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Ministry of Physical Planning and Works
Department of Roads**

ROAD SECTOR DEVELOPMENT PROJECT (AF)

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(New Project Preparation and Supervision Services)

**FEASIBILITY STUDY REPORT FOR UPGRADING OF
Birgunj to Narayanghat Section**



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in JV with
SAI Consulting Engineers (P) Ltd. (India)
in association with
ITECO Nepal (P) Ltd. (Nepal) &
Total Management Services (Nepal)

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

1	INTRODUCTION	1-1
1.1	Background	1-1
1.2	Study Road Section.....	1-1
1.3	Fesibility Study	1-3
2	PROJECT DESCRIPTION	2-1
2.1	Project Roads	2-1
2.2	Study Options	2-4
2.3	Improvement Standards	2-4
2.3.1	Asian Highway Standards	2-4
2.3.2	Recommended Standards.....	2-4
3	FIELD WORK	3-1
3.1	Desk Study	3-1
3.2	Road Inventory and Engineer's Survey.....	3-1
3.3	Hydrological Survey	3-1
3.4	Construction Material Investigation	3-1
3.5	Bio-Engineering Survey.....	3-1
3.6	Traffic Survey	3-2
3.7	Pavement and Subgrade Investigations.....	3-2
3.8	Environmental Survey	3-2
3.9	Social Survey	3-2
4	BRIDGE INVENTORY WORK.....	4-1
4.1	Inventory Work	4-1
4.2	General Condition of Bridges	4-1
4.3	New Bridges	4-4
4.3.1	Karra Bridge	4-4
4.3.2	Existing Causeways	4-4
4.4	Recommendations	4-5
5	HYDROLOGICAL STUDIES	5-1
5.1	General.....	5-1
5.2	Rainfall Analysis	5-1
5.3	Design Flood Estimation	5-4
5.4	Drainage Design.....	5-4
5.4.1	Drainage Facilities.....	5-4
5.4.2	Design Criteria	5-5
5.4.3	Cross Drains	5-5
5.4.4	Side Drains.....	5-6
6	GEOLOGICAL STUDY.....	6-1
6.1	Regional Geology and Geomorphology	6-1
6.2	Surface Geology.....	6-1
6.3	Slope Stability Conditions.....	6-2
6.4	Hazard Assessment	6-3

7	BIO-ENGINEERING SURVEY	7-1
7.1	General.....	7-1
7.2	Field Survey	7-1
7.3	Nursery.....	7-1
7.4	Site Assessment and Identification for Bio-engineering Application for Slope Protection	7-1
7.5	Design of Bio-engineering Works.....	7-2
7.5.1	Design of Vegetative Structures	7-2
7.6	Cost Estimates	7-4
7.7	Bio-engineering Planting Programme	7-4
8	CONSTRUCTION MATERIAL AND PAVEMENT INVESTIGATION.....	8-1
8.1	Material Source Survey and Testing	8-1
8.2	Material Sources	8-1
8.3	Laboratory Testing of Samples from Material Sources	8-5
8.4	Existing Road Sub-grade Investigation and Testing	8-5
8.5	General Remarks on Test Results	8-12
8.5.1	Construction Material/Stability of the Pavement Structure.....	8-12
8.5.2	Sub-grade Material.....	8-12
9	TRAFFIC STUDY	9-1
9.1	Introduction.....	9-1
9.2	Desk Study	9-1
9.3	Methodology.....	9-1
9.4	2011 Traffic Estimate	9-3
9.5	Traffic Growth.....	9-3
9.6	Network-wide Traffic Mix	9-7
9.7	Generated & Diverted Traffic.....	9-7
9.8	Base Year 2016 Traffic.....	9-9
9.9	Recommendation for Road Carriageway	9-12
10	PRELIMINARY ENGINEERING DESIGN	10-1
10.1	Data Entry and Calculation.....	10-1
10.2	Design Standards.....	10-1
10.3	Pavement Design	10-4
10.3.1	General	10-4
10.3.2	Existing Pavement Structure	10-4
10.3.3	Existing Pavement Condition.....	10-4
10.3.4	Pavement Structural Strength	10-4
10.3.5	Design Traffic Loads	10-5
10.3.6	Subgrade CBR	10-6
10.3.7	Design Methodology.....	10-6
10.3.8	Homogeneous Sections:	10-6
10.3.9	Overlay design by IRC-81:1997	10-7
10.3.10	New Pavement Design.....	10-7
10.3.11	Recommended Pavement Composition	10-8
10.3.12	Pavement Design on Steep Grades	10-9
10.4	Horizontal Alignment	10-9
10.5	Vertical Alignment	10-9
10.6	Design of Retaining and Cross Drainage Structures.....	10-9

10.6.1	Retaining Structures.....	10-10
10.6.2	Bridges.....	10-10
10.6.3	Longitudinal Side Drains	10-10
10.6.4	Cross Drainage	10-10
10.6.5	Typical Drawings.....	10-10
11	COST ESTIMATES	11-1
11.1	General.....	11-1
11.2	Costing Details	11-1
11.2.1	Unit Rates	11-1
11.2.2	Rate Analysis	11-1
11.2.3	Quantities.....	11-1
11.3	Cost Estimates	11-1
12	ECONOMIC ANALYSIS	12-1
12.1	Introduction.....	12-1
12.2	Project Costs	12-1
12.3	Traffic data summary in 2011 and forecast	12-2
12.3.1	Traffic Volumes Estimated in 2011	12-2
12.3.2	Traffic forecast	12-2
12.3.3	Daily Traffic profile for HDM modeling	12-3
12.4	Road User Costs	12-5
12.4.1	Vehicle operating costs	12-5
12.4.2	Calibration of vehicle maintenance (spare parts) costs	12-7
12.4.3	The value of travel time savings	12-7
12.4.4	Adjustment to Travel time inputs for HDM-4	12-9
12.4.5	Fuel Costs	12-9
12.4.6	Road Accidents (Social Costs)	12-10
12.4.7	Standard Conversion Factor.....	12-10
12.4.8	Road Maintenance Costs	12-11
12.5	Economic Analysis	12-11
12.5.1	Section-wise Analysis.....	12-11
12.5.2	Full Route Analysis.....	12-12
12.5.3	Analysis For Curtailed Route.....	12-12
12.5.4	Sensitivity Tests	12-13
12.6	Economic analysis – Conclusions	12-14
13	ENVIRONMENTAL ASSESSMENT	13-1
13.1	Introduction.....	13-1
13.2	Methodology Adopted for this Study	13-1
13.3	Brief Description of Existing Environment	13-2
13.4	Public Consultation.....	13-3
13.5	Impact Identification, Prediction and Evaluation.....	13-3
13.6	Matrix for Environmental Impact.....	13-4
13.7	Environmental Monitoring.....	13-4
13.8	Environmental Management Plan	13-5
13.9	Summary Costs for Environmental and Social Safeguard Measures	13-5
14	SOCIAL SURVEY FINDINGS	14-1
14.1	General Background	14-1
14.2	Description of the Project	14-1
14.3	Household Survey	14-1

14.4	Demographic Profile.....	14-2
14.4.1	Demography.....	14-2
14.4.2	Ethnic Composition	14-3
14.4.3	Education and Literacy.....	14-3
14.5	Settlement Patterns.....	14-4
14.6	Migration.....	14-4
14.6.1	In-Migration	14-4
14.6.2	Out-Migration	14-5
14.7	Economic Status	14-6
14.7.1	Occupation and Employment	14-6
14.7.2	Land Use.....	14-6
14.7.3	Landownership Status.....	14-6
14.7.4	Cropping Pattern	14-7
14.7.5	Food Sufficiency Status.....	14-7
14.8	Basic Utilities and Services	14-8
14.8.1	Drinking Water and Sanitation.....	14-8
14.8.2	Energy Use	14-8
14.9	Status of Women & Disadvantaged Group	14-9
14.10	Loss of Assets	14-9
14.11	Public Consultation.....	14-10
14.11.1	Methods of Public Consultation	14-10
14.11.2	Scope of Consultation	14-11
14.11.3	Issues Raised in Public Consultation.....	14-11
14.12	Social Mitigation and Monitoring	14-12
14.12.1	Impact & Effect Monitoring	14-12
14.12.2	Compliance Monitoring.....	14-12

FIGURES

Figure 1.1:	Location Map of Birgunj - Narayanghat Road.....	1-4
Figure 1.2:	Longitudinal Profile Birgunj - Narayanghat Road	1-5
Figure 2.1:	Proposed Alignment of Hetauda By Pass Road	2-7
Figure 2.2:	Proposed Road Alignment of Jaganathpur Simara Section	2-8
Figure 5.1:	IDF for Narayanghat – Hetauda Sector	5-2
Figure 5.2:	IDF for Hetauda-Amlekhgunj Sector.....	5-3
Figure 5.3:	IDF for Amlekhgunj-Simara Sector	5-3
Figure 5.4:	IDF for Simara-Birgunj Sector.....	5-4
Figure 10.1:	Typical Cross Sections	10-3
Figure 12.1:	Daily traffic profiles by section (March 2011)	12-4
Figure 12.2:	Daily traffic histogram Birgunj-Naryanghat road (2011)	12-4

TABLES

Table 1.1:	List of Settlement along Hetauda-Narayanghat Road section.....	1-2
Table 1.2:	List of Settlement along Hetauda-Birgunj Road section	1-2
Table 2.1:	Project Chainages Along Various Alternatives.....	2-1
Table 2.2:	List of Village along New Alignment in Link3	2-3
Table 2.3:	Asian Highways Classification	2-4
Table 2.4:	Design Speeds for Terrain Types (Asian Highway)	2-4
Table 2.6:	Asian Highways Design Standards (1993).....	2-6
Table 4.1:	Summary of Bridge Inventory	4-1
Table 5.1:	Rainfall intensities of different frequency at station near the project site.....	5-1
Table 5.2:	I-D-F Analysis for Narayanghat - Hetauda Sector.....	5-2
Table 5.3:	I-D-F Analysis for Hetauda - Amlekhgunj Sector.....	5-2
Table 5.4:	I-D-F Analysis for Amlekhgunj – Simara Sector	5-3
Table 5.5:	I-D-F Analysis for Simara - Birgunj Sector	5-3
Table 5.6:	Floods of different frequency in Karra River by different approaches.....	5-4

Table 5.7: Hydraulics of pipe culverts.....	5-6
Table 5.8: Hydraulics of slab culverts and causeways.....	5-6
Table 5.9 Selection criteria of CD Structures based on design flood	5-6
Table 5.10: Hydraulics of proposed side drain.....	5-7
Table 6.1: Sectionwise Hazard Category.....	6-3
Table 7.1: Location of Bio-engineering Works	7-2
Table 7.2: Selected Bio-engineering Species	7-3
Table 8.1: Summary of Laboratory Tests on Construction Material	8-2
Table 8.2: Summary of Lab Test Result	8-6
Table 9.1: 2011 AADT along the Birgunj - Narayanghat Road Corridor.....	9-3
Table 9.2: Traffic Growth along the Birgunj - Narayanghat Road Corridor.....	9-4
Table 9.3: Network Wide Traffic Growth along the Birgunj - Narayanghat Road Corridor.....	9-6
Table 9.4: Estimated GDP Growth Rate	9-6
Table 9.5: Assumed Income Elasticity of Transport Demand	9-7
Table 9.6: Calculated Traffic Growth Rate Adopted in Projections	9-7
Table 9.7: Traffic Analysis Zone	9-8
Table 9.8: Trip Pattern Observed	9-9
Table 9.9: Base Year 2016 AADT (Case 1 and 2)	9-9
Table 9.10: Case 1 Forecast 2026 AADT	9-10
Table 9.11: Case 2 Forecast 2026 AADT	9-11
Table 9.12: Case 1 Forecast 2036 AADT	9-11
Table 9.13: Case 2 Forecast 2036 AADT	9-12
Table 9.14: Case 1: Recommended Road Carriageway without North South Fast Track Corridor ..	9-13
Table 9.15: Case 2: Recommended Road Carriageway with North South Fast Track Corridor	9-14
Table 10.1: List of Sections with Provision of Service Roads	10-1
Table 10.2: Equivalent Standard Axles Observed at Aptari, NMH	10-5
Table 10.3: Cumulative Equivalent Standard Axles (ESA)	10-5
Table 10.4: Details of Homogenous Sections.....	10-6
Table 10.5: Overlay Thicknesses in Homogenous Sections.....	10-7
Table 10.6: New Pavement Design as per TRL-Overseas Road Note 31 (ORN-31)	10-7
Table 10.7: New Pavement Design as per IRC:37-2001	10-8
Table 10.8: Recommended Overlay Thickness	10-8
Table 10.9: Recommended New Pavement Thickness	10-9
Table 10.10: Number of Existing & Proposed Structures.....	10-10
Table 11.1: Summary of Cost Estimate	11-2
Table 11.2: Summary of Cost Estimate	11-3
Table 11.3: Summary of Cost Estimate	11-5
Table 12.1: Engineering cost.....	12-1
Table 12.2: Traffic (AADT) in 2011	12-2
Table 12.3: Motorized traffic compositions used in HDM analyses	12-2
Table 12.4: Vehicle fleets in 2008 and 2009, and change (%).....	12-3
Table 12.5: Traffic growth rates for HDM analyses.....	12-3
Table 12.6: Flow-group data input to HDM-4	12-5
Table 12.7: Capacity by road type in HDM-4	12-5
Table 12.8: Vehicle operating costs – main parameters for HDM-4.....	12-6
Table 12.9: VOC inputs common to all types.....	12-6
Table 12.10: Value of travel time calculation	12-8
Table 12.11: Adjustment factors for Value of Travel Time input to HDM-4	12-9
Table 12.12: Economic cost of vehicle fuel.....	12-9
Table 12.13: Injury-accidents by district, August 2010-March 2011	12-10
Table 12.14: Road injuries per 100 million vehicle-km.....	12-10
Table 12.15: Road Maintenance Costs (US\$/sq. metre)	12-11
Table 12.16: Cost Benefit Analysis (Section-wise)	12-11
Table 12.17: Cost Benefit Analysis for Complete Routes	12-12
Table 12.18: Sensitivity tests: for Various Routes	12-13
Table 14.1: Population Distribution in the Project Districts.....	14-2
Table 14.2: Population Composition of the Affected VDCs/Municipalities	14-2
Table 14.3: Ethnic Composition of Project Area (%).....	14-3
Table 13.4: Literacy Rate of Project Districts (%)	14-3
Table 14.5: Educational Status of Surveyed Population (%).....	14-4

Table 14.6: Type of Houses (%)	14-4
Table 14.7: In-Migration Trend (%)	14-4
Table 14.8: Purpose of In-Migration (%)	14-5
Table 14.9: Destination of Out-Migration (%)	14-5
Table 14.10: Purpose of Out-Migration (%)	14-5
Table 14.11: Occupational Status of Study Area (%)	14-6
Table 14.12: Land Type and Size of Study Area (Hectare)	14-6
Table 14.13: Distribution of Households According to Tenancy Pattern (%)	14-6
Table 14.14: Production of Food Grains	14-7
Table 14.15: Production of Vegetables	14-7
Table 14.16: Cash Crop Production	14-7
Table 14.17: Food Sufficiency Status of Project Area Households (%)	14-8
Table 14.18: Sources of Drinking Water (%)	14-8
Table 14.19: Toilet Facility (%)	14-8
Table 14.20: Sources of Energy for Cooking (%)	14-9
Table 14.21: Sources Energy for Lighting (%)	14-9

ANNEXES

- Annex 1: Strip Maps
- Annex 2: List of Structures
- Annex 3: Traffic Study
- Annex 4: Pavement and Soil Investigation and Material Reports
 - Benkelman Beam Deflection Measurement
 - Surface Distress Index (SDI)
 - MDD of Existing Gravel/Earthen Road Surface
 - Existing Subgrade CBR (Soaked)
 - Atterberg Limit of Existing Gravel/Earthen Road Surface Materials
 - Seive Analysis of Existing Gravel/Earthen Road Surface Materials
 - Natural Moisture Content of Existing Gravel/Earthen Road Surface Materials
 - Field DCP (by Kleyn & Van Method) Existing Road Surface
 - Construction Materials Test Reports
- Annex 5: Cost Estimate
- Annex 6: Social Data and Check List
- Annex 7: Economic Analysis Data
- Annex 8: Cross Drainage and Side Drain
- Annex 9: Photographs
- Annex 10: Standard Drawings

ABBREVIATIONS

AADT	Annual Average Daily Traffic
ACV	Aggregate Crushing Value
AIV	Aggregate Impact Value
AMSL	Average Mean Sea Level
ASL	Average sea level
CBO	Community Based Organization
CBR	California Bearing Ratio
CFUG	Community Forestry Users Group
COI	Corridor of Impact
CSB	Crushed Stone Base
Cu.m	Cubic Meter
DADO	District Agriculture Development Office
DBST	Double Bituminous Surface Treatment
DCP	Dynamic Cone Penetration
DDC	District Development Committee
DFO	District Forest Office
DHM	Department of Hydrology and Meteorology
DoR	Department of Roads
EMAP	Environmental Management Action Plan
EPR	Environmental Protection Rule
FGD	Focus Group Discussion
GESU	Geo Environmental And Social Unit
GoN	Government Of Nepal
GPS	Global Positioning System
GSB	Gravel Sub-Base
HH	House Holds
IEE	Initial Environmental Examination
IFD	Intensity Frequency Duration
IRR	Internal Rate of Return
ISB	Improved Sub-Base
LCF	Local Consultative Forum
LL	Liquid Limit
MC	Moisture Content
MDD	Modified Dried Density
MoPPW	Ministry Of Physical Planning And Works
MSA	Million Cumulative Standard Axles
NAB	Natural Aggregate Base
NGO	Non Governmental Organization
NPV	Net Present Valuye
NRDUC	New Road Development and Upgrading Component
OD	Origin and Destination
OMC	Optimum Moisture Component
OS	Otta Seal
PI	PlasticityIndex
ESA	Equivalent Standard Axle
RCC	Reinforced Cement Concrete
RL	Reduced Level
RMDP	Road Maintenance and Development Project
RoW	Right of Way
STDs	Sexually Transmitted Disease
VAT	Value Added Tax
VCDP	Vulnerable Community Development Plan
VDC	Village Development Committee

EXECUTIVE SUMMARY

General

Under the RSDP(AF) the Feasibility Study (FS) for Birgunj - Narayanghat road section had been carried out as additional work instructed under V.O. – 1 to the services of ongoing RSDP(AF) and findings are presented herein. As part of the original assignment (ToR) feasibility study for the Narayanghat – Mugiling road was conducted. The DoR planned to upgrade the complete road upto the India border and accordingly asked the Consultants to carry out the FS. This complete road from India border to the China border passing through the Capital city of Kathmandu is part of the Asian Highway network (AH42). Presently this road section is existing as two lane road with width varying from 5.5m to 7.0m. Road section from Birgunj to Pathlaiya and through other towns / markets along the road is quite congested and needs improvements. With coming up of ICD and proposed ICP, it has become urgent to improve the Kathmandu – Birgunj route to Asian Highway Standards.

