095	1.0	1.0		4.575	504.335	0.968	505.400	505.400
2	Jagire Khola	5.65	62	501.90	1.40	500.50	6.67	0.192	0.0	0.6		2.192	502.692	0.968	503.700	504.044
3	Bhadaure Khola	10.87	186	485.71	0.00	485.71			0.8	0.6		1.400	487.110	0.968	488.100	491.971
4	Bhalu Khola	11.00	29	464.07	0.00	464.07			0.8	0.6		1.400	465.470	0.968	466.500	470.000
5	Nigule Khola	3.37	1101	481.46	3.97	477.49	2.01	0.058	1.6	1.0		6.628	484.118	0.968	485.100	485.100
6	Gadaule Khola	8.85	37	509.86	1.28	508.58	8.86	0.255	0.8	0.6	0.788	3.723	512.303	0.968	513.300	515.000
7	Chainpur Khola	2.40	922	492.50	3.16	489.34	3.08	0.089	1.3	1.0		5.549	494.889	0.968	495.900	495.900
8	Khahare Khola	6.88	230	485.41	0.87	484.54	7.11	0.205	0.8	0.8		2.675	487.215	0.968	488.200	488.200
9	Bhote Khola	3.19	916	503.17	3.68	499.49	3.42	0.098	1.5	1.0	0.783	7.061	506.551	0.968	507.600	507.600
10	Gangate Khola	2.86	966	534.78	2.78	532.00	3.00	0.086	1.1	1.0		4.966	536.966	0.968	538.000	538.000
11	Dhamile Khola	3.24	1439	522.76	4.25	518.51	2.81	0.081	1.7	1.0		7.031	525.541	0.968	526.600	526.600
12	Sadhi Khola	5.00	366	529.76	0.00	529.76			0.8	0.8	1.535	3.135	532.895	0.968	533.900	533.900

Source: Study Team

5) Design details

- The origin and location of causeway are determined based on site conditions, overall design of the road elevations and hydrological conditions.
- The causeway span of 10m is idealized considering economic efficiency.
- The setting height of bottom slab is below 2.0m (avalanche or sediment) or 1.5m (flood) from the inlet height of existing riverbed.
- The thickness of concrete cover is 150mm at the intermediate wall (pier) and at the front of the side wall (abutment). At other locations, concrete cover is 100mm.
- A 1.1m high guard pipe is installed along the Niguli Khola causeway to secure safety of pedestrians while crossing the 190m long causeway.

iii) Design Results

1) Key design conditions

Live load A-live load, as stated in the Specifications for Highway Bridges

Impact coefficient i=0.3, as stated in Earth Works for the Road (Culvert)

Seismic load Design horizontal seismic coefficient k=0.15, as stated in IRC

Allowable strengths of materials

Concrete - 24N/mm^2 compressive strength

Reinforcing bar - IRC (equivalent to SR 235), maximum diameter of 25mm

2) Design cases

The outline for design calculations of causeways were considered for seven cases as defined below, based on the number of spans, structural height and effect of earth pressures.

Table 2-33 Design Cases

case	Structural height (m)	No. of span	earth pressure	objective causeways
1	8.5	4	both sides	#1, #6
2	8.0	4	one side	#9
3	8.0	3	one side	#2, #7, #8
4	8.0	3	none	#2
5	7.0	2	both sides	#3
6	7.0	2	one side	#4
7	4.0	4	one side	#5

Source: Study Team

3) Load cases

Loads considered for the outline design calculations are as follows:

A dead load

B live load

C earth pressure

D reaction from earth (spring support)

E temperature change (increase 20 degree, decrease 15 degree)

F seismic load (k_h=0.15)

The load case combinations considering above design loads, are presented below:

Table 2-34 Load Case Combinations of Design Loads

		A	B	C	D	E	F	increase coefficient
1	dead load only	O		O	O			1.00
2	with live load	O	O	O	O			1.00
3	with temperature+	O		O	O	O		1.15
4	with live load & temperature+	O	O	O	O	O		1.15
5	with temperature-	O		O	O	O		1.15
6	with live load & temperature-	O	O	O	O	O		1.15
7	with seismic load	O		O	O		O	1.50

Source: Study Team

4) Live load

T-load is adopted as design live load for the causeways. The live load is applied to the most critical locations of each member. The load at each axle can be calculated as:

Rear axle: Pl1=[(2×100)/2.75]×(1+0.3)×4.75=449 (kN)

Front axle: Pl2=[(2×25)/2.75]×(1+0.3)×4.75=112 (kN)

Impact load was considered for every case. Traffic load was applied directly to the slab, with consideration that the structure is a rigid frame. The value of impact coefficient is 0.3 as per "Earth Works for the Road Facilities (Culvert)".

5) Spring support of ground

Reactions from earth were considered as spring supports, calculated using the formula from clause IV of the Specifications for Highway Bridges. Reaction coefficients are shown in Table 2-35.

$$k_v = k_{v0}\left(\frac{B_v}{0.3}\right)^{-\frac{3}{4}} = \frac{1}{0.3}\alpha E_0\left(\frac{\sqrt{A_v}}{0.3}\right)^{-\frac{3}{4}}$$

Table 2-35 Length of Causeways and Reaction Coefficients

L(m)	A_v(m^2)	k_v(kN/m^3)	k'_v(kN/m^2)
20	115.0	19,200	110,000
30	172.5	16,500	95,000
40	230.0	14,800	85,000

Source: Study Team

6) Design Results

Table 2-36 Properties of Designed Causeways

#	River Name	Stations		Length (m)	Skew (degrees)	Spanning
		Origin	Destination			
1	Bhalu Khola	0+850	0+880	30	70	1
2	Niguli Khola	4+506	4+696	190	90	3+1+3+1+3+1+3+1+3
3	Gadaule Khola	5+390	5+410	20	90	2
4	Chainpur Khola	9+875	9+925	50	90	2+1+2
5	Khahare Khola	11+145	11+235	90	90	4+1+4
6	Bhote Khola	18+210	18+250	40	90	4
7	Gangate Khola	20+920	20+980	60	90	2+1+3
8	Dhamile Khola	23+170	23+240	70	90	3+1+3
9	Sadhi Khola	26+46	26+136	90	70	4+1+4
total length of Section III causeways(m)				640		

Source: Study Team

9) Traffic Safety Facilities

i) Traffic Safety Facilities

Delineators and guard blocks will be installed as shown in Table 2-37, and as installed in Section II, in reference to the delineator drawing shown in the Standard Drawings (1978), DOR (details of guard blocks are not included in the Standard Drawings).

Table 2-37 Installation of Delineators and Guard Blocks

Delineator	* General sections * Installed with intervals in accordance with curvature (max. 5m)
Pre-cast Concrete L shape Guard Block	* Curves of which parabola opens to mountain side * Sections which make accidents serious when vehicles fall due to their steep slopes and large height * Zigzag sections which make accidents serious with affect to lower sections when vehicles fall
Guard Block for Warning Width Reduction	* Locations where the road becomes narrow by causeways etc.

Source: Study Team

ii) Traffic Signs

Traffic signs listed in Table 2-38 will be installed based on Traffic Signs Manual, Traffic Engineering and Safety Unit Design Branch, DOR.

Table 2-38 List of Traffic Signs

Name of Traffic Sign	Code
[Regulations]	
Maximum speed	A22
[Warning Sign]	
Crossroads	B1
Side road right (left)	B3
Staggered junction	B4
Sharp curve to the right (left)	B10
Hair-pin curve to the right (left)	B11
Double curve first left (right)	B12
Sharp change of direction	B13
Road Narrows on both sides	B14
Road Narrows on the right (left)	B15
Steep hill downward	B18
Steep hill upward	B19
Pedestrians in road ahead	B24
Children	B25
Falling rocks	B33
Narrow bridge	B35
Other danger	B36
Delineator post	B48
[Guiding Sign]	
Parking place	C3
Hospital	C10
Bus-stop	C17
Diversion ahead	C20
Other information (Michi-no-eki, etc.)	C22
Causeway name plate	C29

Source: Study Team

10) Passing Place and Bus Stops

Passing places for large vehicles will be installed with intervals of about 200 m. These are designated at locations where succeeding passing places can be viewed. Bus stops meanwhile are installed at the following 17 villages:

- STA. 4+380 Dihiphat
- STA. 5+280 Neupanetar
- STA. 5+820 Khalte Chainpur
- STA. 6+500 Shitalpati
- STA. 8+560 Ghumaune Chainpur
- STA. 9+300 Ghumaune Chainpur
- STA. 11+280 Tinkhopre
- STA. 13+030 Riththe

- STA. 17+220 Mulkot
- STA. 19+280 Bhulkot
- STA. 20+260 Ramtar
- STA. 21+520 Boretar
- STA. 22+440 Ratmate
- STA. 25+100 Khaharetol
- STA. 26+160 Sadhi Khola
- STA. 31+440 Gajulidaha
- STA. 32+810 Nepalthok

11) Spoil Bank

Based on the mass curve, spoil banks were constructed at the following three locations:

- STA.5+650 Khalte Chainpur (fill of gully)
- STA.7+400 (eroded hill)
- STA.11+000 (river flood plain)
- STA.19+000 (river flood plain)
- STA.29+000 (river flood plain)

12) Borrow Pit

Following locations are proposed sites for borrow pit considering earth distribution plan, quality of material and ease of operation.

- STA.37+000 of Section II (Andheri River)
- STA.28+000 (Sunkoshi River)
- Nepalthok (Roshi River)

13) Effective Use of Open Lands

Following locations are going to become open as a result of construction. Effective use of these lands is expected aiming to stimulate of regional activities.

- Khurkot (STA.39+300 of Section II)
- Ghumaune Chainpur (STA.7+800)
- Mulkot (STA.17+300)
- Ramtar (STA.20+260)
- Nepalthok (STA.32+900)

2.2.3 Basic Design Drawing

The Basic Design drawings are provided in Appendix 5.

2.2.4 Implementation Plan

(1) Implementation Policy

The implementation plan of the Project was prepared based on the guidelines of Japan's Grant Aid and considering the site conditions. The policies for the implementation of the Project are summarized as follows:

- Maximize use of local labor and construction materials for the Project for purposes of strengthening the regional economy, generation of job opportunities and promotion of capacity development.
- Maximize use of existing roads extending from Khurkot and from Nepalthok as pilot road and/or as project road.
- Avoid traffic accidents caused by construction vehicles and minimize negative impacts of the Project against public transportation services.
- Minimize negative impacts to the surrounding environment such as traffic accidents, noise, vibration, exhaust gas, dust, etc., considering the existence of many villages and cultivated lands along the road.
- Prepare construction method taking into consideration the monsoon season from June to September.

(2) Implementation Conditions

1) Labor Law

The contractor should manage its labors properly with an adequate safety control plan and should prevent conflicts with local labors. In any circumstance, the contractor should abide by the labor laws and regulations in force in Nepal.