General Review of Existing Studies

From Pathlaiya to Birgunj bypass / International border the DoR have got the detail design with 4 lanes carriageway + Service roads carried out under a separate study. The MoPPW had also approved alignment for the proposed Hateuda bypass under a separate study. Consultants reviewed these studies and noted the findings. These studies gave a preliminary view of the expected traffic and costs of works.

Study Options

From Narayanghat to Pathlaiya (NP) there is single alignment (km 108+670) and no alternatives are available.

From Birgunj to Pathlaiya leaving the road section through the Birgunj town for the municipality there are other 3 alternative alignments (refer **Figure 1.1**) in this section i.e. Pathlaiya – Parwanipur – ICD (L1), Pathlaiya – Birgunj bypass (L2), and Pathlaiya – Jaganathpur – ICD (L3 - 13 km new alignment and then joining with existing road to ICD).

To have a continuous chainage, km 0+000 has been assigned to Narayanghat (Aaptari).

Full Length Options: Accordingly 3 full lengths options from Birgunj to Narayanghat had been studied as follows -

Option 1: NP+L1 km 134+685, Option 2: NP+L2 km 136+510 and Option 3: NP+L3 km 133+150.

For the present two lane Hateuda bypass (7.50 km) is proposed as existing two lanes through town can also be used.

Other Options: In addition further curtailed options from Birgunj ICD (L1) – Pathlaiya – Ratomate – Hateuda bypass has been studied in detail to make use of the different (limited) funding scenarios available. These option sections are as follows –

Option 4: ICD-Parwanipur-Pathlaiya section (L1), Option 5: Pathlaiya – Ratomate section, HB: Hateuda bypass.

Feasibility study of combination of various options has also been carried out.

Hydrological Studies

Fresh hydrological studies had been carried out based on data collected through walk-over survey and inventory survey. Discharges have been calculated with latest available rainfall data upto year 2010 and catchment areas from site and topo maps scale (1:25,000).

Geological Studies

Geological formations along the alignment had been studied. As there are no large cut sections etc. so slope stability is not a major issue. Important issues along this road are the flow of debris and erosion along the streams. Check dams for controlling the debris flow and retaining structures to control the erosion needs to be provided.

Bio-Engineering

Bioengineering provisions are based on field observations of the slope stabilisation requirements and techniques available. Techniques adopted on some other projects in similar conditions in India (HP etc.) have also been adopted.

Traffic Studies

Fresh 3 day traffic counts, origination – destination surveys at 5 locations had been conducted. Studies for traffic diversion, generation and traffic reassignment to reflect the traffic flow pattern following road upgrading have also been done. Year 2011 traffic has been counted as varying from 1,003 to 13,308 MVs at various locations. Base year (2016) traffic is estimated as varying from 5,201 to 17,597 MVs at various locations. This amount of traffic requires provision of 4-laned road in full length in year 2016. The design loading for pavement design has been worked out based on axle-load survey. Estimated ESAs for 10 year at the Birgunj - Narayanghat – Mugling sections is estimated to be varying from 14.53 to 49.19 million standard axles (MSA) in various sections.

Pavement Investigations and Construction Materials

Existing road is a bituminous pavement. For widening to Asian Highway Standards, it shall be required to be widened and strengthened. For strengthening of existing pavement Subgrade CBR had been tested by taking Subgrade samples and DCP testing. Pavement strength has been checked by carrying out Benkelman Beam tests. New pavement has been designed using IRC and TRL design methods. Construction materials have been sampled and tested in the laboratory for their suitability.

Engineering Design

Preliminary engineering design has been carried out based on the data collected through field inventory survey, condition surveys and material test results. As per traffic numbers the carriageway has to be four lane, with service roads on both sides in industrial areas / markets etc. All bridges and CD structures shall need to be widened to 4-lane. This shall require new 2-lane bridges. 9 nos existing causeways, 3 choked bridges shall also be replaced by 4-lane bridges. As far as possible it shall be attempted to make the existing 2-lane pavement as one carriageway by making eccentric widening. Incongested areas concentric widening has to be done.

Cost Estimates

Analysis of Rates have been prepared based on approved district rates from Chitwan, Bara, Parsa and Makwanpur Districts for the fiscal year 2010-11 (B.S. 2067/068). For items for which rates from District Authorities are not available, rates have been worked out based on the basic market rates from Narayanghat, Hetauda and Birgunj markets with addition of cost of haulage. Quantities for BOQ have been based on the preliminary design and cost estimates worked out accordingly.

Financial costs of various full length options are (i) Option 1, NP+L1 NRs 21,703 million, (ii) Option 2, NP+L2 NRs 22,490 million, (iii) Option 3, NP+L3 NRs 21,501 million.

To address the limited funds availability scenario and viability of the project, costs were also calculated for ICD- Pathlaiya- Ratomate section (Option 4) and ICD- Pathlaiya- Ratomate-Hetauda sections (Option 5) i.e. with and without Hetauda bypass. To improve the viability of the project service roads were dropped and surfacing for ICD-Parwanipur and Hetauda bypass was changed to DBST.

Economic Analysis

Present AADT (traffic) on various sections of BN road is varying between 1,003 to 13,308 MVs. In year 2016 it is expected to be varying from 5,201 to 17,597 MVs.

Birgunj ICD – Pathlaiya – Ratomate – Hetauda bypass – Narayanghat (Full length of study road): Accounting for VOC using the HDM 4 model, time savings, accident reduction savings etc. the EIRR has been calculated as 15.1%, 15.2% and 14.8% for Options 1, 2 and 3 respectively as summarised in Table below. Project is highly feasible and the normal cost fluctuations ($\pm 20\%$) will not affect its feasibility. Option 1 is the recommended option as it connects to the ICD / ICP and also provide 4/6 laning of Pathlaiya - Parwanipur section.

Table 14.1: Economic Analysis for Full Length Options

Route	Detail	Length Km	Costs \$m	Cost \$m without Bridges	EIRR % (with Bridges)
Option 1 (NP+L1)	Naryanghat-Hetauda bypass- Pathlaiya -Parwanipur-ICD (4-lane)	134.68	301.43	223.90	15.1%
Option 2 (NP+L2)	Naryanghat-Hetauda bypass- Pathlaiya - Birgunj bypass-Border	136.51	312.35	231.86	15.2%
Option 3 (NP+L3)	Naryanghat-Hetauda bypass- Pathlaiya -Jaganathpur-ICD (bypass ext'n) 4 lanes	133.15	298.63	224.45	14.8%

Birgunj ICD-Parwanipur – Pathlaiya – Ratomate – Hetauda bypass (Curtailed length)

To cater for the limited availability of funds, economic viability has been checked for various curtailed road section options between Birgunj ICD to Hetauda bypass, i.e. with and without Hetauda bypass as given in Table below.

Table 0.2: Economic Analysis for Options with Curtailed Lengths

Route	Detail	Length Km	Costs \$m	Cost \$m without Bridges	EIRR % (with Bridges)
Option L1.3	Birgunj ICD - Patlaiya	26.015	16.71	13.39	15.8%
	4-Lane without service road and footpath, Bituminous Concrete Surfacing in Pathlaiya – Parwanipur Section and DBST in Parwanipur – ICD Section				
Option PRH 3	Pathlaiya – Ratomate – Hetauda bypass	32.03	55.52	28.42	14.7%
	<i>Pat – Ratomate:</i> 4-Lane without service road and footpath, with Bituminous Concrete Surfacing in entire section <i>Hetauda Bypass:</i> 2-lane DBST Surfacing				
Option 4	Birgunj ICD-Parwanipur – Pathlaiya – Ratomate (without Hetauda bypass)	50.54	61.84	38.80	16.7%
Option 5	Birgunj ICD-Parwanipur – Pathlaiya – Ratomate – Hetauda bypass	58.04	72.23	43.60	15.1%

Environmental Assessment

For carrying out a fresh IEE, Terms of Reference were prepared, and submitted to the GESU / Ministry for approval. Then response shall be collected from the concerned VDCs. Environment assessment shall be carried out to collect the baseline information on physical, biological, socio-economic and cultural environment of the project road. Public Consultation shall be held with the local stake holders within the VDC areas along the road to update the baseline data of the area. Accordingly IEE shall be prepared.

Social Survey Findings

Social survey carried out during study and data collected through reconnaissance survey, public consultation meetings, key informant interview and sample household surveys. Accordingly socio economic baseline data has been compiled incorporating information related to present socio-economic situation and peoples' perception towards the road project. The survey focused on the impact of the road especially on land acquisition. The findings showed that majority of the households are agrarian followed by trade. Improving the road shall be beneficial for traders and shall generate lot of employment.

Conclusions

As can be noted from the results of the economic analysis (Table 0.1), full length option for Narayanghat-Hetauda bypass-Pathlaiya -Parwanipur-ICD with 6-lane in market areas and full asphalt pavement is economically feasible. With the EIRR of 15.1% the investment is sound and cost fluctuations of $\pm 20\%$ shall not affect the project viability.

In case of reduced funding option road sections from Birgunj ICD- Parwanipur – Pathlaiya – Ratomate (Option 4) and Birgunj ICD- Parwanipur – Pathlaiya – Ratomate – Hetauda bypass (Option 5) had also be examined as shown in Table 0.2 above. In this section the cost of construction of bridges is proportionately quite high, over 40% of total cost. Therefore to improve the project viability pavement surfacing in sections from ICD to Parwanipur (10.78 Km) and Hetauda bypass (7.50 Km) had to be changed to DBST. As result of economic analysis it can be seen both of these options (Option 4 & 5) are also economically feasible.

1 INTRODUCTION

1.1 Background

Road section from Birgunj- Hetauda- Narayanghat is one of the most important highway section connecting the Nepal's capital city Kathmandu to outside world via Terai to India at Birgunj. About 65 % of all international trade in the form of daily consumer goods, commodities, industrial raw materials and fuel required in Nepal are being transported through this road link. Import and export of the country heavily depends on this road section. Thus, the day to day economy of the country is influenced by the status of this very road.

Nepal being a landlocked country, and consequently it has to pay about 10-15% additional charges on international imports. To minimise the transportation costs of goods, the GoN is actively taking up the up-gradation of the dry ports at Kakarbhitta, Biratnagar, Birgunj and Bhairahawa with rail / road based Inland Clearance Depots (ICD's) and Integrated Check Posts (ICP's). Further more dry ports at Tatopani, Rasuwa, Krishnanagar, Nepalgunj and Sarlahi are under consideration. With the construction of the ICD in Birgunj, all imported goods in containers are directly transported from Haldia port (India) by rail to the ICD in Birgunj.

At a distance of about 1.5 km from the Birgunj ICD, Integrated Check Post (ICP) is being constructed. After construction of the ICP, all truck traffic shall be routed through it.

Birgunj is a major business centre of Nepal, especially for trade with India and other countries. Almost all trade with India occurs through this route. The 29 KM distance from Birgunj to Pathlaiya is the Busiest highway in Nepal. Important industries in the area are cigarette manufacture, drugs manufacture, steel mills, cement factories chemical industries, paper manufacturing and fish-breeding.

1.2 Study Road Section

Project road section is presently of National Highway standard (2 lane bituminous surface) starting at Birgunj (ICD) and ends at Aptari (2.4 km north of Narayanghat, with km. 0+000 at Narayanghat) on East West Highway (EWH, H01). Study section starts at Birgunj (ICD) and joins with Tribhuvan Raj Path (TRP, H02) at Parwanipur. This 11km highway standard two lane road between ICD and Parwanipur had been constructed recently under ADB assistance.

From Parwanipur the study road alignment follows TRP upto Ratomate (Hetauda) from where a 7.5km long Hetauda bypass road is proposed. The length of road stretch between Parwanipur and Ratomate is 39.8km. The Hetauda Bypass Road joins EW Highway at Km 395+750 east of Rapti bridge at Hetauda. After connecting with the EWH the alignment follows the EWH upto Bharatpur (Narayanghat) Km 467+640. The last stretch Bharatpur (km467+800)- Aptari (km 2+425) section is a bypass road within the Bharatpur Municipality in Chitwan district.

The 12.6km long existing road section from Birgunj border (km 189+740) along Birgunj bypass - Pratima Chowk - Parwanipur Junction (km 177+135) is also a part of study road. The Birgunj bypass (from International border) joins back to the TRP south of canal bridge and leads to Parwanipur.

Another new link from the ICD to Simra via Jagannathpur has also been considered.

The topographical setting of the road alignment area is characterized by plain, rolling and river basin. The Birgunj- Narayanghat (Aptari Km 2+425) road gradually ascends from Amlekhgunj (km 152+200) to Hetauda (TRPkm 137+370) along the Siwalik hills. From Hetauda (EWH Ch: 395+520 the road alignment runs along the southern face of the hills for next 25km and afterwards follows nearly along the flat land of the old river deposits upto Bharatpur Municipality.

The alignment passes through a number of built-up areas as listed in **Table 1.1** below:

Table 1.1: List of Settlement along Hetauda-Narayanghat Road section

S.No	EWH Chainage	Settlement	Remarks
1	395+520	Proposed By-Pass(Hetauda)	EWH chainage (H-01)
2	399+200	Nawalpur	
3	410+610	Newarpani	
4	419+700	Jyamere	
5	420+950	Simpani	
6	422+500	Beluwa	
7	423+900	Manahari	
8	425+650	Bijhauna	
9	433+100	Churachuri	
10	435+350	Lothar	
11	439+700	Gadaule	
12	441+000	Pipletar	
13	444+900	Bhandara	
14	452+700	Parsa	
15	457+800	Ratnanagar Municipality	
16	460+600	Tikauli	
17	467+800	Bharatpur	EWH chainage

Table 1.2: List of Settlement along Hetauda-Birgunj Road section

S.No	TRP Chainage	Settlement	Remarks
1	-	Hetauda	TRP chainage (H-02)
2	137+370	Ratomate	
3	143+240	Churiya	
4	152+200	Amlekhgunj	
5	161+900	Pathlaiya	
6	164+950	Simra	
7	169+250	Jitpur	
8	177+135	Parwanipur Junction	TRP Chainage from Hetauda-Birgunj section
9	182+195	Parwanipur(way to Raxaul)	
10	183+550	Pratimachowk	
11	188+455	Raja janti	
12	189+740	Raxaul (Boarder)	TRP chainage
13	10+780	New Link to ICD Dryport	Chainage from Parwanipur Junction (km 0+00) to ICD Dryport

The overall location of the project road is illustrated in **Figures 1.1** and longitudinal profile in **Figure 1.2.**, which also indicate the main settlements along the alignment.

1.3 Fesibility Study

The objective of this Feasibility Study is primarily for appraisal purposes, and to prepare a sufficiently accurate cost estimate for the works involved to enable the feasibility of the improvement to be assessed.

This volume contains preliminary engineering design including the findings of pavement investigations, road inventory survey, preliminary design, environmental / social assessment, cost estimate and economic analysis for the improvement of Birgunj (from ICD for freight) to Narayanghat (Aptari Km 4+520 on NM road) road to Asian Highway Standards. For passenger traffic Parwanipur Junction (km177) - Birgunj Bypass - Raxaul (km189+740) section is also studied. Road is located in Parsa, Bara, Makwanpur and Chitwan districts in the Central Development Region of Nepal.

Figure 1.1: Location Map of Birgunj - Narayanghat Road

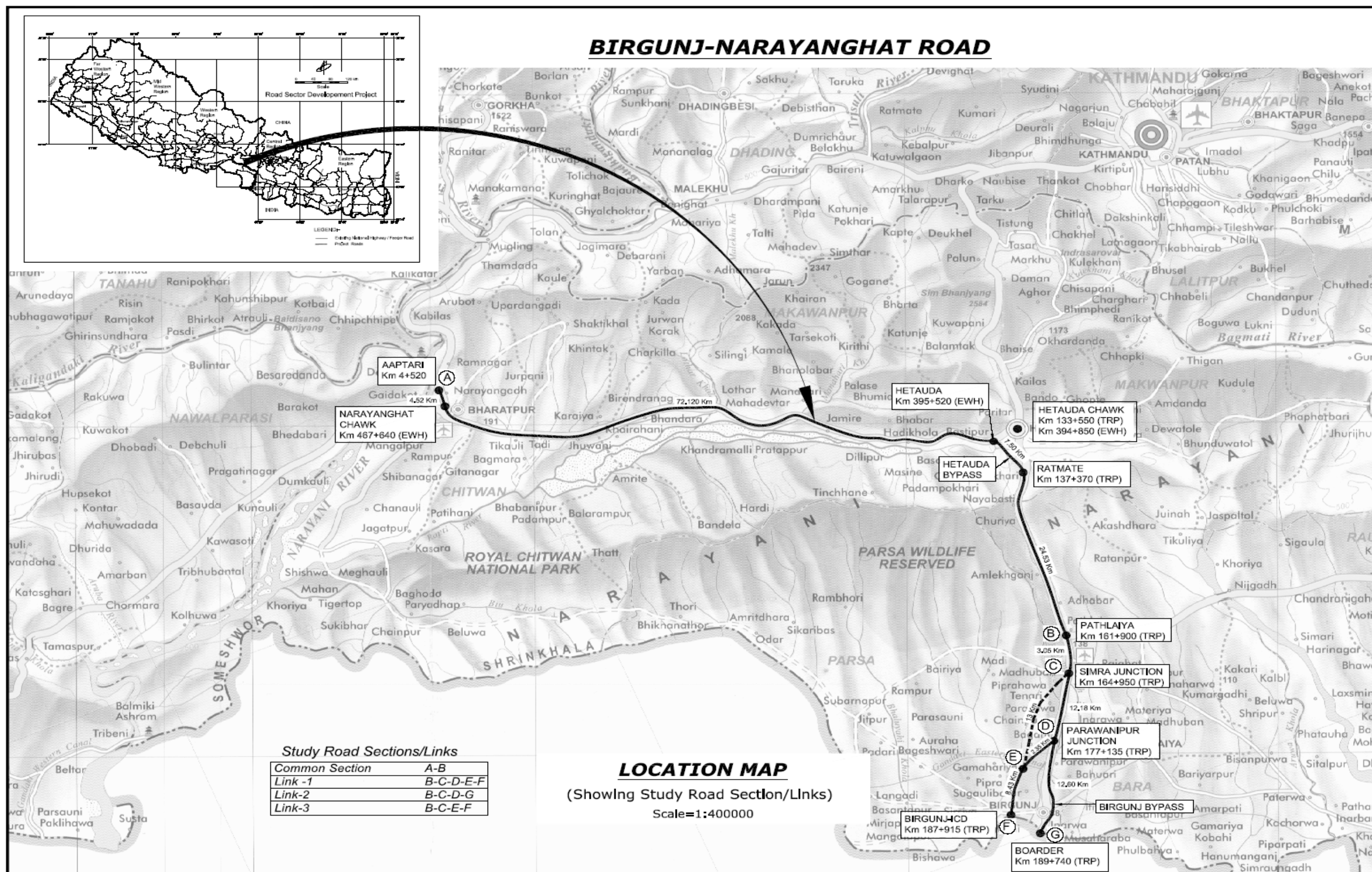
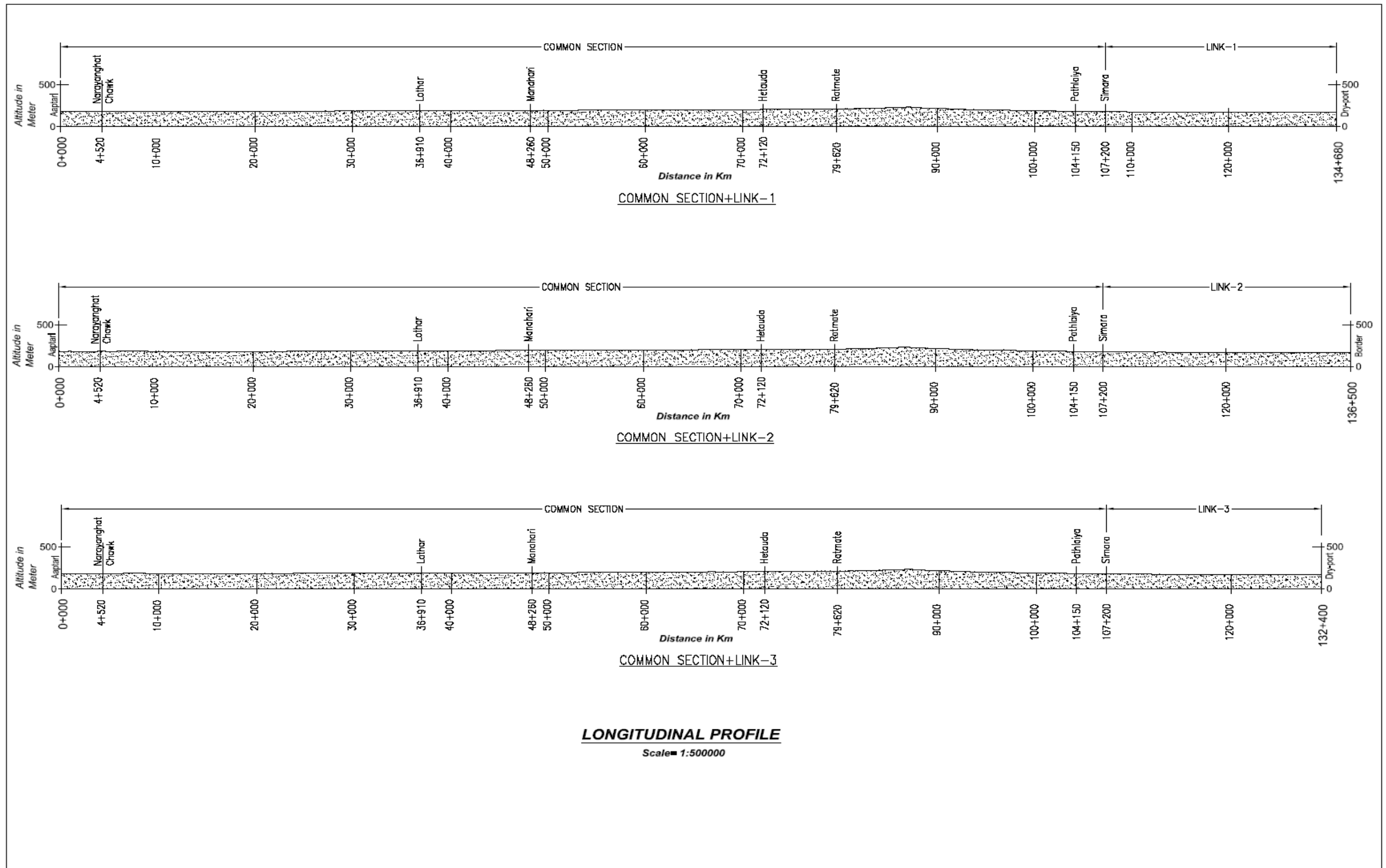


Figure 1.2: Longitudinal Profile Birgunj - Narayanghat Road



2 PROJECT DESCRIPTION

2.1 Project Roads

Project road is presently of National Highway standard starting at Birgunj and ends at Aptari (4.52km north of Narayanghat / Bharatpur with km. 0+000 at km 467+640 on EWH). As shown on the location map (**Figure 1.1**) study road have common section from Aptari to Pathlaiya. After that there are 3 links i.e. Pathlaiya – Parwanipur – ICD, Pathlaiya – Birgunj bypass – International Border and Pathlaiya Simra – Milan Chowk - Jagan Nath Pur – ICD. Length of various links involved are given in **Table 2.1** and plan shown in **Figure 1.1**.

As link from Aptari to proposed Simra junction is common in all cases, for simplification, chainages have been started with km 0+000 at Aptari. Accordingly chainages of all links are given in **Table 2.1**.

Table 2.1: Project Chainages Along Various Alternatives

Section	Location	Project Chainage	Remarks
Common Section	Aptari	0+000	Narayanghat – Mugling Road
	Narayanghat Chowk (EWH km 467+640), Bypass km 0+000	4+520	
	Hetauda bypass (start)	76+640	East West Highway
	Hetauda bypass (end) / Ratomate Bazaar	84+140	Hetauda bypass (7.50km)
	Pathlaiya	108+670	Tribhuvan Rajpath
Link 1	Pathlaiya	108+670	Tribhuvan Rajpath
	Parwanipur	123+905	Tribhuvan Rajpath
	ICD	134+685	
Link 2	Pathlaiya	108+670	Tribhuvan Rajpath
	Parwanipur	123+905	Tribhuvan Rajpath
	International Border	136+510	
Link 3	Pathlaiya	108+670	Tribhuvan Rajpath
	Simra	111+720	Tribhuvan Rajpath
	Jaganathpur - ICD	133+150	Partly new alignment (13km) and 8.43km existing road

Common Section: From Aptari, alignment follows Narayanghat bypass and joins EWH at Bharatpur, km 467+640. Aptari - Bharatpur section is within the Bharatpur Municipality in Chitwan district. Project alignment continues eastward along EWH upto km 395+520 where it crosses river Rapti with a 210m long bridge. Immediately after crossing the river, alignment



View from Rapti River bridge – with Hetaudua bypass along left bank

turns right along proposed Hetauda bypass. Feasibility study for the proposed Hetauda bypass (7.5 km long) had been got conducted by the MoPPW under a separate study and alignment approved as shown in **Figure 2.1**. Same approved alignment for the Hetauda bypass is followed for this study. From EWM km 395+520 Hetauda bypass follows the left bank of the Rapti river and then crosses its tributary, Karra river and then goes from back of an existing cement plant. Thereafter it follows another Khola and links to the TRP (km 137+370) in Ratomate bazaar avoiding the forest.

upto Pathlaiya, km 161+900 on the TRP. Project chainage / length of this common section is km 108+670. After Simra the study has been carried along 3 links as indicated in **Table 2.1**.

Common alignment for all cases continues

Selected 3 links are study options are described in the following.

Link-1: Pathlaiya - Parwanipur- ICD

From Pathlaiya this link continues along TRP to Parwanipur (km 164+950 TRP) and then turns right towards the ICD. This 10.78 km long highway standard two lane road between ICD and Parwanipur was constructed under ADB assistance. Total length of this option along Link -1 is 134.680km.



Hume pipes at Karra River crossing on Hetaudua bypass

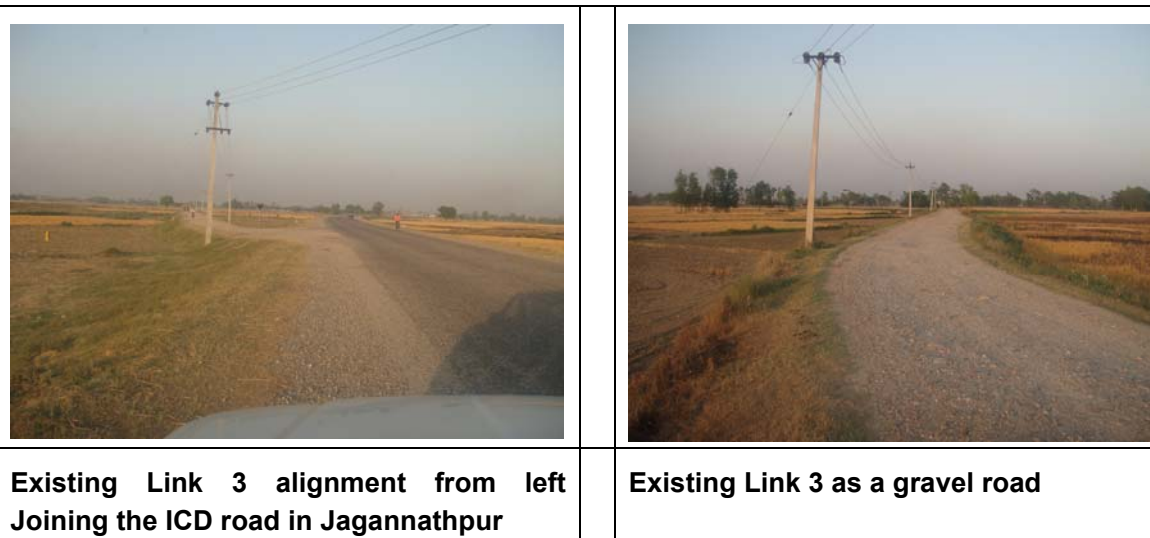
Link-2: Pathlaiya - Parwanipur- Pratima Chauk- Raxaul / Birgunj border

From Simra this link follows TRP through Parwanipur to Gandak canal bridge and follows the Birgunj bypass on east of town. Birgunj Bypass road was constructed as an urban road constructed between Birgunj custom and Pratima Chauk. This bypass road has a defined ROW and by now market has come up all along the length of about 7km. At end of bypass it again joins back with the TRP at Rajatjayanti Chawk and goes upto International broder. Total length of this option along Link-2 is 136.505km.

Link-3: Pathlaiya Simra- Milan Chauk- Jagan Nathpur- ICD

Pathlaiya to Simra it follow TRP. From Simra this link turns right to west of TRP along a proposed new alignment through agricultural fields. From Simra upto Milan Chauk there is

only an earthen track existing. It then joins with the existing gravel road in Milan Chauk and follows the gravel road upto Jagan Nathpur. Existing gravel road has about 4.5 to 5.0 gravel surface with 8.5-9.0m wide embankment, with road alignment passes through congested villages. Upgrading this road



shall require realignments to save houses / properties and improving sub-standard geometrics.



Link 3 – Milan Chowk, Rural market

Alignment is passing through populated villages and agricultural fields. Names of the villages along the new alignment / gravel road are given in **Table 2.2**. Cost of land in this area shall be quite high.

In Jagannathpur the the gravel road joins back on the Parwanipur – ICD road section. Alignment of this gravel road is shown in **Figure 2.2**. Total length of this option-3 is 133,150 km.

Table 2.2: List of Village along New Alignment in Link3

S.No.	VDC	Village
1	Pipra Simara	Rambantadi, Narbasti, Simra Bazar
2	Chorni	Solakpur, Tedagau
3	Belwa	Parsauni, Bhediyahi
4	Lalparsa	Lalparsa, Prasotipur
5	Maniyari	Jagannathpur

2.2 Study Options

Considering the abovementioned links, feasibility of following options is being studied.

- Option-1:** Aptari - Narayanghat - Hetauda Bypass – Ratomate - Pathlaiya (Common section)
Option-2: Pathlaiya - Parwanipur - ICD (Link 1)
Option-3: Pathlaiya - Parwanipur - PratimaChauk- Raxaul/Birgunj International border (Link 2)
Option-4: Pathlaiya Simra - Milan Chauk - Jagan Nathpur - ICD (Link 3)

2.3 Improvement Standards

2.3.1 Asian Highway Standards

Project road sections are generally existing as two lane bituminous surfaced roads in fair condition except portion (13km) of Link-3. Considering the present traffic the GoN intends to improve the roads to meet future traffic requirements.

The Asian Highway network includes two road sections in Nepal i.e. AH 2 (1042 km) from Kakarbhitta – Pathlaiya – Narayanghat – Kohalpur – Mahendranagar – Bramhadev Mandi and AH42 (298 km) Kodari – Kathmandu – Narayanghat – Pathlaiya – Birgunj. Project road is part of the link AH42, and therefore the GoN proposes to upgrade it to the Asian Highway Standards.

The Asian Highway classification and design standards provide the minimum standards and guidelines for the construction, improvement and maintenance of Asian Highway routes. It is desired to make every possible effort to conform to these provisions both in constructing new routes and in upgrading and modernizing existing ones. Asian Highways are classified as under:

Table 2.3: Asian Highways Classification

Classification	Description
Primary	Access controlled motorway
Class I	4 or more lane highway
Class II	2 lanes
Class III	2 lanes (narrow)

The minimum standard for Asian Highway Network is bituminous paved road with two lanes. Birgunj - Aptari road is to be widened to 2/4/6 lanes as per traffic requirements. Asian Highway Design Standards propose following design speeds (**Table 2.3**) for various terrains. AH Design standards are given in based on speeds and terrain types are given in **Table 2.4**.

Table 2.4: Design Speeds for Terrain Types (Asian Highway)

Terrain	Primary	Class I	Class II	Class III
Level (L)	120	100	80	60
Rolling (R)	100	80	60	50
Mountain (M)	80	60	50	40
Steep (S)	60	60	40	30

2.3.2 Recommended Standards

Abovementioned Asian Highway Standards shall be adopted for the project depending of lane requirements as per traffic and the terrain type. Project road can be broadly divided in terrain types as below.

From	To	Project Chainage		Level (L)	Rolling (R)
Aaptari	EWB km 444+900	0+000	27+000	27+000	
EWB km 444+900	Amlekgunj	27+000	99+000		72+000
Amlekgunj	Birgunj / ICD	99+000	136+510	37+510	
Total				64+510	72+000

As per existing traffic it is not desired to go in for grade separated interchanges. All intersections shall be designed as at grade intersections. Accordingly it is proposed to provide a facility with least interference from local traffic. So it shall be limited access road with separate service roads on either side in congested markets, industrial areas etc.

Table 2.6: Asian Highways Design Standards (1993)

Highway classification		Primary (4 or more lanes)				Class I (4 or more lanes)				Class II (2 lanes)				Class III (2 lanes)			
Terrain classification		L	R	M	S	L	R	M	S	L	R	M	S	L	R	M	S
Design speed (km/h)		120	100	80	60	100	80	60		80	60	50	40	60	50	40	30
Width (m)	Right of way	50				40				40				30(40)			
	Lane	3.75				3.50				3.50				3.00(3.25)			
	Shoulder	3.00		2.50		3.00		2.50		2.50		2.00		1.5(2.0)		1.0(1.5)	
	Median strip	4.00		3.00		3.00		2.50		N/A		N/A		N/A		N/A	
Min. horizontal curve (m)		520	350	210	115	350	210	115		210	115	80	50	115	80	50	30
Pavement slope (%)		2				2				2				2 - 5			
Shoulder slope (%)		3 - 6				3 - 6				3 - 6				3 - 6			
Type of pavement		Asphalt/cement concrete				Asphalt/cement concrete				Asphalt/cement concrete				Dbl. bituminous treatment			
Max. superelevation (%)		10				10				10				10			
Max. vertical grade (%)		4	5	6	7	4	5	6	7	4	5	6	7	4	5	6	7
Structure loading (minimum)		HS20-44				HS20-44				HS20-44				HS20-44			

Notes: Figures bracket are desirable values.

Figure 2.1: Proposed Alignment of Hetauda By Pass Road

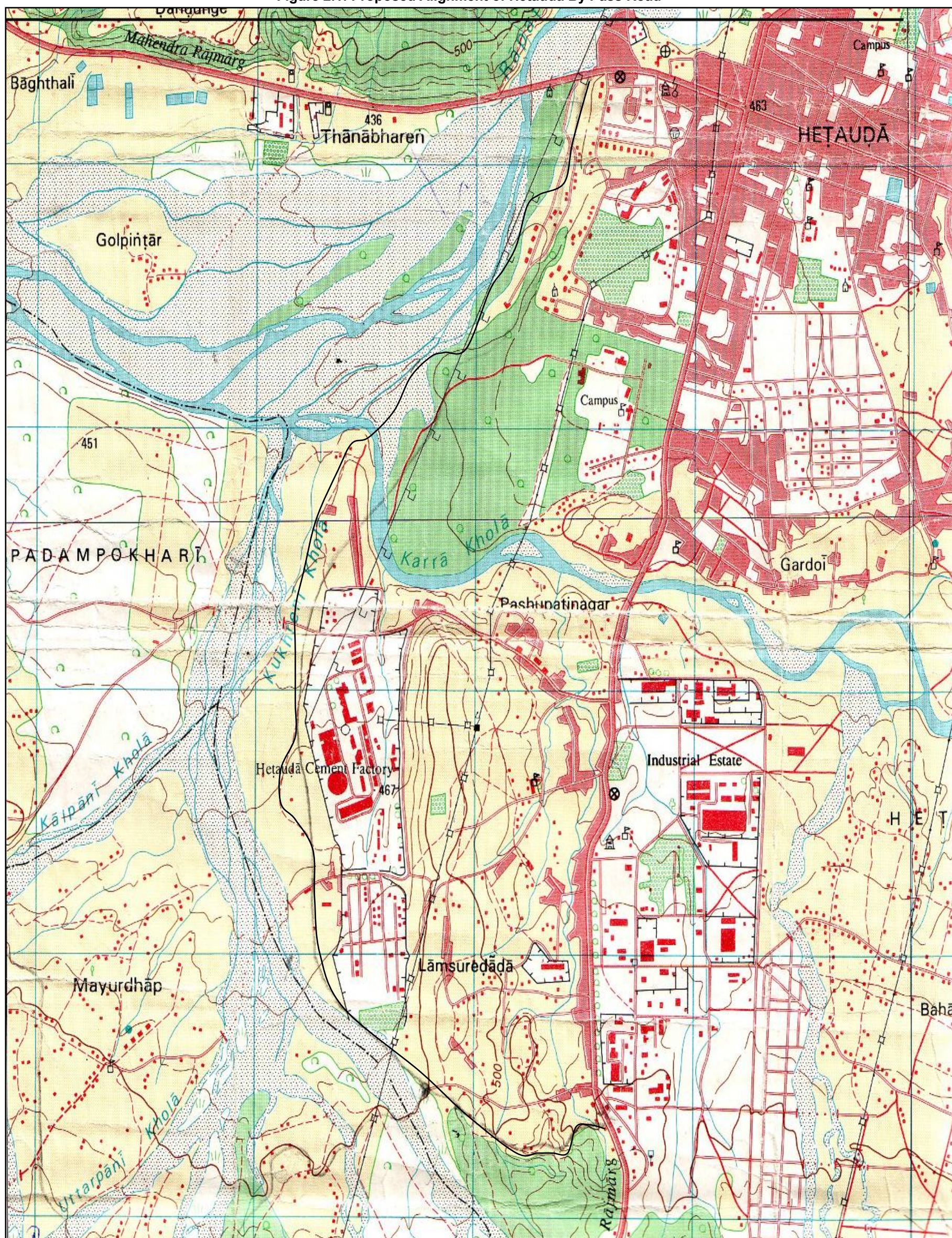
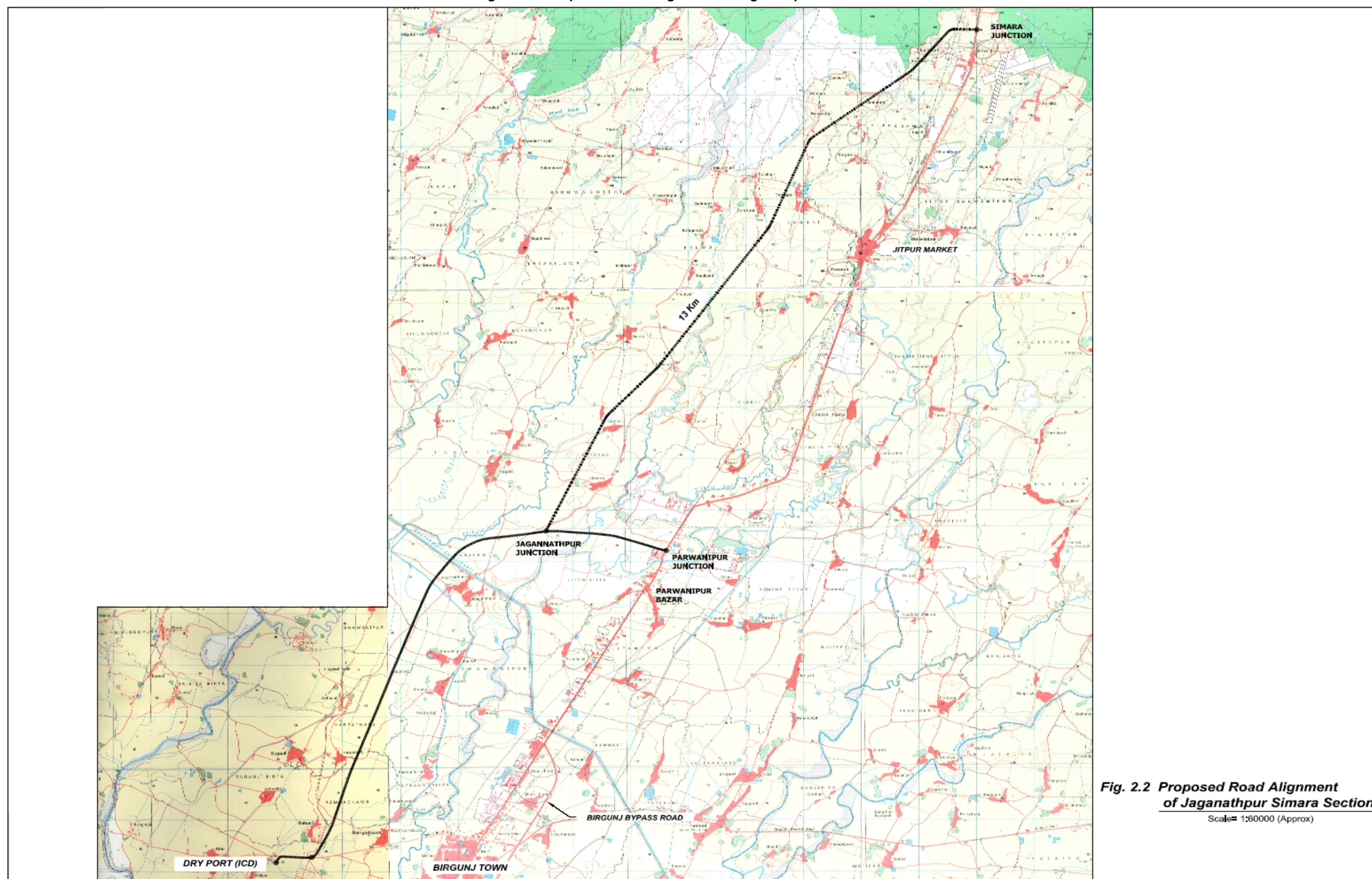