2) Improvement of Existing Road during Construction

Existing road is extended by about 3km from Khurkot and about 25km from Nepalthok to accommodate additional volume of vehicles. The width of the existing road is 3–4m with sections having a vertical grade of 30%. Furthermore, its surface is not paved and extremely rough. The existing roads also traverse streams without any crossing structures. Therefore, it is necessary to widen it to 4m effective width. Moreover, gravel layer should be applied and compacted to achieve a thickness of 15cm. Pipes should also be installed at river beds in cases where the existing road is utilized as a construction road.

3) Traffic control, Safety management during Construction

The Project involves a road construction with maximum utilization of existing road that traverses many villages/relevant meeting places and cultivated lands. Traffic volume on the existing road includes combination of common and construction vehicles. Therefore, flagmen need to be designated to control the movement of vehicles and secure smooth and safe traffic.

Furthermore, traffic signs should be installed at access-restricted and traffic-controlled locations to avoid any accidents in the working area. Public relations on safety should be actively implemented as well.

There are possible danger zones at the site due to steep topography, cutting in narrow working spaces, deep structure excavations at valley side, etc. Therefore, rock-fall prevention works, installation of safety fences and designation of access-restricted areas should be carried out.

4) Consideration for Surrounding Environment and Residents

It is required to consider the surrounding environment and residents to minimize the negative impacts due to construction. The following measures are to be conducted:

- Low speed driving of construction vehicles, with a maximum speed of 10km/hr
- Use of low noise and low vibration generator type
- Water sprinkling on the road
- Selection of proper sources of aggregate to avoid any erosion of cultivated land on the river banks
- Avoidance of negative impacts to vegetation and/or fields located at elevations below the road, which may be caused by outflow of excavated soil

5) Construction during the monsoon season

It is substantially impossible to execute construction works during the monsoon season except for small-scale activities such as ditch works. Therefore, it is necessary to formulate a construction schedule on the assumption that works can not progress during the monsoon season, and to ensure that no unstable earthwork areas are left before said season is expected.

6) Transport of Construction Material to the Site

All construction materials will be transported from Sindhuli Bazar and Nepalthok. Under this condition,, supply of construction materials needs to be ensured since it greatly influences the progress of construction. Hence, it is always necessary to provide a transportation route in Sindhuli Road.

7) Important Items on Quality Control

The life span of the road depends much on the quality of the main structures of the Project such as gabion walls and concrete structures. Therefore, quality of gabion wires and concrete shall be controlled with great care.

(3) Scope of Works

The scope of works to be undertaken by the GOJ as well as the GON is shown below.

Table 2-39 Scope of Works undertaken by GOJ and the GON

Works, Facilities and Services to be provided by the GOJ	Works, Facilities and Services to be provided by the GON
Consulting services for detailed design, preparation of tender documents, assistance to DOR in tender process, and construction supervision Construction of road, subsidiary works and 12 causeways shown in the basic design Installation and removal of temporary facilities (construction yard) Surface improvement and maintenance of existing road that will be utilized as a pilot road during construction Protective measures for environmental pollution in execution of construction works Procurement, import and transport of equipment/materials required for the improvement works and re-export of imported equipment.	Free provision of site (land), temporary facilities and other construction activities for the execution of works Execution of environmental monitoring Compensation to private houses in the right-of-way (ROW) and removal of these houses Removal and relocation of the existing public utilities Free provision of traffic control and management for detour road and temporary roads Execution of traffic safety awareness training for local residents, students, bus-users, bus-drivers and policemen Proper operation and maintenance for all the completed facilities (excluding surface maintenance of road used for construction) Continuous monitoring for landslide in Mulkot area after completion of the construction Advice and support for effective use of vacant land of local residents

Source: Study Team

(4) Construction Supervision

1) Supervision

After signing the Exchange of Notes (E/N) and Grant Agreement (G/A) between the GON and the GOJ regarding the detailed design, JICA would recommend the consultant to carry out the detailed engineering design and preparation of the tender documents.

Almost at the end of the consulting services for detailed design, another E/N will be signed between the two governments for the construction work and the consulting services. The consultant would assist DOR in the tender process for construction work, that is, pre-qualification, tender opening and evaluation, and subsequent negotiation to conclude the contract between DOR and the successful tenderer.

The engineering services for construction supervision will commence with the acceptance of the construction contract and the issuance of a Notice to Proceed (N/P) to the contractor.

The Consultant shall perform his duties in accordance with the criteria and standards applicable to the construction works and shall exercise his authority as designated Engineer under the contract, to supervise the works of the contractor.

The Consultant, within his capacity as the Engineer, shall directly report to DOR and JICA Nepal Office on site activities and shall issue field memos or letters to the contractor concerning various matters, including progress, quality, safety and payment for the works under the Project. In addition, the Consultant shall report to the Embassy of Japan in Kathmandu, when required.

After one year from the completion of the construction, the final inspection for defects liability shall be conducted as the final task of the Consultant.

2) Implementation Organization

The Resident Engineer will be basically stationed at the construction site and conducts both construction supervision and project management. Since two site offices will be established, namely, one at Khurkot side and the other at Nepalthok, two Resident Engineers will be necessary. One of the Resident Engineers will concurrently be acting as a Chief Engineer, to ensure that acceptable quality of all the works during construction is achieved. The designated specialists for each stage are as follows:

- Resident Engineer (Chief Engineer) (Nepalthok side)

In charge of coordination and liaison for all the project activities concerning Consultant's agreement, tender assistance and supervision to ensure smooth progress and management of all technical aspects. Detailed full-time at the site during the construction period to conduct coordination and liaison for all the project activities and ensure smooth progress and management of all the technical issues. Activities to be conducted include management of materials, quality, safety, routinary activities, workmanship, progress, schedule and payment. Moreover, coordination and discussions will be initiated.

- Resident Engineer (Khurkot side)

Constantly remain on site during the construction period to execute coordination and liaison for all the project activities for ensuring smooth progress and management of all technical aspects. Related activities to be conducted involve management of materials, quality, safety, routinary activities, workmanship, progress, schedule and payment. Moreover, coordination and discussions will be initiated.

- Causeway Engineer

Responsible for the quality of related works, construction and technical issues that may arise at site concerning large-scale causeway works; Assigned during dry season of each phase; Execute engineering judgement and render advices for the shop drawings of Japanese

Engineer at appropriate timing, which is necessary since modification after commencement of works is difficult.

- Slope Protection Engineer

Assigned at the beginning of the dry season; identify locations with high risks of slope disaster; determine any actual movement after the design stage, including slopes of Section II and Section IV, which is utilized as a material haulage route.

- Shop Drawing Checker and Coordination Engineer

Assigned for coordination and checking of shop drawings at two site offices; Acts in behalf of the Resident Engineer during the latter's absence at Khurkot, who is concurrently designated as Chief Engineer. Since construction works are simultaneously executed at separate locations at Nepalthok side, he acts as assistant to the Resident Engineer. This position contributes to maintaining the stable performance of the Consultant's services even during the absence of the Resident Engineer at Nepalthok, who also oversee activities in Kathmandu.

(5) Implementation Conditions

Adequate quality control plan is formulated for the Project based on design concepts shown in Table 2-40.

Table 2-40 Quality Control Tests Plan

Item			Test Method	Frequency
Concrete	Material	Cement	Quality Guarantee, Chemical & Physical Analysis	Every material lot, Once/half year
		Water	Chemical Analyses	Every source
		Admixture	Quality Certificate, Chemical Analyses	Every lot
		Fine Aggregate	Bulk Specific Dry Gravity, Water Absorption, Sieve Gradation, Finess Modulus, Clay and Friable Particles	Every material site
		Coarse Aggregate	Bulk Specific Dry Gravity, Water Absorption, Sieve Gradation, Abrasion, Clay and Friable Particles, Sodium Sulfate Soundness	Every material site
	Mixing Test		Compressive Strength (Cylinder Mold)	Every mixing test
	Placing		Slump, Temperature, Air content	Every batch
	Test		Compressive Strength (7 days, 28 days)	Daily
Re-bar	Material		Mill Sheet, Tensile Strength	Once/half year
Base	Mixed Materials		Liquid Limit, Plastic Index, Sieve Gradation, Maximum Dry Density（Compaction）	Every mixing
	Placing		Field Density (Compaction)	Once/50m
DBST	Material		Sieve Gradation (mixed), Flakiness Index, Abrasion	Every material site
	Placing		Distribution volume of aggregate	Appropriate frequency
Hot Mix Asphalt	Material	Bitumen	Quality Certificate & Chemical Analyses	Every material lot
		Aggregate	Bulk Specific Dry Gravity, Water Absorption, Sieve Gradation, Abrasion, Clay and Friable Particles, Sodium Sulfate Soundness	Every material site
	Mix Requirement		Marshall Stability, Marshall Flows, Air Void,	Every mix
			Voids in Aggregate Materials,	
			Indirect Tensile Strength, Bitumen Content	
	Compaction		Temperature in Mixing,	Every mix
			Temperature in Compaction	Every transport
			Sampling (Marshall Test)	Every day
Prime Coat	Material	Bitumen	Quality Certificate	Every material lot

Source: Study Team

(6) Procurement Plan

Natural construction materials (aggregate, stone, embankment material, timber) and cement are available in Nepal. Reinforcing bars are also available in the local markets. To ensure quality, special/quality items which are not available in the local markets, need to be imported from Japan, such as materials for geotextile reinforced earth wall. Plaque, which requires its quality to be maintained, should be procured from Japan.

Indicative procurement of construction materials and equipment is summarized in Table 2-41.