Figure 2.2: Proposed Road Alignment of Jaganathpur Simara Section



**Fig. 2.2 Proposed Road Alignment
of Jaganathpur Simara Section**
Scale= 1:60000 (Approx)

3 FIELD WORK

In order to study the project road sections, following tasks were undertaken:

3.1 Desk Study

The Consultants collected all relevant published reports / materials and maps from the Government of Nepal (DoR, Census, and Department of Topographic Survey), UN and WB. These include the feasibility study report of Hetauda Bypass, detail design report of Pathlaiya- Birgunj road, TOR for IEE Study of widening of road to six lanes Package-1: Birgunj-Pathlaiya, topographical maps (1:25,000), land use maps and hazard maps etc. of the project road. After detail review of the feasibility study report, detail design report of Birgunj- Pathlaiya, the consultants went on field visits for collecting the detailed information from site and additional information from District Headquarters. The reports and documents relevant to the road were reviewed and information compiled. Questionnaire and checklist for focus group discussion and data collection on physical, biological and socio-economic and cultural baseline environment of the project area were prepared and teams sent for field data collection.

The field survey methodology for each discipline is briefly outlined below and additional details are provided in individual sections.

3.2 Road Inventory and Engineer's Survey

Reconnaissance surveys were carried out by key professionals using appropriate methods, including GPS and cameras. These were followed up by Inventory Surveys of the road in order to collect all the information in pre-prepared standard formats concerning the actual condition of road, existing structures (such as walls, drains, culverts) and other road furniture. Requirement of additional retaining structures, cross drainage / side drainage works and remedial measures was also assessed. The inventory work also included identification of deficient geometric and weak pavement locations requiring improvements. The results of inventory data are presented in **Annex 2**.

3.3 Hydrological Survey

Records on the rainfall data for recent years were purchased from the DHM. Other information was from published meteorological records. For the discharge estimation, the catchments characteristics were measured/read from the topographical maps of the scale 1:25,000 published by the Department of Topographical Survey. In order to expedite the work scanned maps made for this purpose were used.

3.4 Construction Material Investigation

The construction material investigation was carried out to identify various sources for construction materials. Material Engineer visited the site to assess the sources including the quality of available construction materials.

3.5 Bio-Engineering Survey

A walk over survey to identify vegetation, potential sites and site specific bio-engineering applications was carried out. The length, breadth and slope angle of the different sites were surveyed. Available local species were also noted. It is also noted that previous Bio-engineering works are working appropriately and green vegetations can be seen at many places.

3.6 Traffic Survey

A three day, 24 hour, classified vehicle count was conducted at ICD Bypass, Jeetpur South, Pathlaiya South and Karra Bridge (Hetauda South along the Birgunj- Hetauda TRP) and Tikauli (Narayanghat East) along EW Highway from 13 - 20 March 2011. The classified vehicle counts included both the motorised and non-motorised vehicles.

These data combined with interviews with bus and truck operators has provided a detailed picture of existing traffic movements to be developed.

3.7 Pavement and Subgrade Investigations

Entire existing section of the road is bituminous surfaced. During improvement it shall be attempted to use the existing pavement by strengthening it as far as possible. Accordingly the Benkelman Beam Deflection and Surface Distress of the pavement have been investigated.

Existing road subgrade has been sampled and tested for grain size analysis, MDD and soaked CBR. In addition DCP test have also been conducted.

3.8 Environmental Survey

Environment assessment is carried out to collect the baseline information on physical, biological, socio-economic and cultural environment of the project road. Public Consultation is held with the local stake holders within the VDC areas along the road to update the baseline data of the area. Accordingly IEE Report and EMAP were prepared.

3.9 Social Survey

Fresh social surveys were carried out. These surveys were organized in close coordination with the environmental surveys. Consultations, interviews and dialogue with the local population, particularly with disadvantaged and vulnerable groups, were carried out in the affected areas. Throughout the survey period, attention was paid to involve the potentially affected households, local communities, residents, community leaders, local NGOs and local officials within the influence areas of the study roads.

4 BRIDGE INVENTORY WORK

4.1 Inventory Work

The consultants conducted a field evaluation of all bridges along the alignment from 15 March to 25 March 2011 and undertook condition assessment of all the bridges.

4.2 General Condition of Bridges

There are 26 numbers of Bridges in this section and the majority of bridges are of similar type construction (RCC beam and slab) and overall condition of the bridges is reasonable. Summary of bridge inventory is presented in **Table 4.1** below:

Table 4.1: Summary of Bridge Inventory

S.No.	Name of River / Chainage	Chainage Km	Bridge Length, Width & Height (m)	Spans Nos.	Bridge Type	Remarks / Condition
Hetauda - Narayanghat Section of East – West Highway, H01						
1	Rapti Bridge	395+760	210		RCC B & S	Good
2	Manahari Bridge	423+655	240		RCC B & S	Good, Bridge on curve
3	Lother Bridge	435+503	144		RCC B & S	Good, Bridge on curve
4	Dandude Khola	436+810	12		RCC B & S	Good
5	Martal Kola	442+591	45		RCC B & S	Good
6	Panpa Khola	447+440	45		RCC B & S	Good
7	Ladra Khola	453+595	42		RCC B & S	Good
8	Kayar Khola	456+231	62		RCC B & S	Good
9	Khageri Khola	460+778	66		RCC B & S	Good
10	Khageri Khola	460+903	40		RCC B & S	Good
Hetauda - Birgunj Section of Tribhuvan Raj Path (TRP) H02						
11	Karra bridge	135+378	L=108.5,w=8.7, h=8.7	3	RCC B & S	Good
12	Saffite Khola Bridge	141+698	L=24 ,w=7.3, h=2	5	RCC slab	Choked/debris flow
13	Existing Bridge	141+884	L=12 ,w= 6.7, h=1.15	2	RCC slab	Choked/debris flow
14	Existing Bridge	142+082	L=18 ,w= 6.7, h=2	2	RCC B & S	Good
15	Churiya bridge	142+349	L=59.2 ,w= 7.6, h=6	2	RCC B & S	Good
16	Gundo Bridge	144+994	L=67.5 ,w=6.9, h=4.5	10	RCC B & S	Good, with stone masonry piers
17	Badahakim Bridge	145+987	L=28 ,w=7.2, h=2.3	5	RCC B & S	Good, with stone masonry piers
18	Bridge no.4	147+774	L= 59.5,w=7.5, h=10.6	2	RCC B & S	Good
19	Bridge no.3	148+168	L= 63,w=7.5, h=6.5	2	RCC B & S	Good
20	Bridge no.2	150+097	L=104 ,w=8.1, h=8.5	4	RCC B & S	Good
21	Bridge no.1	151+964	L=70.2 ,w=8.1, h=7.2	4	RCC B & S	Good
22	Existing Bridge	163+263	L=12 ,h=2.6	1	RCC B & S	Good
23	Lalka Bridge	168+944	L= 29,w=7, h=7.4	1	RCC B & S	Good

S.No.	Name of River / Chainage	Chainage Km	Bridge Length, Width & Height (m)	Spans Nos.	Bridge Type	Remarks Condition
24	Sirsiya bridge	177+322	L= 44,w=8, h=6.5	2	RCC B & S	Good
25	Existing Bridge	189+601	L=140 ,w=7.6		RCC B & S	Good
26	Nepal- Bharat Maitri bridge(Border)	189+741			RCC B & S	Good
Parwanipur – ICD (Dryport) Road						
27	Bangi Khola Bridge	1+323	L= 40,w=7.7, h=6.5		RCC B & S	Good

Two of the major bridges i.e. Manahari Bridge and Lothar Bridge at Km 423+655 and 435+503 of the East West Highway are on horizontal curves. Photograph below shows the Manahari bridge on curve. As can be noted most of the bridges are with footpath, allowing for safe movement of pedestrians and animal.



Manahari Bridge on Horizontal Curve; Km 423+655 of East West Highway

Three bridges i.e. Saffite Khola bridge (km 141+198), bridge at km 144+884 and bridge at km 142+082 on the Hetauda – Birgunj section of the TRP are nearly choked as the debris in the flow from hill has raised the bed river bed level as shown in the photographs below. When improving the road to 4 lane Asian Highway standards, it shall be desirable to raise the deck level of these bridges providing sufficient clearance.



Saffite Khola Bridge at Km 141+698 of TRP (H02) getting choked due to rising of bed level



Bridge at Km 141+884 of TRP (H02) getting choked due to rising of bed level

Gundo bridge (km 144+994) and Badahakim bridge (km 145+987) on TRP are having stone masonry piers as shown in photographs below.

4.3 New Bridges

4.3.1 Karra Bridge

Karra river is crossing the TRP at Km 135+378 between Hetauda and Ratomate bazaar and there is an existing bridge as shown in photo below. The alignment proposed now is along Hetauda bypass, on west of the existing town. This alignment shall also cross the Kara river and a similar new bridge shall be provided.



Karra river Bridge at km 135+378 of the TRP (H02)

4.3.2 Existing Causeways

On the East West Highway and TRP, there are existing causeways at following locations. These shall be replaced with new bridges.

S. No.	Chainage (Km)	Highway	Length of Causeway (m)	Proposed Bridge Length (m)
1	419+525	EWB	25	30
2	420+200	EWB	30	35
3	425+490	EWB	30	35
4	428+232	EWB	33	38
5	436+770	EWB	40	45
6	465+570	EWB	70	80
7	139+245	TRP	30	35
8	140+340	TRP	20	25
9	140+565	TRP	25	30

4.4 Recommendations

- i. Most of the bridges are in good condition and require minor repairs.
- ii. Repair the stone masonry piers.
- iii. Replace existing causeways (9 nos.) by bridges and provide check dams to catch debris.
- iv. Raise the deck levels of 3 choked bridges and provide check dams to catch debris.

5 HYDROLOGICAL STUDIES

5.1 General

The road section lies in the Central Region of Nepal. It starts from Narayanghat and ends at Birgunj. The road is in operation for more than 40 years. From Narayanghat to Hetauda all drainages drop to East Rapti. Most of the major river crossings are with existing bridges in well condition. Medium sizes of streams are facilitated with slab culverts, box culverts and causeways. Some pipe culverts are provided for monsoon water ways in the route.

Some pipe culverts and slab/box culverts are of insufficient capacity which should be either replaced by bigger sizes on it and should be extended for proposed width. Some of pipe culverts are chocked or blocked by debris which should be cleaned before monsoon. Pipe culverts and slab/box culverts which are in good condition should be extended for proposed 4-lane road. At some locations new pipe culverts of 900 mm are proposed to cater flow coming from side drains. Some new locations of cross drains are also identified where pipe culverts, causeways and slab culverts are proposed for crossing the flows.

For hydrological analysis, following stepwise procedures are followed:

- Collection of precipitation data in the vicinity of road alignment
- Review of previous studies/reports
- Identification of cross drains and side drains with their catchments
- Verification of cross and side drains during field visit and with survey data
- Estimation of design flows for cross and side drains based on available rainfall data
- Selection of drainage type

5.2 Rainfall Analysis

Five rainfall stations (Bharatpur, Hetauda, Amlekhgunj, Simra Airport and Birgunj) are located in the road corridor with adequate rainfall data and hence used to assess the annual mean and daily extreme rainfalls over the project area. The average annual rainfall varies from 1500 to 2238 mm and average monsoon rainfall varies from 1256 to 1855 mm. About 75 to 80% of the total rainfall occurs in monsoon season (June-Sept) at these stations. The rainfall intensities for different return periods have been assessed by plotting positions (Weibull method) and the results are provided below in **Table 5.1** with its long term average annual and monsoon rainfalls.

Table 5.1: Rainfall intensities of different frequency at station near the project site

Station Name	Duration	Years	Annual Rainfall (mm)	Monsoon Rainfall (mm)	Intensity	I _{2-Yr}	I _{5-Yr}	I _{10-Yr}	I _{20-Yr}	I _{50-Yr}	I _{100-Yr}
Bharatpur	2001-2009	7	2159	1557	mm/day	108	200	269	338	429	498
					mm/hr	38	70	94	118	150	175
Hetauda	1966-2009	43	2238	1855	mm/day	163	247	310	373	456	520
					mm/hr	57	86	109	131	160	182
Amlekhgunj	1973-2009	37	2141	1818	mm/day	160	232	287	341	414	469
					mm/hr	56	81	100	120	145	164
Simara Airport	1966-2009	41	1732	1430	mm/day	147	206	250	295	353	398
					mm/hr	51	72	88	103	124	139
Birgunj	1974-2009	36	1500	1256	mm/day	132	190	234	278	336	380
					mm/hr	46	67	82	97	118	133

For the accuracy of results the Intensity Duration Frequency (I-D-F) curves are derived for different 4 sectors of road using average daily maximum rainfalls of two end stations, viz. Bharatpur and Hetaunda stations are used for Narayanghat – Hetaunda sector. These IDF values are given in **Table 5.2 to 5.5** and are presented in **Figure 5.1 to 5.4**.

Table 5.2: I-D-F Analysis for Narayanghat - Hetaunda Sector

Frequency, Year	2	5	10	20	50	100
Daily rainfall, mm	135.76	223.15	289.26	355.37	442.76	508.88
Design hourly maximum rainfall intensity in mm/hr						
Duration (Hour)	R ₂	R ₅	R ₁₀	R ₂₀	R ₅₀	R ₁₀₀
1	47.57	78.19	101.35	124.51	155.13	178.30
5	16.18	26.60	34.48	42.35	52.77	60.65
10	10.17	16.72	21.67	26.62	33.17	38.12
50	3.46	5.69	7.37	9.06	11.28	12.97
100	2.17	3.57	4.63	5.69	7.09	8.15
500	0.74	1.22	1.58	1.94	2.41	2.77
1000	0.46	0.76	0.99	1.22	1.52	1.74
0.25	120.41	197.93	256.57	315.20	392.72	451.36

Figure 5.1: IDF for Narayanghat – Hetaunda Sector

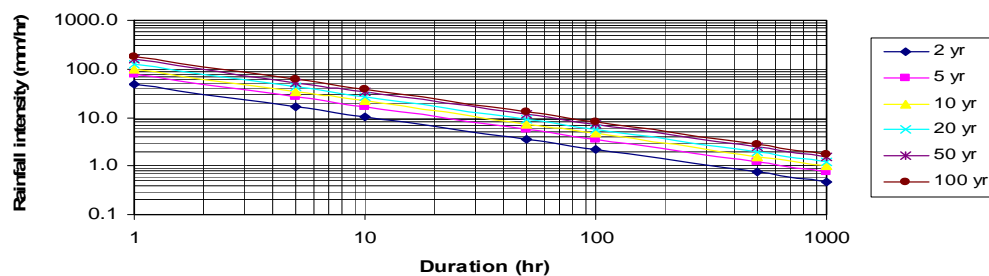


Table 5.3: I-D-F Analysis for Hetaunda - Amlekhgunj Sector

Frequency, Year	2	5	10	20	50	100
Daily rainfall, mm	161.30	239.24	298.19	357.15	435.08	494.03
Design hourly maximum rainfall intensity in mm/hr						
Duration (Hour)	R ₂	R ₅	R ₁₀	R ₂₀	R ₅₀	R ₁₀₀
1	56.52	83.82	104.48	125.13	152.44	173.10
5	19.22	28.51	35.54	42.57	51.85	58.88
10	12.08	17.92	22.34	26.75	32.59	37.01
50	4.11	6.10	7.60	9.10	11.09	12.59
100	2.58	3.83	4.78	5.72	6.97	7.91
500	0.88	1.30	1.62	1.95	2.37	2.69
1000	0.55	0.82	1.02	1.22	1.49	1.69
0.25	143.07	212.20	264.49	316.78	385.90	438.19

Figure 5.2: IDF for Hetauda-Amlekhgunj Sector

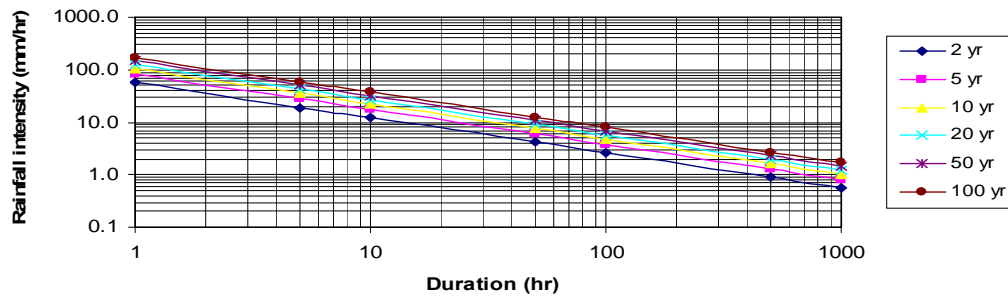


Table 5.4: I-D-F Analysis for Amlekhgunj – Simara Sector

Frequency, Year	2	5	10	20	50	100
Daily rainfall, mm	153.24	218.82	268.43	318.04	383.62	433.23
Design hourly maximum rainfall intensity in mm/hr						
Duration (Hour)	R ₂	R ₅	R ₁₀	R ₂₀	R ₅₀	R ₁₀₀
1	53.69	76.67	94.05	111.43	134.41	151.79
5	18.26	26.08	31.99	37.91	45.72	51.63
10	11.48	16.39	20.11	23.82	28.74	32.45
50	3.90	5.58	6.84	8.10	9.78	11.04
100	2.45	3.50	4.30	5.09	6.14	6.94
500	0.83	1.19	1.46	1.73	2.09	2.36
1000	0.52	0.75	0.92	1.09	1.31	1.48
0.25	135.92	194.09	238.09	282.09	340.26	384.26

Figure 5.3: IDF for Amlekhgunj-Simara Sector

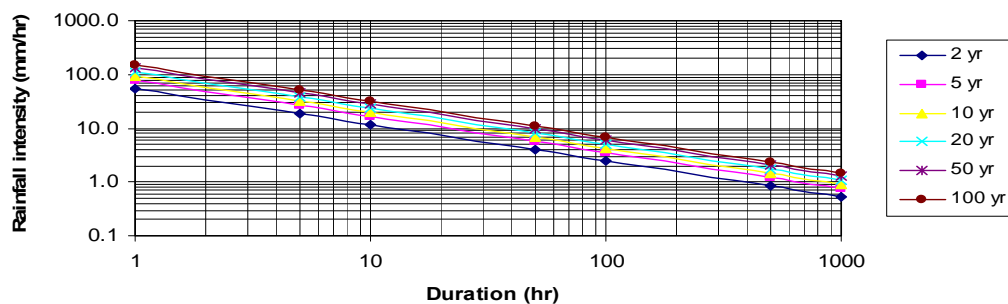
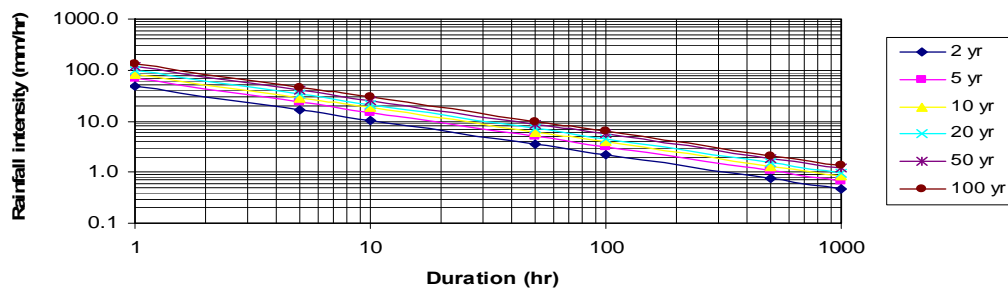


Table 5.5: I-D-F Analysis for Simara - Birgunj Sector

Frequency, Year	2	5	10	20	50	100
Daily rainfall, mm	139.33	197.85	242.12	286.38	344.91	389.17
Design hourly maximum rainfall intensity in mm/hr						
Duration (Hour)	R ₂	R ₅	R ₁₀	R ₂₀	R ₅₀	R ₁₀₀
1	48.82	69.32	84.83	100.34	120.85	136.36
5	16.61	23.58	28.86	34.13	41.11	46.38
10	10.44	14.82	18.14	21.45	25.84	29.15
50	3.55	5.04	6.17	7.30	8.79	9.92
100	2.23	3.17	3.88	4.59	5.52	6.23
500	0.76	1.08	1.32	1.56	1.88	2.12
1000	0.48	0.68	0.83	0.98	1.18	1.33
0.25	123.58	175.49	214.75	254.02	305.92	345.19

Figure 5.4: IDF for Simara-Birgunj Sector



5.3 Design Flood Estimation

The design discharges of different return periods for cross drains and side drains are determined using the Rational method. The catchment areas were determined using scanned topographical maps with AutoCAD. The intensity of rainfall corresponding to the time of concentration was determined from I-D-F analysis. The times of concentration were determined using Kirpich Equation.

If the time of concentration is less than 15 minutes then it is assumed to be 15 minutes as recommended by ASCE (American Society of Civil Engineers). In most of the cases the time of concentration is very small, i.e. less than 15 minutes; hence it is decided to use rainfall intensity for time of concentration equal to 15 minutes for these cases.

The floods of different return periods in Karra river of Hetauda Bypass have been estimated by different approaches and are presented in **Table 5.6**. A flood value of 800 Cumecs may be recommended as design flood for the Karra bridge. The length of the bridge is proposed 130 m.

Table 5.6: Floods of different frequency in Karra River by different approaches

Methods/RP (yrs)	10	20	50	100	200
WECS	201	251	322	380	442
Dicken's	222	265	322	365	409
Snyder's	370	448	622	706	772
Rational	424	517	713	808	885
PCJ	248	370	742	947	1094
B.D. Richard's	676	891	1355	1605	1797
Velocity Area				739	

5.4 Drainage Design

5.4.1 Drainage Facilities

Highway drainage is the process of interception and removal of water from over, under and the vicinity of the road surface. Highway drainage is very important for safe and efficient design of the highway and hence is an essential part of highway design and construction.

Two types of drainage facilities are provided in this road alignment so as to safely manage the surface water: Cross drains and Side drains. Cross drains are mainly designed to pass the stream flows where as side drains for catching the flows from road surface and upside adjoining areas. However in some cases the cross drains are provided to divert the flows

coming from side drains. Side drains are provided along hill side only except in built up areas where side drain is provided both side of the road.



SC at Km 421+260, EWH blocked be debris

5.4.2 Design Criteria

Design Flood

Drainage facilities should have sufficient capacity to carry off safely not only peak runoffs, which occur frequently, say several times a year, but also larger runoffs, occurring less frequently. Highway culverts having intermediate traffic can be designed for 10 - 25 years return period [Ref. 8]. Following this recommendation cross drains are recommended to design for 20 years and side drains for 5 years return period flood.

Design Intensity

Design intensities of 20 years return period for cross drains (except bridges) and of 5 years return period for side drains are worked out and used to estimate the design flood.

Run-off Coefficient

The runoff coefficient depends on catchment characteristics such as slope, vegetation, shape and size of the catchment. These characteristics are different even in a single watershed. However it is very clear from topographical maps and field visit that the catchments are more or less homogeneous. Hence the single value of runoff coefficient may be used for all the catchments in the project area. Slope of these catchments are not so steep, most of the catchments are well vegetated and forested. It seems that more than 50% of rainfall will be retained by catchments due to dense vegetation and forests as well as by infiltration. Considering all these factors an average value of 0.4 (Ref. 8) is recommended for all catchments.

5.4.3 Cross Drains

Most of the existing pipe, slab and box culverts of this road are in working condition. Discharging capacity of these existing cross drains are checked with the design flood of 20 years return period and if not adequate, replaced or added to by new cross drains. New

cross drains are provided in the form of pipe culverts of 90 cm diameter. At some places where the design flood discharge exceeds slab culverts are proposed.

Hydraulics of pipe culverts are shown in **Table 5.7** and that of slab culverts and causeways in **Table 5.8**. The floods have been estimated only where the streams are shown in topographical map of 1:25000 scale. Hence based on inventory records structures are verified and checked for the estimated design flood and recommended to replace the existing at some places. Similarly new cross drainage structures are proposed according to the design flood and field condition. Other existing or proposed structures where discharge could not worked out are kept as earlier.

Table 5.7: Hydraulics of pipe culverts

CD type	Size (m)	Full flow area (m ²)	Design slope, %	Length of CD, m	Max. Head loss, m	Friction coeff.(f)	Max. vel. m/sec	Max. flow m ³ /sec
Pipe culvert	0.60m	0.28	3	18	0.18	0.05	2.66	0.74
Pipe culvert	0.90m	0.63	3	18	0.18	0.05	3.26	2.05
Pipe culvert	1.20m	1.12	3	18	0.18	0.05	3.76	4.21

Table 5.8: Hydraulics of slab culverts and causeways

CD type	Size, m ²	Flowing area, m ²	slope, %	Hydraulic radius, m	Manning's coeff. (n)	Max. vel. m/sec	Max. flow M ³ /sec
Slab culvert	6m*2m	12	1	1.2	0.02	5.65	67.8
Causeways	14 m	5	1	0.4	0.02	2.7	13.5
Causeways	20 m	10	1	0.5	0.02	3.14	31.4

The type and size of CD structures are selected based on design flood (according to **Table 5.9**) and details of existing and proposed structures are given in **Annex 8**.

Table 5.9 Selection criteria of CD Structures based on design flood

Q ₂₀ , m ³ /s	Size and CD Type	Remarks
<0.75	600 HPC	HPC: Hume Pipe Culvert
0.75 to 2	900 HPC	
2 to 4.2	1200 HPC	
4.2 to 8.4	1200 DBHPC	DBHPC: Double Barrel HPC
8.4 to 20	2x2 SC	SC: Slab Culvert
20 to 40	4x2 SC	
40 to 68	6x2 SC	
> 68 <300	MB or CW	MB or CW: Minor Bridge or Causeway
>300	LB or CW	LB or CW: Large Bridge or Causeway

5.4.4 Side Drains

In some stretches side drains of stone and/or brick masonry already exists but most of the side drains are damaged or blocked. In some hilly sections additional two lane is proposed on hillside hence new side drains are proposed along the full length of the road. In plain areas where road embankment is required no side drain is required. In built up areas such as municipalities and markets concrete side drain with cover is proposed.

The flowing capacity of proposed side drain is worked out in **Table 5.10**. The proposed side drains types and sides in different sectors are given in **Annex 8**.

Table 5.10: Hydraulics of proposed side drain

Drain Type	Shape	Base (m)	Depth (m)	Width (m)	Area (m ²)	Perimeter (m)	Hydraulic Radius(m)	Manning's n	Slope %	Velocity (m/s)	Discharge (m ³ /s)
CSMD	Trapezoid	0.425	0.6		0.345	1.696	0.203	0.017	6	4.99	1.721

6 GEOLOGICAL STUDY

6.1 Regional Geology and Geomorphology

Geologically, the road alignment runs through three distinct geological units **1) sediments of the Dun valley** and **2) Siwalik rocks** comprised of interbedded sandstone and mudstone and **3) Terai belt**.

The Dun valley deposits are loose recent sediments deposited by river and extend between the Siwalik rocks on the north as well as on the south. In both the cases, the Siwalik rocks constitute a part of the lower Himalayas and both of them consist of interbedded sandstone and mudstone but those bordering on the south of the Dun Valley are termed as Churia deposits. An additional feature of the Churia deposits is that they contain distinct layers/deposits of gravels and boulders of more recent origin as well as interbedded layers of sandstone and mudstone. Generally, these are more friable and loosely cemented and represent a group of lower Siwaliks.

The Terai region consists primarily of alluvial deposits

6.2 Surface Geology

In this case surface geology can best be described on the basis of topography, types of rocks and overburden material. Most of this road, excepting Section 3 mentioned below, is on flat land while Section 3 runs along gently rolling Churia hills. Except along a few short stretches the road bed is on overburden material and, therefore, surface geology is dominated by the nature overburden material.

Section I: Narayanghat – Hetauda Section. (EWH Ch: 467+640 – EWH Ch: 395+520)

(NB: Chainage of this section is according to that for the E-W Highway)

The road alignment runs more or less parallel to the foothills of the Siwalick rocks. The bed rocks are composed of sandstones and mudstones, but the roadbed itself is primarily on the Dun valley deposits. The overburden consisting of colluvial, alluvial and residual deposits is estimated to be around 3m.

Section II: Hetauda – Beginning of Churia Range or Hetauda to Ratmate (EWH Ch: 395+520 – TRP Ch: 137+370)

In this case the roadbed is entirely on the Dun Valley deposits. The surface layer consists almost entirely of the valley deposits consisting of mainly of alluvial and residual soils. The thickness of the overburden material is estimated to be more than 5m.

Section III: Ratmate – Amlekhgunj (Beginning of Terai belt) (TRP Ch: 137+370 – TRP Ch: 151+960)

The surface material along this section consists mainly of gavels, boulders, conglomerates and occasionally of unconsolidated sandstones. Thick layers of unconsolidated sandstones were observed at TRP Ch: 142+ 550 (on both sides of box cuts), and TRP Ch:150+097 (Bridge No 2), while thick layers of conglomerates (h > 20m) were observed at TRP Ch: 141+698, TRP Ch: 142+349, TRP Ch: 148+168 (Bridge No.3).

Section IV: Amlekhgunj – Birgunj (TRP Ch: 151+906 – TRP Ch: 189+741)

Surface geology of the Terai belt is entirely dominated by thick alluvial material

6.3 Slope Stability Conditions

Section wise slope stability condition described below.

The geological conditions including surface geology are described above separately for each section and so will not be repeated.

Section I: Narayanghat – Hetauda section, (EWH Ch: 467+640 – EWH Ch:395+520)

(NB: Chainage according to the chainage of the EW Highway where the starting point is Kakarbhitta. Ch: 394+850 EW Highway corresponds to TRP Ch: 133+550 of this road)

The width of the existing road bed is more than 12 m. Currently, the road bed is stable but retaining walls may be required at a few locations where road bed will be widened. The height of the retaining walls will have to be adjusted according to the design width of the road bed.

Section II: Hetauda – Ratmate (EWH Ch: 395+520 – TRP Ch: 137+370)

The section is basically on river flood plain and flat paddy field (land) and so can be considered to be stable for slope stability.

Section III: Ratmate – Amlekhgunj (Beginning of Terai belt) (Ch: 137+370 – Ch: 151+960).

This section is likely to encounter some stability problems mainly related to the damage of the road bed by debris flows and erosion.

Problems associated with debris flows.

Debris flows have filled up and damaged a number of culverts in this section. Slab and/or box culverts are blocked and/or damaged at Ch: 140+125, 140+952, 141+117, 152+445. In most of the cases, the upstream sections of the dry nalas are wider than the width of culverts. In some cases, a type of fan of debris material downstream of existing culverts or causeway has extended up to the Churia khola.

Crossings with dry nalas should be designed in order to protect them from future debris flows. Debris flows should be channelized both upstream and downstream of the road crossings.

Problems associated with erosion.

In areas where the road bed is in cuts erosion gullies have developed on both sides of the road. For example, erosion gullies have developed on both sides of the box cut section at Ch: 142+550. Minor slips were observed in the unconsolidated layers of sandstone below bridge No 2 at Ch:150+097.

These cut slopes will require extra bioengineering measures to stabilize them. The erosion gullies developed on these slopes will have to be repaired/filled up prior to the application of bio-engineering measures, most probably in conjunction with nets. Some of the length of this section will require extra strengthening by gabion walls.

Soils along most of this road contain sizeable amount of silts and, therefore, are erodible.

Section IV: Terai belt (Ch: 151+960 - Ch :189+436).

The surface geology of this belt is entirely dominated by thick alluvial material. It is a flat land and no stability problems related to topography and material properties of the ground are expected in this section.

6.4 Hazard Assessment

Since most of the alignment is on overburden material hazard assessment has been made primarily on the basis of overburden material and so the effect of parameters related to rock and rock structures has not been considered explicitly. As such the input parameters for hazard assessment included information related landslides, major gully erosion, debris flow, physical/index properties of overburden material including the type of rock wherever encountered.

For the purpose of hazard assessment this road has also been divided into four sections. Geological conditions including surface geology and overburden material are described above. A summary of hazard categories for each section is provided in the following table.

Table 6.1: Sectionwise Hazard Category

Section	Hazard category
Section I: Narayanghat – Hetauda section, (EWH Ch: 467+640 – Ch: 395+520)	Low to medium
Section II: Hetauda – Beginning of Churia range (TRP Ch:137+370)	Low
Section III: Beginning of Churia range – Beginning of Terai belt (Ch: 137+370 – Ch: 151+960).	Medium to high
Section IV: Terai belt (Ch: 151+960 – 189+741).	Low

7 BIO-ENGINEERING SURVEY

7.1 General

The main objective of Bio-engineering is the use of local plant species in conjunction with small civil engineering structures to protect from, and stabilize, earth movements and land slides. The overall aim of bio-engineering is to produce a long-term effect.

Landslides were recorded at various locations. The altitude of the bio-engineering sites varies from 58m to 675m.

Bio-engineering works are required for different types of problem, such as; landslides, gully erosion, surface erosion, and slumps. They may be required above or below the level of the road. There are various causes of these problems, including; surface water, ground water, rock weathering, road under cutting, and plane failure. All of these factors have been taken into consideration in assessing the requirement for bio-engineering works.

7.2 Field Survey

Surveying of the proposed bio-engineering sites along the road corridor has been carried out during a walkover survey along the road. The length, breadth and slope angle of the bio-engineering sites were surveyed. Other necessary information about the tree, shrub and grass species to be used for bioengineering works was collected.

7.3 Nursery

The Department of Roads has not established any bio-engineering nursery along the road corridor. The suitable locations for nursery establishment are considered at *Manahari Area*. The contractor shall arrange to establish nursery at suitable location to supply required plants.

7.4 Site Assessment and Identification for Bio-engineering Application for Slope Protection

Site assessments have been carried out for existing and potential slope failures on the road to identify site specific stabilization measures. New cut and fill slopes are also identified for bio-engineering purposes.

During the field visit, the following slope failures were identified, which require bio-engineering application for stabilization and protection of slopes.

- Hill and valley slope failure due to undercutting
- Slope failure due to drainage problem
- New cut and fill slope

The main causes of failures are due to undercutting on the slope, surface water, ground water and rock weathering.

There are number of hill and valley slope failures along the road. These are surface erosion and shallow failures. Mainly bio-engineering measures are required to protect the surface from erosion. At some locations bio-engineering works in combination with civil structures would require.

Drainage problems are found at various locations. These require drainage management and bio-engineering.

The location and descriptions of existing slope failures and bio-engineering applications for the slope protection are presented in **Table 7.1** below.