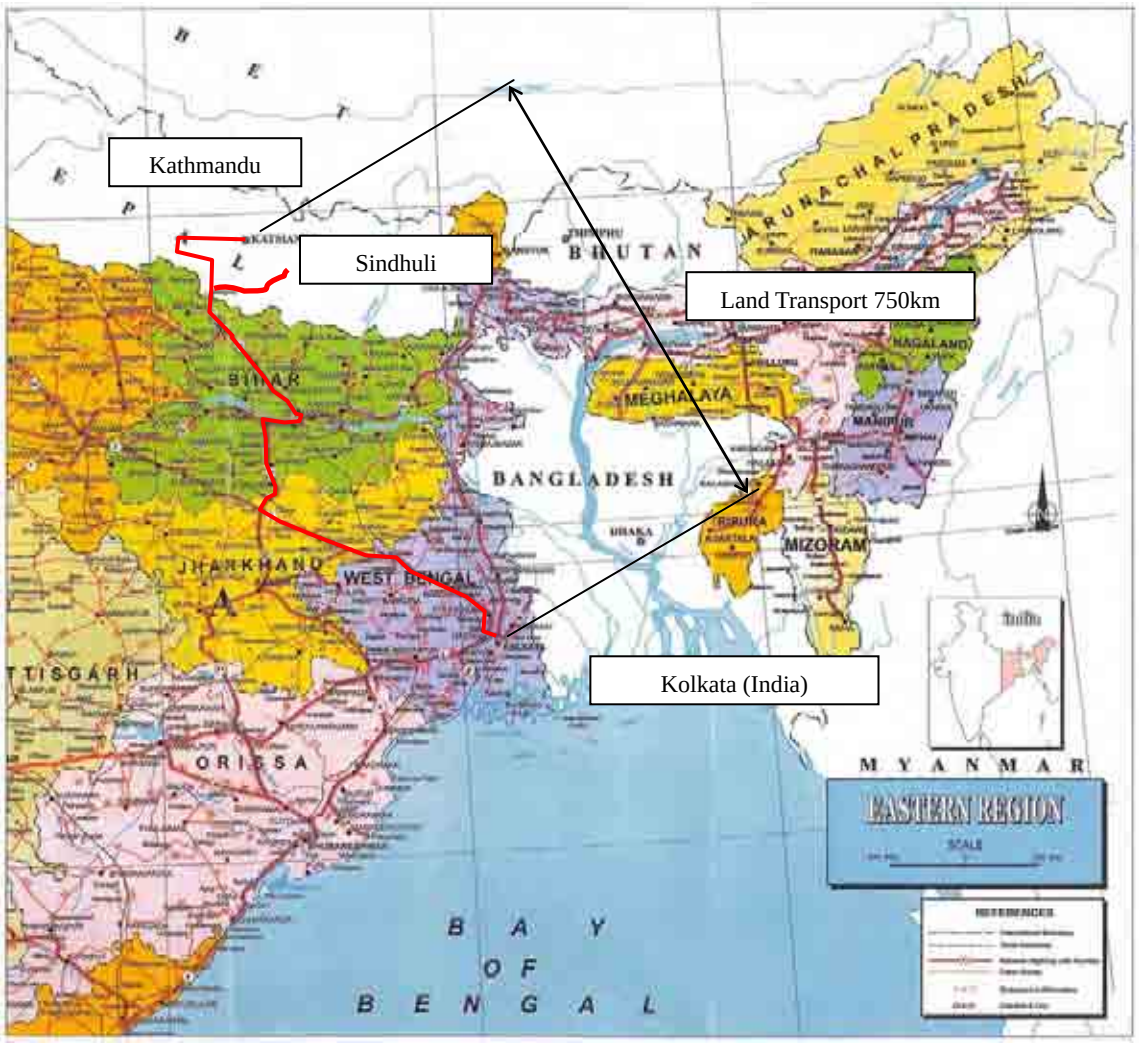
Table 2-41 Indicative Procurement of Construction Materials/Equipment

Items of Materials/Equipment		Nepal	Third Country (India)	Japan	Note
Materials					
Cement		○	○		Nepalese/Indian Products available
Aggregate (Coarse, Fine)		○			
Concrete Admixture		○	○		
Re-bars		○	○		Nepalese/Indian Products available
Gabion Wire		○			Export is possible
Bituminous Materials		○	○		Imported items available
Anchor for Geotextile Earth Wall				○	Quality and durability reasons
Wood/Plywood		○			
Fuel (oil, gasoline)		○			Imported items available
Steel Materials (Steel Sheet Pile, H-shaped)		○			Imported items available
Equipment					
Bulldozer	15 t			○	
Backhoe	0.6 m^3			○	
Dump Truck	10t			○	
Vibration Roller	3.0-4.0 t			○	
Road Roller	10 t			○	
Grader	3.1 m			○	
Concrete Batching Plant	30m^3/h			○	
Asphalt Mixing Plant		○			Lease is possible
Trailer Truck	20 t			○	
Truck Crane	25 t			○	

Source: Study Team

(7) Operational Guidance Plan

Construction materials and equipment that are procured from Japan will be shipped to Kolkata Port then transported by land. The distance from Kolkata to the construction site via Pathalaiya (southern direction from Hetauda, Narayangadh and Muglin) is about 750km. The good condition of the road enables the equipment to be transported within three days. The transportation route is shown in Figure 2-19.



Source: India Map by India Tourism Authority modified by Study Team

Figure 2-19 Transportation Map

(8) Implementation Schedule

Pavement works and causeway/revetment works should not be conducted during the monsoon season from the viewpoint of quality control and safety. The monsoon season within the area occurs from late May to early October. Construction costs and duration can be reduced by simultaneously commencing works from both ends of the Project site, i.e., from Section II side and from Section IV side. Based on this implementation method of construction, the Project could be completed within 53 months, with due consideration to anticipated slippages in activities during the monsoon seasons. Construction works of the Project could be implemented in two phases within three budgetary years of the GOJ, in accordance with the Japan Grant Aid Guideline.

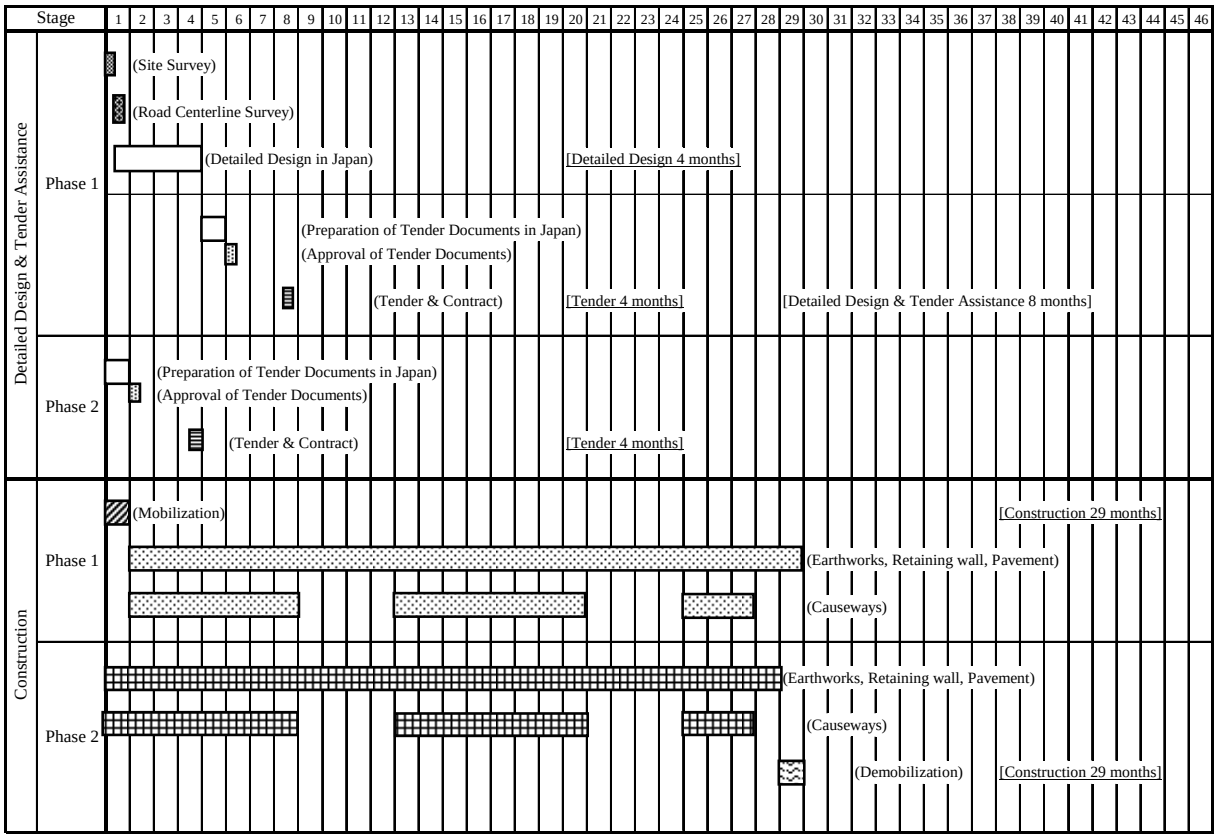
After the signing of the E/N and G/A between the GON and the GOJ concerning the detailed design of the Project, the Consultant will immediately carry out the detailed engineering design and preparation of the tender documents for the construction works, under Japan's

Grant Aid Scheme. The consulting services for the detailed design would be completed in 4 months. The first two weeks, allotted for the review of topographic surveys and alignment as per the basic design, will be conducted in Nepal. After completing the detailed engineering design, preparation of drawings and tender documents will be carried out in Japan.

Prior to the total completion of detailed design consulting services, another E/N will be signed between the two governments, for the construction works and the consulting services for construction supervision. Initially, the Consultant will assist the DOR for about 4 months in the tendering process for construction works, which includes pre-qualification, tender opening and evaluation, and subsequent negotiations to conclude the contract between DOR and the successful tenderer. The signed contract will then be verified by the GOJ.

After issuance of the N/P, construction will commence. The estimated duration for construction of phase 1 and phase 2 will be 29 months for each phase (overlapped schedule), to meet the 53-month anticipated project completion. Implementation schedule is shown in Table 2-42

Table 2-42 Tentative Implementation Schedule



Source: Study Team

2.3 Obligations of Recipient Country

2.3.1 Common Items of Japan's Aid Scheme

For smooth implementation of the Project, the government of the recipient country shall fulfill the following undertakings:

- To provide the necessary data and information for the implementation of the Project;
- To secure the land necessary for the project site (for the road, spoil bank, borrow pit, construction yard and restore of materials and equipment);
- To clear, level and reclaim the land prior to the commencement of the Project;
- To conduct access restriction to the site and to maintain security;
- To open a bank account under the Government's name, in a bank in Japan (B/A), and issue the authorization to pay (A/P) ;
- To ensure all the expenses for, and prompt execution of, unloading and customs clearance;
- To exempt Japanese nationals from customs duties, local taxes and other fiscal levies imposed in the recipient country, with respect to the supply of the products and services under the verified contracts;
- To accord Japanese nationals, whose services may be required in connection with the supply of the products and services under the verified contracts, such facilities necessary for their entry into the recipient country and stay therein for the performance of their works;
- To accord Japanese nationals the permission and other competence, if required, for the implementation of the Project
- To ensure proper maintenance, management and preservation of the facilities provided under Japan's Grant Aid;
- To bear all expenses, other than those borne under the Japan's Grant Aid, necessary for the construction of facilities as well as for the transportation and installation of equipment.

2.3.2 Special Items of the Project

(1) Before Construction

- To complete the site clearance following the compensation of private residents in the ROW
- To complete all procedures related to tree-cutting works at the site including transportation and management
- To relocate affected public utilities on-ground/overhead and those buried below the proposed road

(2) During Construction

- To provide the right to use river gravel for free
- To lend the construction equipment granted by GOJ to the Project contractor for free, as long as it does not affect the daily maintenance works of DOR
- To conduct all procedures regarding the diversion of traffic from the existing road (RTO) and pedestrian tracks , and to secure land for required diversion
- To broadcast to the public through mass media, the detour road and traffic diversion from the RTO and pedestrian tracks, during construction period
- To conduct all procedures regarding diversion of water supply from the existing facilities, and to implement such required diversion
- To secure traffic in Sections I, II and IV of the Sindhuli Road
- To conduct environmental monitoring through the DOR
- To maintain partially handed-over sections of the road (except for the maintenance of the road surface of the section utilized as construction pilot road)
- To arbitrate between residents and/or RTO users and the contractor

(3) After Provisional Handover

- To conduct environmental monitoring and inspection through the DOR
- To conduct traffic safety awareness training for bus commuters, drivers and traffic police.
- To prepare the land for required parking spaces
- To prepare the land for roadside stations (Michi-no-eki facilities), and provide road information.
- To plant trees in order to compensate cut plantation during construction
- To develop sidewalks in the vicinity of the Project
- To offer advice for regional development
- To maintain the road in cooperation with DWIDP.
- To organize network for O&M of whole Sindhuli Road

2.4 Project Operation Plan

2.4.1 Necessary O&M Works during Construction

The construction of the road will begin at Khurkot (Section II side) and Nepalthok (Section IV side), proceeding towards its central section. This is scheduled to be completed within 53 months. An existing road exists at the site, and although it is small, traffic due to common vehicles occurs. Therefore, the road segment to be completed each year will be provisionally handed over to the DOR and will be opened to the public by section, subject to

restrictions on vehicle types and the road should be maintained in good condition so that materials and equipments could be transferred to the remaining construction site. It is thought that DOR has sufficient number of staff and fund to conduct such kind of maintenance works.