Table 7.1: Location of Bio-engineering Works

Sn	Chainage	Side	Length (m)	Height (m)	Area	Slope preparatio	Planting rooted	Planting Tree/Shru	Bruss Layering	Broadcastin g grass	Turfing	Remarks
						m ²	m ²	Nos	Rm	m ²	m ²	
1	429+000	RHS	100	30	3000	3000	3000	3000	3000	3000		
2	413+200	RHS	500	25	12500	12500	12500	5000	3000	10000		
	fill slope in different chainage					9500	9500	2000	4000	2000	5000	
Total					15500.00	25000.00	25000.00	10000.00	10000.00	15000.00	5000.00	

7.5 Design of Bio-engineering Works

Bio-engineering design for slope stabilization and protection is mainly based on causes of failure and problems on the site. In this regards The World Bank paper on bio-engineering to road networks in himanchal pardesh (India)¹ and Roadside Bio-engineering (Reference Mannual & Site Handbook) published by DoR has been referred.

The design of bio-engineering works includes the following:

- Design of vegetative structures
- Design of minor civil engineering structures
- Selection of species

7.5.1 Design of Vegetative Structures

The plantation design for each bio-engineering site is made by taking into consideration many factors, such as; the causes of landslides, erosion, gully formation and slump, together with the slope degree, altitude of the site, the soil type, whether above the road or below the road, and the condition of the bio-engineering site.

Along the road, the following vegetative structures have been designed for stabilizing and protection of slopes.

Horizontal grass plantation Rooted grass slips or clumps are planted in lines across the slope. They protect the slope with their roots and, by providing a surface cover, reduce the speed of runoff water. The deep rooted grass will reinforce the slope.

Diagonal lines grass plantation

Rooted grass slips or stem cuttings are planted in lines running diagonally on the slope. They armour the slope with their roots and by providing a surface cover. It is used in gullies and where drainage may be a problem due to poor draining materials.

¹ World Bank papers on "Introducing Bio-engineering to the Road Networks of Himachal Pardes" by J H Howel, S C Sandhu, N Vyas and R Sheikh.

Shrub and tree plantation

Shrubs or trees are planted at regular intervals on the slope. As they grow, they create a dense network of roots in the soil. The main engineering functions are to reinforce and later to anchor.

Palisade

Woody cuttings are planted in lines across the slope, usually following the contour or diagonal. These form a strong barrier and trap material moving down the slope. In the long term, a small terrace will develop. The main engineering functions are to catch debris, and to armour and reinforce the slope. If angled, palisades also provide a drainage function.

Brush layering

Woody cuttings are laid in lines across the slope, either following the contour or on the diagonal. These form a strong barrier, preventing the development of rills, and trap material moving down the slope. In the long term, a small terrace will develop. The main engineering functions are to catch debris, and to armour and reinforce the slope. If angled, it also provides a drainage function.

Live check dam

Large woody cuttings are planted at gully formation on the slope. These form a strong barrier and trap material moving downwards. In the longer term, a small step will develop in the floor of the gully. The main engineering functions are to catch debris, and reinforce the slope.

7.5.2 Design of Minor Civil Engineering Structures

Small civil engineering structures such as rip-rap drain, catch drain are proposed to be used in slopes prone to rill erosion, gully formation.

7.5.3 Selection of Species

The species for bio-engineering works have been selected as per site suitability and engineering functions. The selected bio-engineering species has been given in **Tables 7.2**.

Table 7.2: Selected Bio-engineering Species

GRASS		
Botanical Name	Local Name	Plant Parts Used for Bio-engineering
Cymbopogon microtheca	Khar	Slip cuttings
Pennisetum purpureum	Napier	Stem cuttings
Saccharum spontaneum	Kans	Slip cuttings
	Khus	Rhizome cuttings
	Narkat	Rhizome cuttings
	Babiyo	Rhizome cuttings
Shrub and Tree		
	Simali	Slip cuttings
	Aasuro	Slip cuttings
	Kadam	Slip cuttings
Castanopsis spp.	Katus	Seeds/ polypots
	Chilaune	Seeds/ polypots
	Shaj	Seeds/ polypots

GRASS		
Botanical Name	Local Name	Plant Parts Used for Bio-engineering
	Shisawo	Seeds/ polypots
	Taki	Seeds/ polypots
Morus alba	Kimbu	Hardwood cuttings
Salis spp.	Bains	Hardwood cuttings

7.6 Cost Estimates

The costs of civil bio-engineering works are based on current local District rates, market prices of materials, and transportation of materials to the work site.

Firstly a detailed identification of small civil engineering structures, as well as bio-engineering activities for each site, is made. Then Following the completion of the engineering and bio-engineering designs the estimate of total quantities and cost estimate is completed for the whole road. Finally the total cost estimate of both civil and bio-engineering works is then prepared by applying the costs from the rate analysis to the estimated quantities.

Cost estimates for bio-engineering are included in the cost estimates submitted separately.

7.7 Bio-engineering Planting Programme

Before plantation works, civil engineering structures and slope preparation should be completed.

The bio-engineering planting works in the first season could be started in the monsoon season at locations where civil works are completed. Further remaining bio-engineering works would be carried out during second year monsoon season.

Immediately after completion of bio-engineering works, care must be taken to protect and maintain the sites. Aftercare and maintenance of plants should be carried out continuously in the Defects Liability Period (DLP).

8 CONSTRUCTION MATERIAL AND PAVEMENT INVESTIGATION

8.1 Material Source Survey and Testing

All the identified sources of construction materials are within a range of less than one kilometer and can yield materials such as boulder, cobble, gravel and sand. All of them are currently being used by local people, private suppliers of construction materials as well as by DoR and other local bodies/authorities. Samples have been collected from these sources and the same have been subjected to laboratory tests to determine their suitability for different uses. The scope of investigations included investigations for:

- a) construction materials for use as
 - Subbase material
 - crusher run subbase
 - Crushed stone base
 - Concrete
- b) Subgrade materials/condition of the existing subgrade material in terms of
 - Particle size analysis
 - Plasticity Index
 - Moisture content
 - MDD
 - OMC, and
 - CBR

8.2 Material Sources

The sources of construction materials are listed below.

1. Phampha Khola, EW-HW 12 Km East from Bypass Road
2. Lothe khola
3. Manohari khola
4. Rapti River
5. Churiya Khola

Excepting the Churiya Khola site which contains alluvial as well colluvial material, all the other sites are major alluvial and naturally occurring construction material sources that can be used to obtain boulder, cobble, gravel and sand as well as aggregates for concrete.

Details about the volume as well as the type of tests carried out on the samples collected from them are given in the following **Tables 8.1**.

Table 8.1: Summary of Laboratory Tests on Construction Material

A. Summary on Lab Test Results on Sub-base course

S. N.	Chainage	Location	Approx. Qty. Available (m3)	Estimated Qty. of Sub-base (m ³)	Sieve Analysis %			FI %	LAA %	ACV %	AIV %	Compaction		CBR at 95% MDD		Remarks
					Gravel %	Sand %	Silt/Clay					MDD(t/m3)	21.18	18.02	10.6	
1	140+100	Churiya River (Sub-base, Base Course, Pebble, Asphalt Concrete Material, Sand & Stone Aggregate)	900000	313000	77.26	22.34		12.56	32.24	24.454	24.73	2.237	7.50	73.90	83.80	Direct From Source
2	395+800	Rapati River (Sub-base, Base Course, Pebble, Asphalt Concrete Material, Sand & Stone Aggregate)	720000	260000	80.36	19.64		25.44	27.32	23.72	24.42	2.236	7.60	72.00	82.50	Stone Dust Mixed
3		Rapati River (Sub-base, Base Course, Pebble, Asphalt Concrete Material, Sand & Stone Aggregate)	720000	260000	80.36	19.64		25.44	27.32	23.72	24.42	2.230	8.00	69.00	79.50	Red Clay Mixed
4	E-W Highway 17 KM West from Narayanghat	Jhari Khola (Sub-base, Base Course, Pebble, Asphalt Concrete Material, Sand & Stone Aggregate)	75000	25000	73.36	26.64			26.72		23.81	2.237	6.25	71.5	81.8	
5	E-W Highway, 12 KM East from By-pass Road	Pampha Khola (Sub-base, Base Course, Pebble, Asphalt Concrete Material, Sand & Stone Aggregate)	100000	30500	67.66	32.34			26.2		24.86	2.235	7.00	71.5	81.00	

B. Summary on Lab Test Results on Base course

S. N.	Chainage	Location	Approx. Qty. Available (m3)	Estimated Qty. of Sub-base (m ³)	Sieve Analysis %			FI %	LAA %	ACV %	AIV %	Compaction		CBR at 95% MDD		Remarks
					Gravel %	Sand %	Silt/Clay					MDD(t/m3)	21.18	18.02	10.6	
1	140+100	Churiya River (Sub-base, Base Course, Pebble, Asphalt Concrete Material, Sand & Stone Aggregate)	900000	208000	77.26	22.34		12.56	32.24	24.454	24.73	2.237	7.50	73.90	83.80	Direct From Source
2	395+800	Rapati River (Sub-base, Base Course, Pebble, Asphalt Concrete Material, Sand & Stone Aggregate)	720000	170000	80.36	19.64		25.44	27.32	23.72	24.42	2.236	7.60	72.00	82.50	Stone Dust Mixed

S. N.	Chainage	Location	Approx. Qty. Available (m ³)	Estimated Qty. of Sub-base (m ³)	Sieve Analysis %			FI %	LAA %	ACV %	AIV %	Compaction		CBR at 95% MDD		Remarks
					Gravel %	Sand %	Silt/Clay					MDD(t/m ³)	21.18	18.02	10.6	
3	Along EWH	Rapati River (Sub-base, Base Course, Pebble, Asphalt Concrete Material, Sand & Stone Aggregate)	720000	170000	80.36	19.64		25.44	27.32	23.72	24.42	2.230	8.00	69.00	79.50	Red Clay Mixed
4	E-W Highway 17 KM West from Narayanghat	Jhari Khola (Sub-base, Base Course, Pebble, Asphalt Concrete Material, Sand & Stone Aggregate)	75000	16500	73.36	26.64			26.72		23.81	2.237	6.25	71.5	81.8	
5	E-W Highway, 12 KM East from By-pass Road	Pampha Khola (Sub-base, Base Course, Pebble, Asphalt Concrete Material, Sand & Stone Aggregate)	100000	20000	67.66	32.34			26.2		24.86	2.235	7.00	71.5	81.00	

C. Summary on Lab Test Results on Asphalt Concrete Material

S. N.	Chainage	Location	Approx. Qty. Available (m ³)	Estimated Qty. of Sub-base (m ³)	Sieve Analysis %			FI %	LAA %	ACV %	AIV %
					Gravel %	Sand %	Silt/Clay				
1	140+100	Churiya River (Sub-base, Base Course, Pebble, Asphalt Concrete Material, Sand & Stone Aggregate)	900000	173000	77.26	22.34		12.56	32.24	24.454	24.73
2	395+800	Rapati River (Sub-base, Base Course, Pebble, Asphalt Concrete Material, Sand & Stone Aggregate)	720000	144000	80.36	19.64		25.44	27.32	23.72	24.42
3	E-W Highway 17 KM West from Narayanghat	Jhari Khola (Sub-base, Base Course, Pebble, Asphalt Concrete Material, Sand & Stone Aggregate)	75000	16500	73.36	26.64			26.72		23.81
4	E-W Highway, 12 KM East from By-pass Road	Pampha Khola (Sub-base, Base Course, Pebble, Asphalt Concrete Material, Sand & Stone Aggregate)	100000	20000	67.66	32.34			26.2		24.86

D. Summary on Lab Test Results on Coarse Sand

S. N.	Chainage	Location	Approx. Qty. Available (m3)	Estimated Qty. of Sub-base (m ³)	Sieve Analysis %			FI %	LAA %	ACV %	AIV %
					Gravel %	Sand %	Silt/Clay				
1	140+100	Churiya River (Sub-base, Base Course, Pebble, Asphalt Concrete Material, Sand & Stone Aggregate)	900000	201000	77.26	22.34		12.56	32.24	24.454	24.73
2	395+800	Rapati River (Sub-base, Base Course, Pebble, Asphalt Concrete Material, Sand & Stone Aggregate)	720000	141000	80.36	19.64		25.44	27.32	23.72	24.42
3	E-W Highway 17 KM West from Narayanghat	Jhari Khola (Sub-base, Base Course, Pebble, Asphalt Concrete Material, Sand & Stone Aggregate)	75000	20000	73.36	26.64			26.72		23.81
4	E-W Highway, 12 KM East from By-pass Road	Pampha Khola (Sub-base, Base Course, Pebble, Asphalt Concrete Material, Sand & Stone Aggregate)	100000	32000	67.66	32.34			26.2		24.86

E. Summary on Lab Test Results on Stone Aggregate

S. N.	Chainage	Location	Approx. Qty. Available (m3)	Estimated Qty. of Sub-base (m ³)	Sieve Analysis %			FI %	LAA %	ACV %	AIV %
					Gravel %	Sand %	Silt/Clay				
1	140+100	Churiya River (Sub-base, Base Course, Pebble, Asphalt Concrete Material, Sand & Stone Aggregate)	900000	180000	77.26	2.74		12.56	32.24	24.454	24.73
2	395+800	Rapati River (Sub-base, Base Course, Pebble, Asphalt Concrete Material, Sand & Stone Aggregate)	720000	144000	80.36	19.64		25.44	27.32	23.72	24.42
3	E-W Highway 17 KM West from Narayanghat	Jhari Khola (Sub-base, Base Course, Pebble, Asphalt Concrete Material, Sand & Stone Aggregate)	75000	20000	73.36	26.64			26.72		23.81
4	E-W Highway, 12 KM East from By-pass Road	Pampha Khola (Sub-base, Base Course, Pebble, Asphalt Concrete Material, Sand & Stone Aggregate)	100000	30000	67.66	32.34			26.2		24.86

Crushed Stone aggregate of various sizes in sufficient quantity on demand

8.3 Laboratory Testing of Samples from Material Sources

Material samples from selected sources were taken to Consultant's laboratory in Kathmandu and subjected to various tests with a view to evaluate the suitability and strength characteristics of the material. The laboratory tests include:

- Particle size distribution test
- Plasticity Index Test
- Maximum Dry Density Test (MDD) and Optimum Moisture Content ((OMC)
- LAA (Los Angeles Abrasion Test)
- AIV (aggregate Impact Value)
- ACV(aggregate Impact Value)
- Flakiness Index
- CBR

8.4 Existing Road Sub-grade Investigation and Testing

The purpose of testing sub-grade material was to evaluate its strength properties for the design of pavement. As such the sub-grade material was subjected to field and laboratory testing. Field tests as specified by the client included.

- 1) Field density tests and
- 2) DCPT tests.

DCPT tests were used to evaluate CBR values of the sub-grade material.

Laboratory tests included

- 1) Particle size determination
- 2) Plasticity Index Tests
- 3) Maximum Dry Density
- 4) CBR

Test results of field and laboratory tests on the existing sub-grade material are presented in the following tables.

Table 8.2: Summary of Lab Test Result

S. No.	TRP Chainage	NMC	Grain Size Analysis			Compaction Test	OMC%	CBR Test		DCP Test (Layers)
			Gravel	Sand	Fines	MDD%		2.50mm	5.00mm	CBR Value
Hetaunda - Birgunj Dryport - Birgung Border Road Section										
1	135+580	9.80	13.450	8.400	78.150	1.98	12.00	8.00	9.80	11
2	136+500									
3	137+500									
4	138+500									
5	139+500	8.16	22.199	33.415	44.386	2.00	9.50	8.40	10.50	
6	140+000									
7	141+000									
8	142+000									
9	143+300	8.00	41.060	29.220	29.710	2.00	10.50	11.30	14.50	28.5
10	144+000									32
11	145+000									
12	146+060									
13	147+000	7.69	15.389	50.437	34.174	2.05	11.50	10.15	13.35	
14	148+000									25.5
15	149+000									
16	150+000	8.23	2.987	31.979	65.034	1.92	11.90	6.80	8.55	
17	151+000									
18	152+050									
19	153+000	8.21				2.03	11.40	9.85	12.50	9
20	154+000									
21	155+000									
22	156+000	8.24	24.138	37.467	38.395	2.02	11.00	10.00	12.80	
Hetaunda - Birgunj Dryport - Birgung Border Road Section										
23	157+000									
24	158+000									

S. No.	TRP Chainage	NMC	Grain Size Analysis			Compaction Test		CBR Test		DCP Test (Layers)
			Gravel	Sand	Fines	MDD%	OMC%	2.50mm	5.00mm	CBR Value
25	159+500	9.75	12.394	46.415	41.119	1.94	11.00	6.95	8.40	12.5
26	160+000									
27	161+000									
28	162+000	8.07	0.034	56.231	43.735	1.96	10.50	8.50	9.70	13.5
29	163+000									14.5
30	164+000									
31	165+000		6.335	30.759	62.907	1.84	12.70	7.85	9.15	5
32	166+000									9.5
33	167+000									12.5
34	168+000	8.69	3.940	26.400	69.650	1.92	14.00	8.90	10.20	12.5
40	169+100									
41	171+000		0.151	38.491	61.357	1.86	11.00	7.65	9.90	8.5
42	172+000									
43	173+000									
44	174+000		0.210	11.334	88.456	1.82	11.80	5.25	7.60	
45	175+000									
46	176+000									
47	177+000		1.411	16.761	81.828	1.85	11.50	5.70	8.00	8
48	178+000									13
49	179+000									24.5
50	180+000		0.131	12.752	87.752	1.82	12.00	5.20	7.85	20.5
51	181+000									10
52	182+000									
53	183+000		0.247	20.128	79.625	1.85	11.75	5.50	7.75	
54	184+000									
55	185+000									23
56	186+000		0.697	13.436	85.807	1.80	11.90	5.60	6.50	15
57	186+900									21.5

S. No.	TRP Chainage	NMC	Grain Size Analysis			Compaction Test		CBR Test		DCP Test (Layers)
			Gravel	Sand	Fines			MDD%	OMC%	2.50mm
Parwanipur Junction - Birgunj Border Road Section										
1	177+335									9
2	178+335									
3	179+335									
4	180+335		0.070	23.940	75.990	1.89	12.00	6.00	7.30	
5	181+335									20.5
6	182+335									
7	183+335		0.096	17.534	82.370	1.79	14.00	4.95	6.20	16
8	184+335									41.5
9	185+335									
10	186+335		0.000	15.562	84.438	1.87	12.00	6.15	7.75	
11	187+335									
Parwanipur Junction - Birgunj Border Road Section										
12	188+335									
13	189+335									5

S. No.	E-W H Chainage	NMC	Grain Size Analysis			Compaction Test		CBR Test		DCP Test (Layers)
			Gravel	Sand	Fines	MDD%		OMC%	2.50mm	5.00mm
Hetaunda - Narayanghat Road Section										
1	395+325	8.26	64.619	20.181	15.200	2.19	7.80	18.75	21.10	
2	396+025									
3	397+000									
4	398+000	8.71	21.942	31.794	46.274	1.88	10.80	9.50	12.00	24.5
5	398+900									
6	400+000									
7	401+000	9.17	1.483	39.091	59.426	2.09	11.80	8.70	11.00	10