2.4.2 Necessary Routine (Daily and Annual) O&M Items after Construction

O&M activities to be conducted on a daily-basis include cleaning of road facilities, simple maintenance of slopes, and small-scale repairs. These involve clearance of sediment on drainage facilities, patching of surface cracks/potholes and cutting of grass on road shoulders and slopes. These activities have already been implemented by the DOR for the opened sections of the road. The DOR engineers of Sindhuli Road project office have conducted periodic observation to obtain information on the road condition, which will be utilized in carrying out efficient maintenance works.

Annual O&M activities include repairs of damaged ditches, cross drains, DBST surfaces, etc. and medium-scale rehabilitation works for slopes, retaining walls and other structures damaged or destroyed by disasters that occur almost every year. These works are carried out by contractors which are selected through a tendering process. Necessary routine (daily and annual) O&M items are shown in Table 2-43.

Table 2-43 Necessary Routine (Daily and Annual) O&M items

Category	Structure	Activity
Daily	Side-ditch	Removal of debris, Simple repair
	Culvert	Removal of debris, Simple repair
	Slope	Grass cutting, Removal of collapsed deposit
	Road surface	Sweeping, Patching of cracks and potholes
	Sign board	Removal of dirt
	Shoulder	Reshaping, Simple repair
	Bridge	Cleaning of outlet, railing, joints
Annual	Side-ditch	Repair of damaged portion
	Culvert	Repair of damaged portion
	Road surface	Re-sealing of surface
	Retaining wall	Repair of damaged portion
	Slope	Repair of damaged portion

Source: Study Team

2.4.3 Periodic O&M Items after Construction

Periodic O&M activities to be carried out for the Project are mainly for overlay of DBST, painting of ancillary works, and repair of drainage structures. It is preferable that these works are conducted once in 3-5 years. Furthermore, repair of gabion wires is important as well. These works are carried out by contractors which are selected through a tendering process. Necessary periodic O & M items are shown in Table 2-44.

Table 2-44 Necessary Periodic O&M Items

Category	Structure	Activity
Periodic (once in 5 years)	Road surface	Sealing of DBST, Overlay Re-pavement of gravel base course
	Steel Bridge	Painting
	Sign board	Painting, Re-installation
	Others	Medium/large-scale repair, repair of gabion wire

Source: Study Team

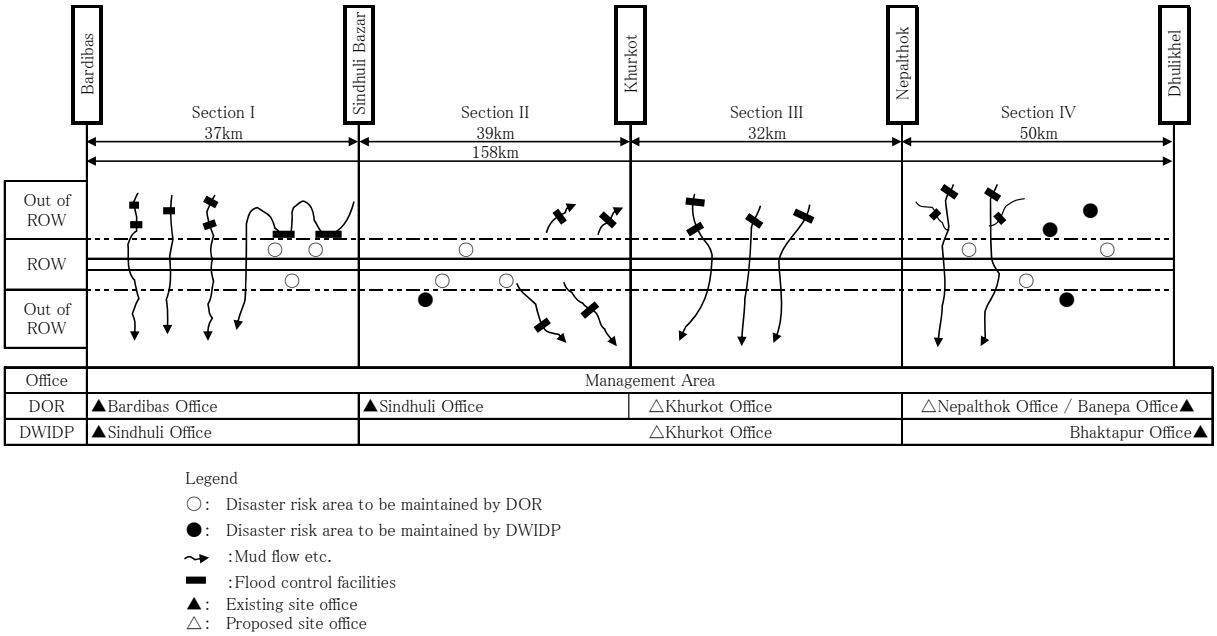
2.4.4 Urgent Rehabilitation Works and Preventative Maintenance

In the project area, unexpected natural disasters such as flood, mud flow, slope collapse, landslide, etc. are sometimes caused by heavy rains. In case the scale of these disasters is too large, it might be difficult for DOR to deal with the damages. However, based on the experiences in Section IV and II, normal-scale rehabilitation works can be conducted by DOR if sufficient budget is secured. Removal of collapsed deposit, urgent repair, construction of detour route, traffic control and urgent countermeasures are conducted by DOR staff.

Preventative works against rock-fall, collapse, failure, scouring, and mud-flow are planned at necessary occasions.

2.4.5 Cooperation with DWIDP

DOR offices will be established at Khurkot and Nepalthok, in addition to their existing offices, for purposes of conducting O&M tasks after completion of the Project. Furthermore, it is considered to be important, based on the operations of the Section I, to build cooperation organization with DWIDP to determine countermeasures against landslide, slope collapse and mud flow from tributaries of Sunkoshi River, which affect the road even if these occur at distant locations from the road. The framework for cooperation between DWIDP and DOR is shown in Figure 2-20.



Source: Study Team

Figure 2-20 Framework for Cooperation of DOR and DWIDP

2.4.6 Key Issues for O&M

Sindhuli Road, with a total length of 160km, is located in a topographically and geologically complicated area. During the monsoon seasons, heavy rains occur, causing natural disasters almost every year. Considering that the road is an arterial road supporting the socio-economy of the region, it is a social need to secure safe and stable transport in Nepal, which depends much on road transport. Therefore, for disaster prevention, O&M activities should be conducted in consideration of the following:

- Prepare annual inspection plans which includes segments to be inspected with care, inspection schedules and frequency;
- Conduct well-planned and effective inspection and patrol;
- Prepare disaster prevention sheet and inspection map, and record inspection and repair history;
- Record inspection items and progress;
- Secure budget for repairs required based on inspection;
- In case a high risk disaster is found, report the matter to senior staff and conduct joint re-inspection with experts;
- In case access restriction is implemented due to risk identified, designate an observer, install necessary traffic signs and provide information to public; and
- In case urgent rehabilitation is required, discuss measures with the personnel involved in relevant ministries and agencies, and in case difficult technical judgment is required, request the donor to dispatch experts.

2.5 Project Cost Estimation

2.5.1 Initial Cost Estimation

The project costs required for the undertakings by the GON are shown in Table 2-45.

Table 2-45 Project Costs Required for the Undertakings by the GON

Category	Item	Cost	
		x 1,000 NRs.	x 1,000 JPY
(1) Benefit Augmentation	Dissemination of the project information	50	87
	Provide construction related training to the local people	260	451
	Total	310	538
(2) Compensatory and Mitigation Measures	Tree plantation (2,480 nos.)	248	430
	Compensatory plantation (37ha)	1,850	3,208
	Maintenance of saplings (5 years)	720	1,248
	House (67 nos.)	10,720	18,588
	Land (28.35ha)	55,513	96,260
	Fruit trees (135 nos.)	1,350	2,341
	Crop compensation	2,303	3,993
	Total	72,704	126,069
(3) Environmental Monitoring	Baseline survey	1,200	2,081
	Monitoring (EMU)	7,825	13,569
	Total	9,025	15,650
(4) Relocation of Public Utilities	Electric line, Electric pole, Water facilities	530	919
(5) Bank Commission	AP	6,290	10,907
(6) Traffic Safety Training	Bus commuter, driver, traffic police	1,200	2,081
(7) Landslide Monitoring	Mulkot landslide area	176	305
Total Cost to be Borne by Sindhuli Road Project Office Before and During Construction		90,235	156,467
(8) Monitoring after completion	Monitoring after completion of construction	1,850	3,208
(9) Environmental Auditing	Auditing after 2 years of completion	1,259	2,183
Total Cost to be Borne by Nepalese Side After Construction		3,109	5,391
Total Cost to be Borne by Nepalese Side		93,344	161,858

Source: Study Team

The Nepalese side would be responsible for the acquisition and compensation of private houses, forests and cultivated lands, relocation of public utilities, and environmental monitoring before, during and after the Project implementation, and the related costs.

The above requires an indicative amount of NRs 93,344,000 (J¥ 161,858,000), which corresponds to about 2.9% of the DOR's development budget for the fiscal year 2006/2007. As the road is one of the top priority projects in the country, such annual disbursement should be available.

2.5.2 Operation and Maintenance Cost

Daily O&M that is, cleaning of road facility surfaces and O&M for the road, would be about NRs 9,600,000 (J¥ 16,646,000) per annum. In addition, DOR would have to bear the cost for maintenance works to be conducted once a year, and urgent rehabilitation works, if necessary. Annual maintenance cost to secure the soundness of the whole Sindhuli Road is NRs 66,400,000 (J¥ 115,138,000). Since this corresponds to only about 1.8% of the DOR's maintenance budget for the fiscal year 2006/2007, annual disbursement is expected to be available.

Table 2-46 O&M Costs for Whole Sindhuli Road

Category	Item	Cost	
		x 1,000 NRs.	x 1,000 JPY
(1) Daily Maintenance	Cleaning, Reduction of deposit, Grass cutting, etc.	9,600	16,646
(2) Annual Repair	Repair of road surface, side-ditch, etc.	14,400	24,970
(3) Repair conducted once in 5 years (converted to annual cost)	Overlay, Painting, Reshaping, repair of structures, etc.	32,000	55,488
(4) Urgent Rehabilitation Works	Removal of collapsed soil, Urgent rehabilitation, Construction of detour route, etc.	2,400	4,162
(5) Preventative Works	Preventative works against rock-fall, collapse, scouring and mud-flow, etc.	8,000	13,872
Total		66,400	115,138

Source: Study Team

CHAPTER 3 PROJECT EVALUATION AND RECOMMENDATION

3.1 Project Effect

According to information related to socio-economics, traffic and field surveys, and the basic design results executed under the Study, the project implementation would generate the following impacts and effects:

3.1.1 Direct Impacts and Effects

Present Status and Issues	Countermeasures taken by the Project	Direct Impacts and Effects
There are two routes that connect Kathmandu Valley with Terai Plain near the Indian border, that is, Tribhuvan Highway and Prithivi Road. Tribhuvan Highway is not used as a major route in Nepal due to its narrow width and winding alignment. On the other hand, Prithivi Road is the only arterial road with comparably good alignment and two lanes. However, this road is also at risk of disasters due to heavy rains and traffic congestion. Moreover, for the eastern area of Nepal, Prithivi Road is a detouring route passing the western area with an additional travel distance of 140km, which is a significant issue on the road network in Nepal.	Construct Section III of Sindhuli Road to realize its connectivity with its adjacent sections, that is, Section I (37km) at Terai Plain side, completed section of Section II (26.5km), on-going section of Section II (9.8km) and Section IV (50km) at Kathmandu side. The road has one lane width of 4.75m, with double bituminous surface treatment (DBST) provided thoughout the section	- Running distance of traffic from Kathmandu to Terai Plain, will be reduced by about 140km. - Roundtrip from Kathmandu and Central Terai Area which takes two days will be reduced by a day. - Risks of interception of transportation to Kathmandu Valley will be reduced and stable supply of goods will be maintained. - Damage to capital functions will be avoided, hence, life of 176 million citizens will become stable. - Time for transport will be reduced and access to market and public facilities will be improved in the less developed areas. - Those who will benefit from the project include residents living along Sindhuli Road of about 117 million, residents in Kathmandu Valley and Eastern Nepal of about 544 million, users of buses and trucks of about 30 thousand per day and 10 million per year.

3.1.2 Indirect Impacts and Effects

1) As a result of the Project, farm villages will be connected to the market, and thus, cash crop farming within the vicinity of the road will be promoted and regional economy will be activated.
2) With the opening of all-weather road in the area which remained underdeveloped due to the civil war, commerce, industry and housing infrastructures will be improved while investment growth will contribute to enhancement of regional development and poverty reduction.
3) Travel time will be reduced, with the commuters benefiting from safe transportation and traffic, thus, stable supply of goods within the region will be promoted. Moreover, improvement of access to public services and welfare facilities including hospitals can be expected.

3.2 Recommendations

It is a precondition that prior to the implementation of the Project, land acquisition along the ROW (resettlement areas and forest woods) should be completed. Consequently, the GON should initiate relocating of public utilities, including electric and telephone lines, poles and drinking water facilities, outside the ROW. Therefore, it is indispensable for DOR to coordinate with the concerned entities through MOPPW.

Many irrigation channels exist in the surrounding fields. Such irrigation facilities within the ROW will be improved accordingly. Although DOR will maintain drainage facilities that will be constructed in the Project, it is also necessary that local water privilege association maintains the improved irrigation facilities, including waterways outside the ROW.

The abovementioned effects of the Project largely rely on safe traffic practices of the road users. Evidently, training courses are strongly required related to driving manners of bus and truck drivers, and for the residents crossing the roads. Special emphasis should be placed on the preparation of a program by DOR and Sindhuli district police regarding the training, including execution of traffic safety awareness campaign for the public similar to the previous project in Section IV and Section II. Participation of a JICA expert for this purpose is recommended (DOR expects JICA to dispatch a Japanese Expert on traffic safety).

Vacant land which can be utilized as rest place and commercial facility will be developed along the project road to be constructed. It is expected that DOR will play a major role in the preparation of a plan for appropriate service facilities, since land use along the road will influence future development plans.

Appropriate budget will be required for road maintenance considering that all the sections of Sindhuli Road (total length 160km) will be opened to the public after the final completion of the Project. It is thus necessary for DOR to acquire and secure sufficient budget for future maintenance.

Appendix

1. Member List

1. Member List of the Study Team

- Field Survey From March 10, 2008 to May 27, 2008

Name	Position	Organization
Koichi KITO	Leader	Japan International Cooperation Agency Team Director, Project Management Group I, Grant Aid Management Department
Hiroshi MURAYAMA	Project Coordinator	Japan International Cooperation Agency Senior Project Administration Officer, Project Management Group I, Grant Aid Management Department
Hideo KATAGIRI	Chief Consultant/Road Planner	Nippon Koei Co., Ltd.
Yoshihisa YAMASHITA	Deputy Chief Consultant	Nippon Koei Co., Ltd.
Naresh STHAPIT	Road Designer	Nippon Koei Co., Ltd.
Ippei IWAMOTO	Road Designer	Nippon Koei Co., Ltd.
Tomokuni HAYAKAWA	Structure Designer	Nippon Koei Co., Ltd.
Humio NAKAMURA	Topographycal/Geotechnical Engineer	Nippon Koei Co., Ltd.
Hideki IMAI	Environmental/Social Impact Assessment Specialist	Nippon Koei Co., Ltd.
Hiroaki UEYAMA	Construction Planner/Cost Estimator	Nippon Koei Co., Ltd.

From July 22, 2008 to August 2, 2008

Name	Position	Organization
Takahiro KAMISHITA	Environmental/Social Impact Assessment Specialist	Nippon Koei Co., Ltd.

From August 17, 2008 to September 27, 2008

Name	Position	Organization
Humio NAKAMURA	Topographycal/Geotechnical Engineer	Nippon Koei Co., Ltd.
Shinichi SUETAKE	Topographycal/Geotechnical Engineer	Nippon Koei Co., Ltd.

- Draft Report Explanation From September 25, 2008 to October 4, 2008

Name	Position	Organization
Noriaki NIWA	Leader	Japan International Cooperation Agency Resident Representative, Nepal Office
Hidetaka SAKABE	Project Coordinator	Japan International Cooperation Agency Senior Project Administration Officer, Project Management Group I, Grant Aid Management Department
Hideo KATAGIRI	Chief Consultant/Road Planner	Nippon Koei Co., Ltd.
Naresh STHAPIT	Road Designer	Nippon Koei Co., Ltd.

2. Study Schedule

2. Study Schedule

- Field Survey

No.	Date Day	Leader Mr. K. Kito JICA	Coordinator Mr.H. Murayama JICA	Consult. Chief Mr. H. Katagiri NK	Rep. Consult. Chief Mr. Y. Yamashita NK	Road Designer Mr. S. Naresh NK	Road Designer Mr. I. Iwamoto NK	Structure Design Mr. T. Hayakawa NK	Topo/Geo Engineer Mr. H. Nakamura NK	Environmental/ Social Impact Assessment Specialist Mr. H. Imai NK	Construction Planner/Cost Estimator Mr. H. Ueyama NK
1	6-Mar Thu		Narita - Bangkok								
2	7-Mar Fri		Bangkok - Kathmandu								
3	8-Mar Sat		Site Inspection								
4	9-Mar Sun	Narita - Bangkok	Site Inspection Section 1 & 2		Narita - Bangkok					Narita - Bangkok	
5	10-Mar Mon	Bangkok - Kathmandu	Inspection for Section 2, Sinduhli - Kathmandu		Bangkok - Kathmandu					Bangkok - Kathmandu	
		Discussion with EOJ & JICA and courtesy call on MOPPW & DOR			Discussion with EOJ & JICA and courtesy call on MOPPW & DOR					Discussion with EOJ & JICA and courtesy call on MOPPW & DOR	
6	11-Mar Tue	Discussion with DOR			Discussion with DOR			Narita - Bangkok		Discussion with DOR	Narita - Bangkok
7	12-Mar Wed					Preparatory Work for Site Investigation		Bangkok - Kathmandu			Bangkok - Kathmandu
8	13-Mar Thu	Discussion & Signing of MD with DOR			Discussion & Signing of MD with DOR			Preparatory Work for Site Investigation		Discussion & Signing of MD with DOR	Preparatory Work for Site Investigation
9	14-Mar Fri	Discussion with EOJ & JICA Kathmandu - Bangkok -			Preparatory Work for Site Investigation					Preparatory Work for Site	
10	15-Mar Sat	- Narita			Kathmandu - Sinduhli			Kathmandu - Sinduhli			
11	16-Mar Sun				Site Survey			Site Survey			
12	17-Mar Mon										
13	18-Mar Tue										
14	19-Mar Wed										
15	20-Mar Thu										
16	21-Mar Fri										
17	22-Mar Sat				Internal Meeting & Summary of Site survey results			Internal Meeting & Summary of Site survey results			
18	23-Mar Sun										
19	24-Mar Mon										
20	25-Mar Tue										
21	26-Mar Wed				Discussion with DOR				Kathmandu - Bangkok -	Reporting	
22	27-Mar Thu				Reporting		Narita - Bangkok		- Narita		
23	28-Mar Fri						Bangkok - Kathmandu	Structure engineering study		Kathmandu - Bangkok -	Construction Plan Study
24	29-Mar Sat				Site Survey		Site Survey			- Narita	
25	30-Mar Sun										
26	31-Mar Mon				Reporting	Road Alignment Study	Road Facilities study	Reporting			Reporting
27	1-Apr Tue			Road Alignment Study							
28	2-Apr Wed										
29	3-Apr Thu										
30	4-Apr Fri										
31	5-Apr Sat										
32	6-Apr Sun										
33	7-Apr Mon				Kathmandu - Bangkok -			Kathmandu - Bangkok -			Kathmandu - Bangkok -
34	8-Apr Tue				- Narita			- Narita			- Narita
35	9-Apr Wed										
36	10-Apr Thu										
37	11-Apr Fri										
38	12-Apr Sat										
39	13-Apr Sun										
40	14-Apr Mon										