S. No.	E-W H Chainage	NMC	Grain Size Analysis			Compaction Test		CBR Test		DCP Test (Layers)
			Gravel	Sand	Fines	MDD%	OMC%	2.50mm	5.00mm	CBR Value
8	402+000									38.5
9	403+000									23.5
10	404+000		5.144	60.147	34.708	1.97	10.50	8.35	11.15	30.5
11	405+000									
12	406+000									
13	407+000	9.07	33.775	41.218	25.007	2.01	8.85	8.00	10.60	
14	408+000									57
15	409+000									
16	410+000	15.27	1.964	26.815	71.221	1.86	12.50	7.65	9.85	
17	411+000									35.5
18	412+000									67.5
19	413+000		30.568	18.156	51.275	2.01	9.50	8.50	12.40	37.5
20	414+000									
21	415+000									
Hetaunda - Narayanghat Road Section										
22	416+000	9.02	16.626	30.134	53.240	1.98	9.90	7.80	10.00	
23	417+000									36
24	418+000									32.5
25	419+000	11.29	8.630	25.990	65.380	1.98	13.00	8.10	10.25	
26	420+000									5
27	421+000									
28	422+000	10.09	8.613	45.817	45.570	2.00	9.90	10.90	13.20	
29	423+000									
30	424+000									
31	425+000	9.51	13.960	38.149	47.891	1.94	11.00	11.20	13.75	17
32	426+000									
33	427+000									6.5
34	428+000	9.40	7.736	29.490	62.774	1.95	12.50	7.60	9.25	

S. No.	E-W H Chainage	NMC	Grain Size Analysis			Compaction Test		CBR Test		DCP Test (Layers)
			Gravel	Sand	Fines	MDD%	OMC%	2.50mm	5.00mm	CBR Value
36	429+000									
37	430+000									
38	431+000	16.25	8.139	10.199	81.662	1.92	13.95	7.50	9.50	
39	432+000									
40	433+000									
41	434+000	9.78	6.069	28.642	65.289	1.94	12.75	6.80	9.70	11.5
42	435+000									
43	436+000									
Hetaunda - Narayanghat Road Section										
44	437+000	10.68	35.799	37.465	26.736	2.06	9.80	12.35	16.25	
45	438+000									15.5
46	439+000									
47	440+000	9.12	9.731	35.254	55.015	1.91	11.00	6.50	8.00	10.5
48	441+000									
49	442+000									2.5
50	443+000	8.41	9.002	19.174	71.824	1.96	11.50	7.00	9.15	
51	444+000									5.5
52	445+000									1.5
53	446+000	8.13	15.545	45.591	38.865	1.97	10.80	8.30	10.75	12
54	447+000									23.5
55	448+000									5.5
56	449+000	9.61	0.121	5.450	94.429	1.87	12.00	5.10	6.50	10
57	450+000									10
58	451+000									11
59	452+000	11.38	1.850	29.526	68.623	1.98	11.80	7.80	10.10	10.5
60	453+000									19.5
61	454+000									27
62	455+080	12.22	20.231	30.672	49.097	1.97	11.70	7.50	9.50	34.5

S. No.	E-W H Chainage	NMC	Grain Size Analysis			Compaction Test		CBR Test		DCP Test (Layers)
			Gravel	Sand	Fines	MDD%	OMC%	2.50mm	5.00mm	CBR Value
63	456+000									36.5
Hetaunda - Narayanghat Road Section										
64	457+000									
65	458+000	10.70	35.472	46.795	17.734	2.01	8.80	14.20	17.50	49
66	459+000									31.5
67	460+000									3.5
68	461+150	10.05	18.574	51.553	29.873	2.09	10.50	11.80	14.00	33.5
69	462+000									8
70	463+000	10.12	0.350	43.390	56.260	2.02	13.00	9.00	11.00	17
71	464+000									4.5
72	465+000									2.5
73	466+000	10.96	0.120	52.170	47.710	2.01	12.00	8.50	10.80	16.5
74	467+000									30

S. No.	Chainage	NMC	Grain Size Analysis			Compaction Test		CBR Test		DCP Test (Layers)
			Gravel	Sand	Fines	MDD%	OMC%	2.50mm	5.00mm	CBR Value
Narayanghat Bypass Road Section										
1	0+300									2
2	1+300	16.24	0.885	56.686	42.429	1.98	12.20	8.50	10.80	15.5
3	2+300									1
4	3+300									1.5
5	4+300	11.02	2.930	46.690	50.370	2.02	11.90	9.00	11.80	11

8.5 General Remarks on Test Results

8.5.1 Construction Material/Stability of the Pavement Structure

- The types of tests for different construction materials selected in the present project conform to STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE WORKS, issued by the Department of Roads, 2058.
- The design CBR value of 80% is met when the binder material is similar to crusher dust collected from landslide material. The CBR tests were also carried out to ascertain the possibility of using the locally available red clay binders (CH:4+000) but the CBR values using red clay binders are considerably below the standard.
- The DOR specification allows increased LAA, AIV and ACV values if rounded aggregates are used as rounded aggregates are better able to resist impact and crushing under similar loading conditions.

8.5.2 Sub-grade Material

Results of field and laboratory tests are presented in **Table 8.2**. The CBR values vary between 11 to 29% while the required minimum soaked CBR value of 8%. The sub-grade material can be used as it is. The CBR values at 5mm deformation are consistently greater than those at 2.55 mm deformation. Therefore CBR values at 5 mm deformation are the suggested CBR values.

9 TRAFFIC STUDY

9.1 Introduction

24-hour, three day classified traffic counts were conducted at Jitpur and Pathlaiya Junction South along the Tribhuvan Highway; Karra Bridge (Hetauda South) and Tikauli (Narayanghat East) along the East-West Highway and at the Pokhariya – Parwanipur ICD Bypass Road during the period from 13th to 20th March, 2011.

This study utilised the findings of the previous 12-hour origin and destination (O-D) survey conducted at Aptari (KM 2+425±) along the Narayanghat – Mugling Highway (NMH) on 23 June, 2010. The classified vehicle counts included both the motorised and non-motorised vehicles.

9.2 Desk Study

These traffic analyses compiled and reviewed the following documents to aid and incorporate necessary adjustments.

- Feasibility Study – Narayanghat- Mugling Highway Improvement; RSDP New Project Preparation & Supervision (IDA Loan No. H339-NEP); Jan. 2011.
- Environment Assessment Document; STIEUP Birgunj Sub-project (ADB Project # 36188); DUDBC; June 2010.
- STIEUP TA Consultant's Report Vol. 4: Roads & Lane; ADB Project # 36188; PADECO-METCON JV; November 2008.
- Socio-economic Profile and Urban Indicator of Bharatpur Municipality – UEIP Vol. 3; (ADB Loan No. 1966 NEP-SF); June 2008.
- Supplementary Appendix 3: Traffic; North South Fast-Track Road Project (Preliminary Design Phase) (ADB TA 4842- NEP); Oriental- ITECO N- NDRI JV; 2008.
- Draft Final Report Vol. I Main Report and Appendix 5: Traffic; NSFTRP (Feasibility Phase): Oriental- ITECO N- NDRI JV; July 2007.
- Birgunj Municipal Profile 2007; Birgunj Municipality, Parsa District.
- Ratnanagar Town Report - UEIP Vol. 10 (ADB Loan No. 1966 NEP-SF); Nippon Jogesuido Sekuilo –PADCO –METCON- PP Pradhan JV; January 2002.
- Hetauda Town Report- UEIP; January 2002.
- Bharatpur Town Report for Bharatpur; UEIP Vol. 9; August 2001.
- Latest land-use data at Birgunj being compiled under ISMP².
- Vision Paper- GoN Ministry of Physical Planning & Works
- San Diego Trip Generation Manual – Revised 2003; City of San Diego; CA, USA.

9.3 Methodology

The traffic-projection along the Project Road corridor evolved through the following steps:

- Projection of the base-year traffic (envisaged to be 2016) at the various sections.
- Compilation of existing land-use pattern and determination of future land-use developments.
- Compilation of planned, ongoing projects and land developments within the influence area of the corridor.
- Compilation of other competing road projects, routes.
- Determination of the generated and diverted traffic over 10 and 20 years.
- Projection of the existing traffic at all sections of the road corridor over 10 and 20 years.
- Calculation of the 10 and 20 year traffic forecast including land-development.

² Institutional Strengthening of Municipalities (ADB TA 7355 NEP); GoN Dept. of Urban Planning & Building Construction.

The 2011 traffic at the different sections of the Project Road corridor was based on the classified counts conducted in March 2011.

The size of all major land developments planned were compiled from the various studies and sources cited earlier in this Chapter. Subsequently, the generated traffic from such specific sites were calculated taking the trip-rates developed during the 1993 JICA study³ for Kathmandu. While these data are rather old and reflects Kathmandu environment, in the absence of trip-rates in Nepal together with the fact that other such trip-rates (e.g. ITE⁴ trip-rates), the former was applied. The Road corridor under study also represents numerous urban areas that are heavily build-up and thus closely reflects the environment in Kathmandu to a fair degree. The JICA trip rates for different developments (residential, commercial, industrial, etc.) was appropriately adjusted compared to other statistics elsewhere (e.g. San Diego Trip Generation Manual) to reflect the existing land-use pattern.

This Study compiled the long-term land-use developments planned within the influence zone of the Road corridor over the 10 and 20 years period from the various sources cited earlier in this Chapter. Subsequently, the resulting generated traffic from such long-term land-developments was also calculated using the adjusted trip-rates based on the 1993 JICA study.

The diverted traffic analysis assumed two scenarios- (1) Case 1, assuming the North- South Fast-Track Road is not constructed within the design periods and (2) Case 2, assuming that the Fast-Track Road is constructed with the same periods. Diverted traffic from or to competing roads was either directly taken from the concerned reports or extrapolated based on the following assumption.

- **Case 1:** Some of the northbound traffic⁵ would divert from the Project Road Corridor beyond Pathlaiya North to the Mid-hill (Chatara- Gurmi) – Dhulikhel Bardibas Highway route. .
- **Case 2:** Northbound traffic beyond Pathlaiya will assign to both the Fast-Track and the Project Road based on the cost of travel (time) in addition to the Mid-Hill Highway route above.

These assumptions are based on recent development that indicate the completion of the Chatara- Khurkot section of the Mid-Hill Highway by 2013, completion of the Tamakoshi-Manthali- Khurkot and Dhulikhel- Sindhuli- Bardibas Highways within the design period for this Project Road Corridor.

The assumed growth-rate along the Project Road corridor was applied to project base year (2017) and future year traffic. However, generated traffic from long-term land-use developments was just added over the applicable sections of the Project Road corridor during the year 2026 and 2036 without application of the historical growth to avoid double counting and be conservative.

To assess the requirement for the number of lanes along the various sections of the Road corridor, this Study compared the forecast traffic over different time horizons (year 2026 and 2036) with the applicable design capacity for different blacktopped carriageway (two lane, Asian Highway Class II with wide shoulders, four lane divided carriageway, etc.) to come up with suitable recommendation.

³ Study on Kathmandu Valley Urban Road Development- Final Report; JICA/GoN DoR; 1993.

⁴ Institute of Transportation Engineers, US.

⁵ Assumed equivalent to 15% of the 2024/2034 traffic forecast for the North-South Fast Track Road.

9.4 2011 Traffic Estimate

Table 9.1 shows the traffic existing at the five locations pertinent to the Project Road under study based on the recent surveys conducted in March 2011.

Table 9.1: 2011 AADT along the Birgunj - Narayanghat Road Corridor

Vehicle	ICD Bypass	Jitpur South	Pathaliaya South	Karra Bridge (Hetauda South)	Tikauli (Narayanghat East)
MaT	167	892	121	1235	295
HT	172	986	1372	1141	2715
LT	11	345	74	146	243
B	1	423	268	869	1193
MB	2	402	119	342	640
MiB	1	126	94	98	342
C	12	442	110	268	742
UV	451	3256	1569	3842	5858
MC	16	404	155	507	441
TRA	141	639	330	375	223
3-wh	6	570	43	553	163
4WD	23	385	176	727	437
P-tiller	0	0	0	0	16
RICK	1	31	237	67	137
BUL/HC	2	59	40	0	0
BC	1025	8959	1049	10170	1633
Total=	2,031	17,919	5,757	20,340	15,078
Total MVs=	1,003	8,870	4,431	10,103	13,308

MaT= multi-axle truck HT= heavy truck LT= light truck B=bus MB =mini-bus
 MiB= micro-bus C=car U=utility vehicle MC=motor-cycle TRA=tractor
 3-wh= three-wheeler 4WD= four wheel drive P-tiller =power tiller RICK =rickshaw
 BUC/HC = bullock cart/hand-cart BC=bicycle MV= motorised vehicle
 Note: ^ Figures are in terms of annual daily traffic only.
 ADT = average daily traffic AADT =annual average daily traffic vpd = vehicle per day
 Source: Consultant's survey, March 2011

The ADT values of all the stations were adjusted using the DoR seasonal variation factors. Though the DoR seasonal factors were established in the late nineties, there have been no updates since and hence the former are still used.

9.5 Traffic Growth

Table 9.2 illustrates the historical growth of the traffic along the Project Road corridor over the recent years. These are based on the annual traffic surveys that DoR have been conducting over the strategic roads of Nepal.

Table 9.2: Traffic Growth along the Birgunj - Narayanghat Road Corridor

Vehicle	East –West Highway at Narayanghat East (Tikauli)					
	2004	2007	2008	2009	2010	Avg. growth/yr
Trucks						
MaT	10	12	21	18	21	21%
HT	1027	1247	2161	1886	1958	18%
LT	120	21	72	451	298	160%
Bus						
BB	555	306	477	676	584	16%
MB	410	170	492	571	344	35%
MiB	174	97	137	243	98	10%
Car	188	22	212	493	423	40%
UV	199	17	194	353	210	14%
MC	633	193	2278	3102	4278	37%
Tractor	54	2	99	199	187	37%
3-wh	83	0	106	0	448	56%
4WD	169	37	353	441	797	42%
Power-tiller	21	1	39	60	0	-37%
RICK	0	0	124	2	210	30%
BUC/HC	0	0	2	0	0	0%
Total=	3,643	2,125	6,767	8,495	9,856	

Vehicle	East –West Highway at Hetauda West (Karra Bridge)					
	2004	2007	2008	2009	2010	Avg. growth/yr
Trucks						
MaT	12	18	18	17	55	59%
HT	1255	1842	1931	1789	2202	9%
LT	84	36	26	428	174	54%
Bus						
BB	508	420	636	641	583	9%
MB	196	172	31	542	541	24%
MiB	84	26	89	231	344	105%
Car	62	66	100	168	484	78%
UV	249	87	111	335	237	43%
MC	584	1183	1025	2944	4051	59%
Tractor	68	53	0	188	150	20%
3-wh	54	386	373	0	21	4%
4WD	153	163	207	419	275	24%
Power-tiller	21	16	60	57	5	42%
RICK	0	10	30	2	13	24%
BUC/HC	0	0	0	0	0	0%
Total=	3,330	4,478	4,637	7,761	9,135	

Vehicle	East-West Highway at Pathlaiya North					
	2004	2007	2008	2009	2010	Avg. growth/yr
Trucks						
MaT	27	46	47	43	54	10%
HT	1476	2576	2585	2382	2008	-1%
LT	37	105	101	80	242	55%
Bus						
BB	553	800	728	648	813	5%
MB	87	171	228	163	306	29%
MiB	44	119	102	82	92	4%
Car	82	89	97	205	232	34%
UV	99	125	155	214	221	18%
MC	472	687	772	1352	1526	28%
Tractor	46	27	31	48	158	70%
3-wh	0	18	29	40	33	27%
4WD	124	290	314	310	483	24%
Power-tiller	0	30	34	0	0	0%
RICK	0	1	12	0	2	0%
BUC/HC	0	0	2	0	0	0%
Total=	3,047	5,084	5,237	5,567	6,170	

Vehicle	Tribhuvan Highway at Pathlaiya South					Avg. growth/yr
	2004	2007	2008	2009	2010	
Trucks						
MaT	31	48	42	53	42	2%
HT	1314	2031	1794	2265	1595	0%
LT	56	132	36	132	181	66%
Bus						
BB	339	354	140	191	514	37%
MB	139	272	331	420	399	17%
MiB	38	259	50	113	181	49%
Car	72	102	128	160	219	25%
UV	138	155	135	191	203	10%
MC	471	766	867	1257	1313	20%
Tractor	186	131	128	218	284	22%
3-wh	0	92	62	126	56	5%
4WD	127	187	234	283	425	28%
Power-tiller	0	0	0	0	0	0%
RICK	0	1	5	0	2	0%
BUC/HC	0	0	0	0	0	0%
Total=	2,911	4,530	3,952	5,409	5,414	

Source: DoR Annual Classified Vehicle Counts, DoR HMIS

Table 9.3 shows the corresponding growth-rates along the Project Road corridor on network-wise basis.

Table 9.3: Network Wide Traffic Growth along the Birgunj - Narayanghat Road Corridor

Vehicle	Network-wide Average growth/year	Network-wide Traffic Mix
Trucks		
MaT	23%	8%
HT	6%	18%
LT	84%	2%
Bus		
BB	17%	3%
MB	26%	2%
MiB	42%	4%
Car	44%	4%
UV	21%	40%
MC	36%	6%
Tractor	37%	3%
3-wh	23%	4%
4WD	29%	0%
Power-tiller	1%	0%
RICK	14%	
BUC/HC	0%	
Total=	27%	22%

Source: Consultant's estimate based on DoR Annual Classified Vehicle Counts, DoR HMIS

Table 9.3 shows that the network-wide growth of traffic is very high and unreasonable for use in traffic forecasts extending for 10, 20 years. Moreover, the traffic growth-rates observed over the strategic roads has been rather erratic and are not consistent. Due to this reason, traffic growth-rate used for the traffic forecasts was based on the elasticity of the real growth of GDP and transport demand. The following elasticity factors of transport demand with respect to the real growth of GDP was adopted, based on the average to that adopted in the North-South Fast-Track Road Project⁶ and Transport Connectivity Sector Project⁷. **Table 9.4** and **Table 9.5** show the GDP growth anticipated in Nepal in the future and the corresponding elasticities assumed.

Table 9.4: Estimated GDP Growth Rate

Period	Growth/yr (%)
2012 ~ 2016	4.4%
2017~ 2021	4.5%
2022 ~ 2024	5.0%

Source: Nepal Rastra Bank, Kathmandu and other sources.

⁶ Feasibility Preliminary Design Report – North South Fast-Track Road Project; GoN DoR/ADB (ADB TA 4842- NEP); Oriental Consultant- ITECO N- NDRI; 2008.

⁷ Transport Connectivity Sector Project; GoN DoR/ADB (ADB TA4347); Oriental Consultant- ITECO N- NDRI;2008.

Table 9.5: Assumed Income Elasticity of Transport Demand

Year	Car/ 4WD	M/C	B/ MB/ MiB	HT/LT/ UV/TRA
2011 ~ 2014	1.1	1.1	1.65	1.40
2015~ 2019	1.1	1.1	1.65	1.4
2020 ~ 2024	1.1	1.1	1.6	1.3

Source: (1) Feasibility Report – North South Fast-Track Road Project; GoN DoR/ADB (ADB TA 4842- NEP); Oriental Consultant- ITECO N- NDRI; 2008.