No.	Date Day	Leader Mr. K. Kito JICA	Coordinator Mr.H. Murayama JICA	Consult. Chief Mr. H. Katagiri NK	Rep. Consult. Chief Mr. Y. Yamashita NK	Road Designer Mr. S. Naresh NK	Road Designer Mr. I. Iwamoto NK	Structure Design Mr. T. Hayakawa NK	Topo/Geo Engineer Mr. H. Nakamura NK	Environmental/ Social Impact Assessment Specialist Mr. H. Imai NK	Construction Planner/Cost Estimator Mr. H. Ueyama NK
41	15-Apr Tue			Road Alignment Study					Narita - Bangkok		
42	16-Apr Wed						Reporting		Bangkok - Kathmandu		
43	17-Apr Thu								Preparatory work for site survey		
44	18-Apr Fri					Traffic volume analysis					
45	19-Apr Sat						Site Survey		Site Survey		
46	20-Apr Sun			Reporting							
47	21-Apr Mon										
48	22-Apr Tue					Reporting			Reporting		
49	23-Apr Wed										
50	24-Apr Thu										
51	25-Apr Fri										
52	26-Apr Sat										
53	27-Apr Sun										
54	28-Apr Mon								Kathmandu - Bangkok -		
55	29-Apr Tue								- Narita		
56	30-Apr Wed										
57	1-May Thu										
58	2-May Fri			Road Alignment Study			Road Facilities study				
59	3-May Sat										
60	4-May Sun										
61	5-May Mon										
62	6-May Tue										
63	7-May Wed					Road Alignment Study					
64	8-May Thu										
65	9-May Fri										
66	10-May Sat										
67	11-May Sun										
68	12-May Mon										
69	13-May Tue										
70	14-May Wed										
71	15-May Thu			Reporting			Reporting				
72	16-May Fri										
73	17-May Sat										
74	18-May Sun									Narita - Bangkok	
75	19-May Mon									Bangkok - Kathmandu	
76	20-May Tue						Kathmandu - Bangkok -			Discussion with DOR	
77	21-May Wed						- Narita				
78	22-May Thu										
79	23-May Fri			Stakeholder Meeting inspection						Stakeholder Meeting inspection	
80	24-May Sat										
81	25-May Sun										
82	26-May Mon			Reporting						Reporting	
83	27-May Tue			Kathmandu - Bangkok -							
84	28-May Wed			- Narita						Kathmandu - Bangkok -	
85	29-May Thu									- Narita	

No.	Date Day	Environmental/Social Impact Assessment Specialist Mr. T. Kamishita
1	22-Jul Tue	Narita - Bangkok
2	23-Jul Wed	Bangkok - Kathmandu
3	24-Jul Thu	Discussion with DOR
4	25-Jul Fri	
5	26-Jul Sat	
6	27-Jul Sun	Discussion with environmental division
7	28-Jul Mon	Discussion with DOR
8	29-Jul Tue	Discussion with JICA
9	30-Jul Wed	Discussion with DOR
10	31-Jul Thu	Discussion with DOR
11	1-Aug Fri	Kathmandu - Bangkok -
12	2-Aug Sat	- Narita

No.	Date Day	Topo/Geo Engineer Mr. H. Nakamura NK	Topo/Geo Engineer Mr. S. Suetake NK
1	17-Aug Tue		Narita - Bangkok
2	18-Aug Wed		Bangkok - Kathmandu Discussion with EOJ & JICA and courtesy call on MOPPW & DOR
3	19-Aug Thu		Internal Meeting
4	20-Aug Fri		Discussion with sub-contractor
5	21-Aug Sat		Kathmandu - Site
6	22-Aug Sun		Site Survey
7	23-Aug Mon		
8	24-Aug Tue		
9	25-Aug Wed		
10	26-Aug Thu		
11	27-Aug Fri		
12	28-Aug Sat		
13	29-Aug Sun		
14	30-Aug Mon		
15	31-Aug Tue		
16	1-Sep Wed		
17	2-Sep Thu		
18	3-Sep Fri		
19	4-Sep Sat		
20	5-Sep Sun		
21	6-Sep Mon		
22	7-Sep Tue		
23	8-Sep Wed		
24	9-Sep Thu	Narita - Bangkok	
25	10-Sep Fri	Bangkok - Kathmandu Discussion with EOJ & JICA and courtesy call on MOPPW & DOR	
26	11-Sep Sat	Technical Transfer to DOR	
27	12-Sep Sun		
28	13-Sep Mon		
29	14-Sep Tue		Technical Transfer to DOR
30	15-Sep Wed	Site survey & stduy	Site - Kathmandu
31	16-Sep Thu		Reporting
32	17-Sep Fri		Kathmandu - Bangkok -
33	18-Sep Sat		- Narita
34	19-Sep Sun		
35	20-Sep Mon		
36	21-Sep Tue		
37	22-Sep Wed		
38	23-Sep Thu		
39	24-Sep Fri		
40	25-Sep Sat		
41	26-Sep Sun	Kathmandu - Bangkok -	
42	27-Sep Mon	- Narita	

➢ Draft Report Explanation

No.	Date Day	Leader Mr. N. Niwa JICA	Coordinator Mr.H. Sakabe JICA	Consult. Chief Mr. H. Katagiri NK	Road Designer Mr. S. Naresh NK
1	24-Sep Wed			Narita - Bangkok	
2	25-Sep Thu			Bangkok - Kathmandu Explanation for DOR	Road Design review
3	26-Sep Fri			Explanation for DOR	
4	27-Sep Sat			Data collection & Selection	
5	28-Sep Sun		Narita - Bangkok		
6	29-Sep Mon		Bangkok - Kathmandu Discussion with EOJ & JICA and courtesy call on MOPPW & DOR	Discussion with DOR	
7	30-Sep Tue	Site survey			
8	1-Oct Wed	Discussion with DOR			
9	2-Oct Thu	Discussion with DOR for MD			
10	3-Oct Fri	Signing on MD, Reporting for EOJ & JICA			
11	4-Oct Sat		Data Selection	Kathmandu - Bangkok -	Road Design review
12	5-Oct Sun		Kathmandu - Bhutan	- Narita	

3. *List of Parties Concerned in the Recipient Country*

3. List of Parties Concerned in the Recipient Country

1.	MOPPW：Ministry of Physical Planning and Works	
	Mr. Purna Kadariya	Secretary
2.	DOR：Department of Roads	
	Mr. Tulasi Prasad Sitaula	Director General
	Mr. Ramesh Raj Bista	Deputy Director General
	Mr. Saroj Kumar Pradhan	Unit Chief, Road Design Unit
	Bindu S. Rana	Project Manager, Sindhuli Road
	Shiva Raj Adhikari	Engineer
	Michinori Hanko	JICA Expert
3.	Embassy of Japan	
	Makoto Yoshino	First Secretary
4.	JICA Nepal Office	
	Noriaki Niwa	Resident Representative
	Yoshio Fukuda	Deputy Resident Representative
	Yusuke Tsumori	Assistant Resident Representative
	Sourab Rana	Program Officer

4. Minutes of Discussion (M／D)

4－1 Field Survey(March 13, 2008)

4－2 Draft Report Explanation (October 3, 2008)

4－1 Minutes of Discussions (M/D) Field Survey(March 13, 2008)

Minutes of Discussions
on the Basic Design Study
on the Project for the Construction of Sindhuli Road (Section III)
in Nepal

Based on the results of the Preliminary Study, the Government of Japan decided to conduct a Basic Design Study on the Project for the Construction of Sindhuli Road (Section III) (hereinafter referred to as "the Project") and entrusted the study to the Japan International Cooperation Agency (hereinafter referred to as "JICA").

JICA sent to Nepal the Basic Design Study Team (hereinafter referred to as "the Team"), which is headed by Mr. Koichi Kito, Team Director, Transportation and Electric Power Team, Project Management Group I, Grant Aid Management Department, JICA, and is scheduled to stay in the country from 7th March to 20th May, 2008.

The Team held discussions with the officials concerned of the Government of Nepal and conducted a field survey at the study area.

In the course of discussions and field survey, both sides have confirmed the main items described in the attached sheets. The Team will proceed to further works and prepare the Basic Design Study Report.

Kathmandu, 13 March, 2008

Koichi Kito
Leader
Basic Design Study Team
Japan International Cooperation Agency

DIRECTOR-GENERAL

Tulasi Prasad Sitaula
Director General
Department of Roads
Ministry of Physical Planning & Works
Nepal

Government of Nepal
Ministry of Physical Planning & Works
Department of Roads
Babar Mahal

1

ATTACHMENT

1. Objective of the Project

The objective of the Project is to construct the Sindhuli Road (Section III) and complete the whole Sindhuli Road linking the northern remote areas of Sindhuli district with East-West Highway and Arniko Highway.

2. Project Site

The Project site is shown in Annex-1.

3. Responsible and Implementing Organizations

3.1 The responsible organization for executing the Project is the Ministry of Physical Planning & Works (MOPPW).

3.2 The implementing agency is the Department of Roads (DOR).

The organization charts of MOPPW and DOR are shown in Annex-2-1 and 2-2 respectively.

4. Items requested by the Government of Nepal

As a result of the discussions, requested component was confirmed as below.

- Construction of Sindhuli Road (Section III) (approximate road length is 35.9km*)

*/ The original requested road length was 32km. However, the ending section (3.9km length) of the Section II will be included in the Section III.

JICA will assess the appropriateness of the request and will report the findings to the Government of Japan.

5. Japan's Grant Aid Scheme

The Nepalese side has shown a full understanding of the Japan's Grant Aid scheme and the necessary measures to be taken by the Nepalese side as explained by the Preliminary Study Team and described in the Annex-3 and 4 of the Minutes of Discussions signed by both sides on 28th February, 2007.

6. Schedule of the study

6.1 JICA will prepare the draft report and dispatch a mission to Nepal in order to explain its contents around the middle of September 2008.

6.2 When the contents of the report are accepted in principle by the Government of Nepal, JICA will complete the final report and send it to the Government of Nepal by November 2008.

7. Environmental and Social Considerations

7.1 Review and determination of the road alignment

(1) The draft road alignment was basically accepted through a series of stakeholder meetings

(SHMs) and simple survey at the preliminary study stage, except for Ratmata Village Development Committee (VDC) or Mulkot area where the resident requested the sectional modification of the road alignment during the simple survey. Based on the draft road alignment examined through the preliminary study, the Team will review the alignment from technical, environmental and social aspect.

(2) The Nepalese side agreed that the final road alignment will be disclosed to and confirmed with Project Affected Persons (PAPs) in an appropriate manner, and for this purpose, stakeholders meetings will be held at four places at least during the Basic Design Study.

7.2 Complementary environmental study

The Nepalese side agreed to conduct a complementary environmental study to update the existing EIA. The complementary study should satisfy following points;

(1) The study should be based on the final road alignment set during the Basic Design Study.

(2) To reflect comments from the JICA Advisory Council of Environmental and Social Considerations.

(3) To ensure effectiveness of EMP (Environmental Management Plan) and monitoring plan.

- Relation between impact assessment and mitigation measure
- Framework and budgetary allocation of EMU (Environmental Monitoring Unit)

7.3 Resettlement and compensation issue

The Nepalese side agreed to pay due considerations for the followings through stakeholders meetings and focused group discussions, in order to comply with its laws and regulations concerning resettlement and compensation as well as JICA Guidelines for Environmental and Social Considerations.

(1) Preservation of living standard, livelihood support and monitoring plan after resettlement.

(2) Special attention to the socially weak such as tenant farmers without land, women and illiterate persons.

(3) Reflection of voices from PAPs to Compensation Fixation Committee (invitation of representatives from VDCs as observers at the Committee).

7.4 Critical Passage to the Implementation of the Project

Both sides reconfirmed that the following items listed below are milestones to advance to the next step for the implementation of the Project.

(1) Milestone during the Basic Design Study (before reporting to JICA Advisory Council scheduled on August 2008)

- Completion of complementary Environmental Study
- Confirmation with PAPs regarding the procedure for the entitlement in accordance with Nepalese laws and regulations

(2) Milestone during Detailed Design

- Determination of the entitlement of PAPs

(3) Milestone before commencement of construction work

- Substantial completion of acquisition, compensation and resettlement

8. Other Relevant Issues

(1) To secure the viability of the whole Sindhuli Road section, the Team requested the Nepalese side to maintain the road timely and appropriately with concrete financial background. The Nepalese side agreed it.

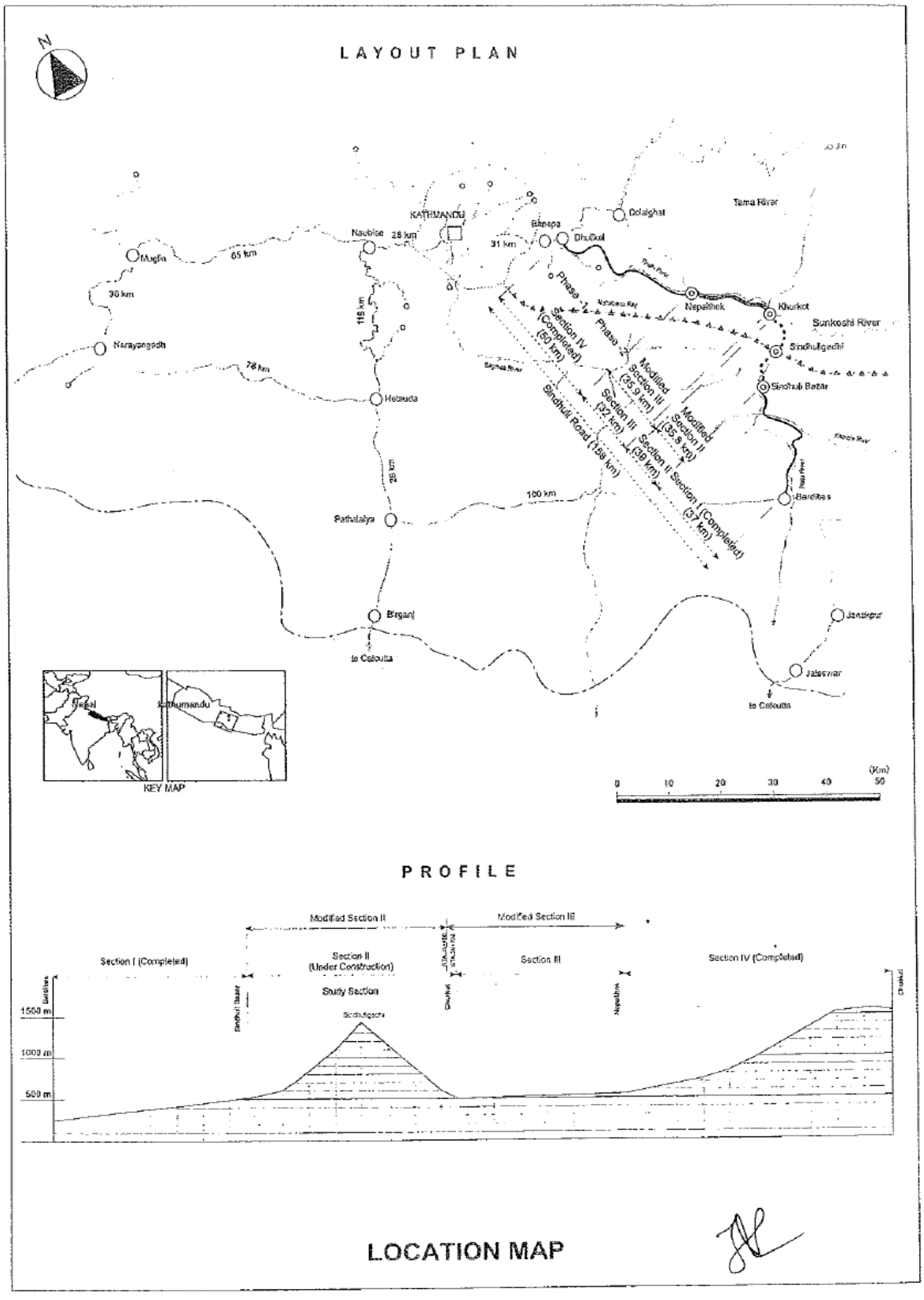
(2) The Nepalese side shall submit answers in English to the Questionnaire, which the Team handed to the Nepalese side, by the end of March, 2008.

(3) The Nepalese side shall provide necessary numbers of counterpart personnel to the Team during the period of their studies in Nepal.

Annex-1 Project Site Map

Annex-2 Organization Charts of MOPPW and DOR

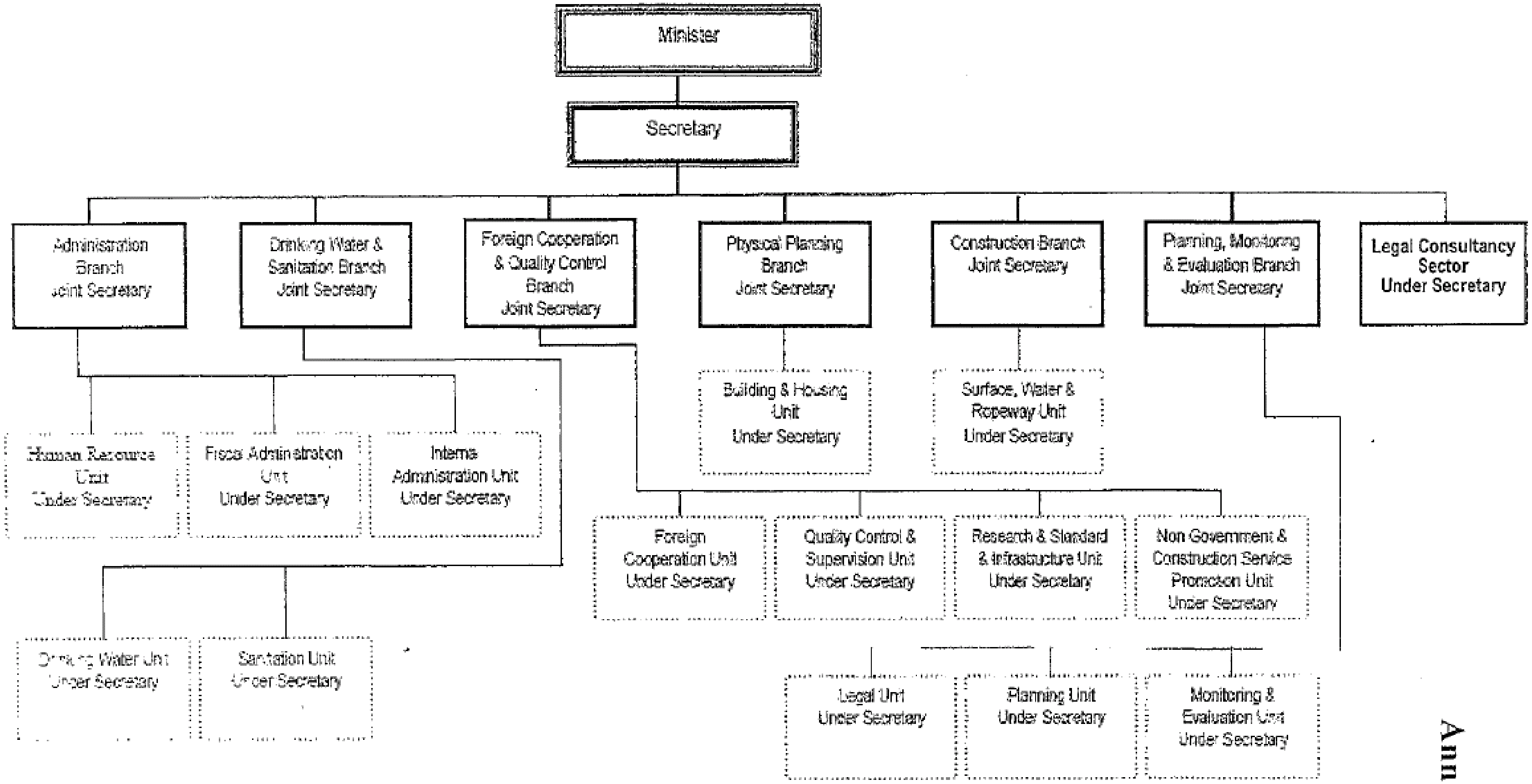
Annex -1


LAYOUT PLAN
N
KATHMANDU
Naubise
28 km
Dolalghat
Banepa
Dhulikel
31 km
Tama River
Mugling
65 km
96 km
Narayangadh
78 km
116 km
Hetauda
Phase 2
Phase 1
Nepalthok
Khurkot
Sunkoshi River
Sindhulgadhi
Sindhuli Bazar
Section IV (Completed) (50 km)
Modified Section III (35.9 km)
Section III (32 km)
Modified Section II (35.8 km)
Section II (39 km)
Section I (Completed) (31 km)
Sindhuli Road (158 km)
Bardibas
225 km
100 km
Pathalaiya
Birgunj
to Calcutta
Janakpur
Jaleswar
to Calcutta
Nepal
Kathmandu
KEY MAP
0
10
20
30
40
50
(Km)
PROFILE
Modified Section II
Modified Section III
Section I (Completed)
Section II (Under Construction)
Section III
Section IV (Completed)
Study Section
Sindhuli Bazar
Sindhulgadhi
Nepalthok
Dhulikel
1500 m
1000 m
500 m
LOCATION MAP

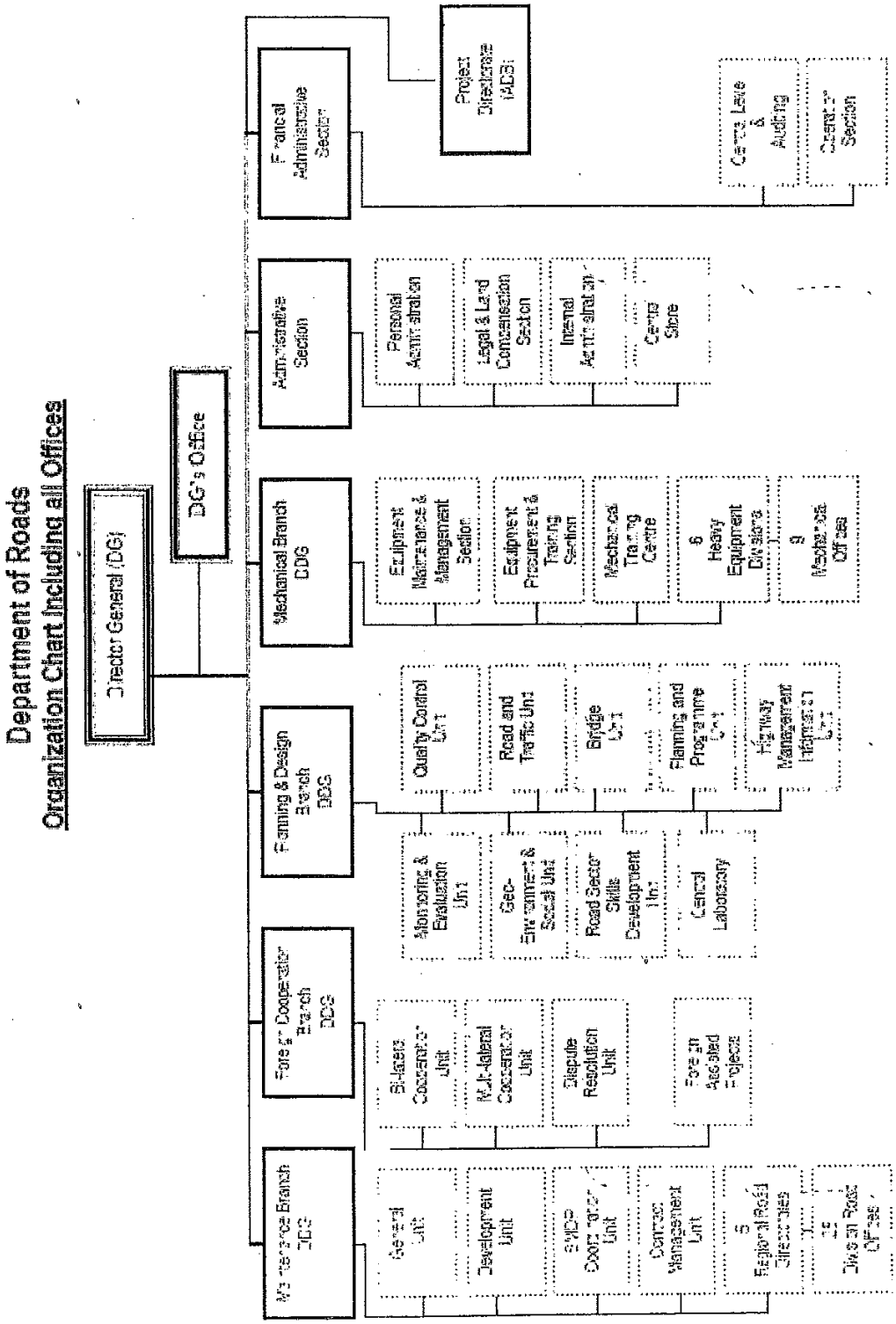
5

Annex 2-1

Ministry of Physical Planning & Works
Organization Chart



Annex 2-2


Department of Roads
Organization Chart Including all Offices
Director General (DG)
DG's Office
Administrative Section
Personal Administration
Legal & Land Concession Section
Internal Administration
Cental Store
Financial Administrative Section
Project Directorate (PDD)
Central Level & Auditing
Secretariat Section
Mechanical Branch DDG
Equipment Maintenance & Management Section
Equipment Procurement & Training Section
Mechanical Training Centre
6 Heavy Equipment Division
9 Mechanical Offices
Planning & Design Branch DDG
Quality Control Unit
Road and Traffic Unit
Bridge Unit
Planning and Programme Unit
Highway Management Information Unit
Monitoring & Evaluation Unit
Geo-Environment & Social Unit
Road Sector Skills Development Unit
Central Laboratory
Foreign Cooperation Branch DDG
Bi-lateral Cooperation Unit
Multi-lateral Cooperation Unit
Dispute Resolution Unit
Foreign Assisted Projects
Maintenance Branch DDG
General Unit
Development Unit
EMDP Coordination Unit
Contract Management Unit
5 Regional Road Directorates
Division Road Offices

4－2 Draft Report Explanation (October3, 2008)

Minutes of Discussions
on Basic Design Study
on the Project for the Construction of Sindhuli Road (Section III)
in Nepal
(Explanation of Draft Report)

In March 2008, the Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched the Basic Design Study Team on the Project for the Construction of Sindhuli Road (Section III) (hereinafter referred to as "the Project") to Nepal, and through discussions, field survey and technical examination of the results in Japan, JICA prepared a draft report of the study.

In order to explain and to consult with the concerned officials of the Government of Nepal on the contents of the draft report, JICA sent to Nepal the Basic Design Explanation Team (hereinafter referred to as "the Team"), which is headed by Mr. Noriaki NIWA, Resident Representative of JICA Nepal Office, from September 25 to October 4, 2008.

As a result of discussions, both sides confirmed the main items described in the attached sheets.

Kathmandu, October 3, 2008

Noriaki NIWA
Leader
Basic Design Explanation Team
Japan International Cooperation Agency

Tulasi Prasad Sitaula
Director General
Department of Roads
Ministry of Physical Planning & Works
Government of Nepal

Government of Nepal
Ministry of Physical Planning & Works
Department of Roads
Babar Mahal

ATTACHMENT

1. Components of the Draft Report
The Nepalese side agreed and accepted in principle the contents of the draft report of Basic Design Study by the Team.

2. Cost Estimation
Both sides agreed that the Project Cost Estimation as attached in Annex-1 should never be duplicated or released to any third parties before the signing of all the Contract(s) for the Project.

3. Japan's Grant Aid Scheme
3-1. The Nepalese side understood the Japan's Grant Aid scheme explained by the Team.
3-2. The Nepalese side understands necessary measures to be taken by the Government of Nepal as explained by the Preliminary Study Team and described in Annex-4 of the Minutes of Discussions signed by both sides on February 28th, 2007.
3-3. The Team explained that the estimated cost borne by the Nepalese side will be large because of the Project size (estimated cost, affected area and persons, etc.) as described in the Draft Report. The Nepalese side replied to secure sufficient budget in a timely manner for smooth implementation of the Project.

4. Schedule of the Study
JICA will complete the Final Report in English, in accordance with the confirmed items and send it to the Nepalese side by the end of January, 2009.

5. Environmental and Social Considerations
5-1. Critical Passage to the Implementation of the Project
Both sides checked the progress of the each work necessary for implementation of the Project as follows, which are agreed in the Minutes of Discussions dated 28th February, 2007.
(1) Both sides confirmed that the Nepalese side had already completed the following items;
(a) Completion of complementary Environmental Study and up-date of the EIA report,
(b) Confirmation with PAPs regarding the procedure for the entitlement in accordance with Nepalese laws and regulations through the Stake Holder Meetings in the Project Site.
(2) Both sides reconfirmed that the Nepalese side should determine the entitlement of PAPs during Detailed Design for the Project.
(3) Both sides reconfirmed that the Nepalese side should complete the acquisition, compensation and resettlement substantially before commencement of construction work of each Phase, and the Nepalese side should report the progress of these activities to JICA Nepal Office.

5-2. Monitoring of the Environmental Management
Both sides confirmed that the Nepalese side should establish the Environment Management Unit for the Project in the Project Office under the DoR and make the Unit to conduct the environmental monitoring based on the up-dated EIA Report.

5-3. The Team explained to the Nepalese side the result of the report to the Advisory Council of Environmental and Social Considerations Review of JICA (hereinafter referred to as "the Advisory Council"). And both sides confirmed that the Nepalese side would share the result of Environmental Monitoring at the site during the construction work with DDC and/or VDC Office in consideration of the opinion of the Advisory Council.

6. Other Relevant Issues

6-1. The Nepalese side confirmed that the following undertakings should be taken by the Nepalese side at the Nepalese expenses.

(1) Before commencement of construction work

(a)Securing of the land for road construction area for the Project,

(b) Relocation of existing utilities (electricity power, telecommunication, water, etc.),

(c) Necessary procedure for removal of existing properties (including trees, plants, etc.),

(2) During construction work

(a) Obtain the permission to use river gravel for the Project without Japanese side's expense,

(b) To lend the construction equipment procured under the Japanese Grant Aid without any affection to the daily maintenance work of the Nepalese side,

(c) To conduct all procedures regarding the diversion of traffic from the existing road (RTO) and pedestrian tracks, and to secure land for required diversion,

(d) Securing smooth traffic in Section I, II, IV for construction vehicles,

(e) Maintenance work for the section which will be handed- over partially.

(f) Necessary coordination among residents and/or RTO users and the Contractor.

(3) After the Completion of the Project

(a) To improve the parking spaces at necessary points,

(b) To improve sidewalks in the vicinity of the Project,

(c) Planting of trees in order to compensate cut plantation during construction.

6-2. The Nepalese side shall secure enough budget and personnel necessary for the operation and maintenance of the facilities improved by the Project, including the periodic maintenance work after the completion of the Project.

6-3. The Team had installed the equipment for monitoring the slope in Mulkot Area, and explained to the Nepalese side the importance of the monitoring. The Nepalese side understood it and requested to the Japanese side to transfer the equipment to the Nepalese side for the continuous monitoring after completion of the Basic Design Study attached as Annex-2.

This page is closed
due to the confidentiality.

Annex - 2

Government of Nepal
Ministry of Physical Planning & Works
Department of Roads

E-mail: dorfcb@dor.gov.np
Fax: 977-1-4257409
Tel: 977-1-4262693

Babar Mahal
Kathmandu, Nepal

Ref. No.: 36/065/066

Date: October 2, 2008

Mr. Noriaki NIWA
Resident Representative
Japan International Cooperation Agency
Nepal Office

Subject: Request for the Transfer of Equipment for Slope Monitoring

Dear Sir,

First of all we would like to express my sincere thanks for your utmost co-operation in successfully carrying out the Basic Design Study on Sindhuli Road, Section III and for explanation of the Draft Report.

We would also like to show our gratitude in installation of the slope monitoring equipment in Mulkot area of Sindhuli Road Section III. DOR has been explained about its concept during the seminar conducted by the team on 17th – 19th of September 2008. Through these we have come to realize its importance in the slope monitoring and its future application in Nepalese context since many of the hill roads are experiencing the problems of landslide. We are very much willing to have this technology transferred to us.

We have also come to know that the monitoring will be done by JICA study team till the end of October 2009. We, therefore, would like to request you to transfer the equipment, as attached list, to DOR so that we can continue the monitoring works in the Mulkot area.

Hence, we would like to request your goodself to be so kind enough and furnish us your kind acceptance on our request above.

Sincerely yours,

Tulasi Prasad Sitaula
Director General, DOR

CC: - Foreign Aid Co-operation Branch, DOR
- Banepa-Sindhuli-Bardibas Road Project
- Office File

Government of Nepal
Ministry of Physical Planning & Works
Department of Roads

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Fax: 977-1-4257409
Tel: 977-1-4262693

Babar Mahal
Kathmandu, Nepal

Ref. No.:

List of Equipment for Slope Monitoring

S.N.	Equipment Name	Quantity	Specification
1	Tiltmeter	24 nos	K-101
2	Data Logger for strain gauge	1 set	STR102W
3	Water Level Gauge	1 set	
4	Hyetometer	1 set	OW-34, RF-3
5	Watchman's hut	1 no	3m x 4m

DIRECTOR-GENERAL