(2) Transport Connectivity Sector Project; GoN DoR/ADB (ADB TA4347); Oriental Consultant- ITECO N- NDRI;2005.

Table 9.6 shows the traffic growth-rates used for projections of the existing traffic over the 10 and 20 years period beyond construction of the road improvement contemplated in this Study.

Table 9.6: Calculated Traffic Growth Rate Adopted in Projections

Vehicle	Network-wide Mix	Assumed growth rate/yr				
		2012~ 2016	2017~ 2021	2022~ 2026	2027~ 2031	2032~ 2036
Trucks						
MaT	8%	6.20%	6.30%	6.50%	6.600%	6.65%
HT	18%	6.20%	6.30%	6.50%	6.60%	6.65%
LT	2%	6.20%	6.30%	6.50%	6.60%	6.65%
Bus	7%					
BB	3%	7.30%	7.40%	8.00%	8.30%	8.45%
MB	2%	7.30%	7.40%	8.00%	8.30%	8.45%
MiB	4%	7.30%	7.40%	8.00%	8.30%	8.45%
Car	4%	4.80%	5.00%	5.50%	5.75%	5.88%
UV	40%	6.20%	6.30%	6.50%	6.60%	6.65%
MC	6%	4.80%	5.00%	5.50%	5.75%	5.88%
Tractor	3%	6.20%	6.30%	6.50%	6.60%	6.65%
3-wh	4%	6.20%	6.30%	6.50%	6.60%	6.65%
4WD	0%	4.80%	5.00%	5.50%	5.75%	5.88%
Power-tiller	0%	6.20%	6.30%	6.50%	6.60%	6.65%
Weighted Average=	22%	5.75%	5.85%	6.10%	6.22%	6.29%

Source Consultant's estimate.

As it is difficult to predict the anticipated growth of GDP beyond year 2024, the corresponding traffic growth rates beyond the year 2024 was factored assuming the trend to be consistent.

9.6 Network-wide Traffic Mix

The mix of the traffic along the Project Road corridor was extrapolated from the existing mix at the individual five stations that were surveyed. The resulting average mix along the corridor was assumed to be constant over the forecast period to ease analysis. **Table 9.6** above shows the traffic mix adopted for all the traffic projections in this Study.

9.7 Generated & Diverted Traffic

Latest and long-term land-use data along the influence zone of the Project Road corridor was lacking in most cases. Therefore, the Consultant also refined these data based on visual inspection of the Road corridor via Google Map⁸ together with available information

⁸ Maps available from Google Inc., US.

and discussions with the concerned officials at the Department of Urban Development & Building Construction (DUDBC).

The area within 1.5 km from the centre-line of the Project Road corridor on both sides was demarcated as the influence area for the generated traffic from long-term land-use developments over the design horizon. This criteria conforms to the practice in Nepal in land development planning for transportation planning and other guideline⁹. The entire influence area was divided into eight blocks or traffic analysis zones (TAZs). These TAZs were formed based on observation of the environment of different sections. **Table 9.7** summarizes the TAZ for the Project.

Table 9.7: Traffic Analysis Zone

TAZ #	Area (hectares)	Area
1	3702	Pokhariya- Parwanipur ICD Bypass
2	255	Raxaul – Pratima Chowk/Bypass Jn
3	2157	Birgunj Bypass
4	1029	Ganaki Canal - Parwanipur
5	4854	Parwanipur - Pathlaiya
6	1602	Hetauda Municipality
7	1089	Ratnanagar Municipality
8	1980	Bharatpur Municipality

Source: Consultant's analysis

The generated traffic from land developments on a long-term was calculated first in terms of person-trips by multiplying the adopted person-trip rate with the population increase residing or commuting from various land-use in each TAZ over the twenty year design period. The resulting person-trips were converted to vehicle trips using the assumed traffic mix while the vehicle occupancies observed at NMH during the origin- destination survey conducted under this Project in 2010. The population increase over each land-use was derived by applying appropriate population densities mostly adopted or prescribed in various urban development projects and DUDBC practice. The following population-densities were used for this assessment:

<u>Land-use</u>	<u>Population Density (per ha)</u>
Industries (IND) –Hetauda & Bharatpur zones	30 employees
Industries (IND) –rest	91 employees
Residential (RES) – Birgunj, Hetauda & Bharatpur zones	150 persons
Residential (RES) – other zones	100 persons
Commercial (COM)	200 persons

The person trip-rates for each land-use were based on the 1993 JICA Study suitably modified based on new data or Consultant's estimate. The generated-traffic over twenty-year analysis period was assumed to develop gradually with 50% maturing in ten years and the full traffic evolving in twenty years. These generated trips were not compounded for historical growth as this is already inherent in the forecast for the same.

Generated traffic from specific developments (Birgunj SEZ in Allau, Adarsha Chowk land-pooling in Ratnanagar) were derived by applying the area-based trip-rate developed from comparison of the San Diego trip-rates with the KVURDP¹⁰ rates. These site-generated traffic were also not compounded with the traffic growth-rate owing to the fact that both development were envisaged in the longer term.

⁹ Kathmandu Valley Long Term Development Perspective 2002; GoN MoPPW Kathmandu Valley Town Development Committee.

¹⁰ Kathmandu Valley Urban Road Development; JICA/DoR; 1993

Based on latest status of the relevant roads that are underway or planned within the Project horizon, diverted traffic to Dhulikhel- Sindhuli- Bardibas Highway, North- South Fast Track Road and Manthali- Khurkot section of the Tamakoshi- Manthali- Khurkot Road was estimated. This Study compared the trip patterns observed from the origination –destination surveys conducted at Narayanghat in 2010 under this Project and similar surveys at Hetauda in 2008 under the North- South Fast-Track Road Project. For this study, the resulting pattern was assumed to be consistent throughout the 10 and 20 year period¹¹.

Table 9.8: Trip Pattern Observed

	EB	NB	WB	Total
Narayanghat	19%	66%	15%	100%
Hetauda	50%	44%	6%	100%

Source: O-D surveys – RSDP New Project Preparation & Supervision, 2010 & North-South Fast Track Project –PPTA. 2008.

This Study assumed that the north-bound traffic beyond Pathaiya would divert to the North-South Fast Track Road. In this respect, it is important to note that the Consultant has assumed that 50 % and 100% of the build-up traffic for the Fast Track Road will evolve by year 2026 and 2036, respectively. 15 % of the build-up traffic at the Fast Track Road is expected to divert to the Dhulikhel- Bardibas and Manthali- Khurkot Roads owing to the Government's plan to open the track from Chatara-to Ghurmi and blacktop the Ghurmi – Khurkot sections of the Mid-hill Highway by 2013.

9.8 Base Year 2016 Traffic

This Study has assumed two case scenarios in forecasting traffic over the 10 and 20 years period.

Case 1: Assumes North-South Fast-Track Road is not constructed and operational.

Case 2: Assumes North-South Fast-Track Road is constructed and operational.

Table 9.9 shows the resulting traffic for the base year 2016 (which is common to both cases) when the road improvements over the Project corridor is expected to be operational.

Table 9.9: Base Year 2016 AADT (Case 1 and 2)

Vehicle	Base Year 2016						
	Pokhariya - Parwanipur ICD Bypass	Raxaul - Pratima Chowk/ Bypass Jn	Birgunj Bypass	Gandaki Canal - Parwanipur	Parwanipur - Pathlaiya	Pathlaiya - Hetauda	Hetauda - Narayan ghat
MaT	469	401	307	313	706	804	1,060
HT	1,057	903	692	706	1,591	1,812	2,387
LT	129	110	84	86	194	221	291
BB	390	333	255	260	586	668	880
MB	187	160	122	125	281	321	422
MiB	94	80	61	62	141	160	211
Car	218	186	143	146	328	374	493
UV	218	186	143	146	328	374	493
MC	2,323	1,984	1,520	1,550	3,495	3,981	5,244
Tractor	343	293	224	229	516	588	774
3-wh	187	160	122	125	281	321	422

¹¹ This assumption leads to some errors as trip pattern slightly change with time and availability of alternative routes. However, this error has ignored this error to ease analysis.

Vehicle	Base Year 2016						
	Pokhariya - Parwanipur ICD Bypass	Raxaul - Pratima Chowk/ Bypass Jn	Birgunj Bypass	Gandaki Canal - Parwanipur	Parwanipur - Pathlaiya	Pathlaiya - Hetauda	Hetauda - Narayan ghat
4WD	249	213	163	166	375	427	563
Power-tiller	-	-	-	-	-	-	-
RICK	94	80	61	62	141	160	211
BUC/HC	16	13	10	10	23	27	35
BC	1,821	1,555	1,191	1,215	2,739	3,120	4,110
AADT =							
MVs AADT=	7,795	6,658	5,100	5,201	11,728	13,359	17,597

Source: Consultant's estimate.

Tables 9.10 to 9.13 show the future traffic projections in 10 and 20 years along the Project Road corridor for both cases.

Table 9.10: Case 1 Forecast 2026 AADT

Vehicle	Year 2026						
	Pokhariya - Parwanipur ICD Bypass	Raxaul - Pratima Chowk/ Bypass Jn	Birgunj Bypass	Gandaki Canal - Parwanipur	Parwanipur - Pathlaiya	Pathlaiya - Hetauda	Hetauda - Narayanghat
MaT	1,737	678	705	836	1,998	1,951	2,348
HT	3,912	1,528	1,588	1,883	4,501	4,396	5,290
LT	478	186	194	230	549	537	646
BB	1,442	563	585	694	1,659	1,620	1,950
MB	692	270	281	333	796	778	936
MiB	346	135	140	167	398	389	468
Car	808	315	328	389	929	907	1,092
UV	808	315	328	389	929	907	1,092
MC	8,594	3,356	3,487	4,135	9,886	9,656	11,620
Tractor	1,269	496	515	611	1,460	1,426	1,716
3-wh	692	270	281	333	796	778	936
4WD	923	360	374	444	1,062	1,037	1,248
Power-tiller	-	-	-	-	-	-	-
RICK	346	135	140	167	398	389	468
BUC/HC	58	23	23	28	66	65	78
BC	6,736	2,631	2,733	3,241	7,749	7,568	9,108
AADT =							
MVs AADT=	28,840	11,263	11,703	13,877	33,175	32,403	38,995

Source: Consultant's estimate

Table 9.11: Case 2 Forecast 2026 AADT

Vehicle	Year 2026						
	Pokhariya - Parwanipur ICD Bypass	Raxaul - Pratima Chowk/ Bypass Jn	Birgunj Bypass	Gandaki Canal - Parwanipur	Parwanipur - Pathlaiya	Pathlaiya - Hetauda	Hetauda - Narayanghat
MaT	1,737	678	705	836	1,998	1,951	2,348
HT	3,912	1,528	1,588	1,883	4,501	4,396	5,290
LT	478	186	194	230	549	537	646
BB	1,442	563	585	694	1,659	1,620	1,950
MB	692	270	281	333	796	778	936
MiB	346	135	140	167	398	389	468
Car	808	315	328	389	929	907	1,092
UV	808	315	328	389	929	907	1,092
MC	8,594	3,356	3,487	4,135	9,886	9,656	11,620
Tractor	1,269	496	515	611	1,460	1,426	1,716
3-wh	692	270	281	333	796	778	936
4WD	923	360	374	444	1,062	1,037	1,248
Power-tiller	-	-	-	-	-	-	-
RICK	346	135	140	167	398	389	468
BUC/HC	58	23	23	28	66	65	78
BC	6,736	2,631	2,733	3,241	7,749	7,568	9,108
AADT =							
MVs AADT=	28,840	11,263	11,703	13,877	33,175	29,204	32,685

Table 9.12: Case 1 Forecast 2036 AADT

Vehicle	Year 2036						
	Pokhariya - Parwanipur ICD Bypass	Raxaul - Pratima Chowk/ Bypass Jn	Birgunj Bypass	Gandaki Canal - Parwanipur	Parwanipur - Pathlaiya	Pathlaiya - Hetauda	Hetauda - Narayan ghat
MaT	3,263	1,226	1,320	1,577	3,785	3,685	4,404
HT	7,351	2,762	2,973	3,553	8,527	8,302	9,921
LT	897	337	363	434	1,041	1,013	1,211
BB	2,709	1,018	1,096	1,309	3,143	3,060	3,656
MB	1,300	489	526	629	1,509	1,469	1,755
MiB	650	244	263	314	754	734	878
Car	1,517	570	614	733	1,760	1,714	2,048
UV	1,517	570	614	733	1,760	1,714	2,048
MC	16,147	6,068	6,531	7,805	18,732	18,237	21,793
Tractor	2,384	896	964	1,152	2,766	2,693	3,218
3-wh	1,300	489	526	629	1,509	1,469	1,755
4WD	1,734	652	701	838	2,011	1,958	2,340
Power-tiller	-	-	-	-	-	-	-
RICK	650	244	263	314	754	734	878
BUC/HC	108	41	44	52	126	122	146
BC	12,656	4,756	5,119	6,117	14,681	14,294	17,081
AADT =							
MVs AADT=	54,185	20,362	21,918	26,190	62,858	61,200	73,130

Source: Consultant's estimate

Table 9.13: Case 2 Forecast 2036 AADT

Vehicle	Year 2036						
	Pokhariya - Parwanipur ICD Bypass	Raxaul - Pratima Chowk/ Bypass Jn	Birgunj Bypass	Gandaki Canal - Parwanipur	Parwanipur - Pathlaiya	Pathlaiya - Hetauda	Hetauda - Narayanghat
MaT	3,263	1,226	1,320	1,577	3,785	3,685	4,404
HT	7,351	2,762	2,973	3,553	8,527	8,302	9,921
LT	897	337	363	434	1,041	1,013	1,211
BB	2,709	1,018	1,096	1,309	3,143	3,060	3,656
MB	1,300	489	526	629	1,509	1,469	1,755
MiB	650	244	263	314	754	734	878
Car	1,517	570	614	733	1,760	1,714	2,048
UV	1,517	570	614	733	1,760	1,714	2,048
MC	16,147	6,068	6,531	7,805	18,732	18,237	21,793
Tractor	2,384	896	964	1,152	2,766	2,693	3,218
3-wh	1,300	489	526	629	1,509	1,469	1,755
4WD	1,734	652	701	838	2,011	1,958	2,340
Power-tiller	-	-	-	-	-	-	-
RICK	650	244	263	314	754	734	878
BUC/HC	108	41	44	52	126	122	146
BC	12,656	4,756	5,119	6,117	14,681	14,294	17,081
AADT =							
MVs AADT=	54,185	20,362	21,918	26,190	62,858	54,801	60,510

Source: Consultant's estimate

9.9 Recommendation for Road Carriageway

Based on the traffic forecasts above, the road carriageway required to accommodate the anticipated traffic for the two cases are given in **Tables 9.14 and 9.15**.

The Asian Highway CLASS II standard shown above include wide 2.5 m shoulder and climbing as appropriate. For the four and six lane road standards, shoulders 2.5 m. The design capacity threshold for these standards are based on calculations using US Highway Capacity Manual 2000 with suitable adjustments based on recent research finding by IRC¹². From the above tables, it is interesting to note that the road carriageway required in both cases are more or less the same with one exception that the Pathlaiya – Hetauda section under Case 1 will operate at a Level of Service C even by 2026 during the peak hours. The traffic operations will thus be more constrained than at LOS B prescribed in Draft Nepal Road Standards, 2005. The Hetauda- Narayanghat section will also operate at LOS C by year 2036 under both conditions. Given the long gestation period, it will be more prudent to revisit the decision to upgrade the Hetauda- Narayanghat section in the future rather than simply upgrade it to eight-lane carriageway. Non-motorised vehicles should be accommodated in separate lanes or local service tracks if possible.

¹² IRC Paper 566: "Critical Evaluation of Roadway Capacity of Multi-lane High-speed Corridor under Heterogenous Traffic Conditions through Traditional and Microscopic Models"; Velmurugan- Errampalli et al; Journal of Indian Road Congress; New Dehli, India; Dec. 2010.

Table 9.14: Case 1: Recommended Road Carriageway without North South Fast Track Corridor

Case 1: Without North-South Fast Track Road											
Project Section	AADT in vpd				Planning Peak Hour Traffic - PCU/hr				Carriageway Required		
	Existing 2011	Road Opening 2016	Year 2026	Year 2036	Existing 2011	Road Opening 2016	Year 2026	Year 2036	Base Year 2016	Year 2026	Year 2036
Pokhariya -Parwanipur ICD Bypass	2,031	7,795	28,840	54,185	150	574	2,125	3,993	7 m	4 L divided	6 L divided - LOS C
Raxaul - Pratima Chowk/ Bypass Jn	10,069	6,658	11,263	20,362	857	566	958	1,733	7 m	4 L divided (BLT-up)	4 L divided (BLT-up)
Birgunj Bypass	7,713	5,100	11,703	21,918	656	434	996	1,865	7 m	4 L divided (BLT-up)	4 L divided (BLT-up)
Gandaki Canal - Parwanipur	7,867	5,201	13,877	26,190	669	443	1,181	2,228	7 m	4 L divided (BLT-up)	4 L divided (BLT-up)
Parwanipur - Pathlaiya	8,869	11,728	33,175	62,858	727	962	2,720	5,154	4 L divided	6 L divided	6 L divided - LOS C
Pathlaiya - Hetauda	10,102	13,359	32,403	61,200	878	1,161	2,816	5,319	4 L divided	6 L divided - LOS C	6 L divided - LOS C
Hetauda - Narayanghat	13,307	17,597	38,995	73,130	1,057	1,398	3,097	5,808	4 L divided (BLT-up)	6 L divided (BLT-up)	6 L divided (BLT-up) - LOS C
Road Standard	Design Capacity according to terrain (PCUs/h)										
	Plain	Rolling	Mountain	Steep							
3.5 m	200	180	180	140							
5.5 m	600	570	520	450							
7 m	1,500	1,000	700	500							
Asian HWY -CLASS II	1,700	1,700	1,400	1,400							
4 L divided	4,530	3,726									
4 L divided (BLT-up)	4,521	3,711									
6 L divided	6,283	5,168									
6 L divided (BLT-up)	6,270	5,168									
6 L divided -LOS C	13,668	11,130									
6 L divided (BLT-up) - LOS C	13,638	11,100									

Table 9.15: Case 2: Recommended Road Carriageway with North South Fast Track Corridor

Case 2: With North-South Fast Track Road											
Project Section	AADT in vpd				Planning Peak Hour Traffic - PCU/hr				Carriageway Required		
	Existing 2011	Road Opening 2016	Year 2026	Year 2036	Existing 2011	Road Opening 2016	Year 2026	Year 2036	Base Year 2016	Year 2026	Year 2036
Pokhariya -Parwanipur ICD Bypass	2,031	7,795	28,840	54,185	150	574	2,125	3,993	7 m	4 L divided	6 L divided - LOS C
Raxaul - Pratima Chowk/ Bypass Jn	10,069	6,658	11,263	20,362	857	566	958	1,733	7 m	4 L divided (BLT-up)	4 L divided (BLT-up)
Birgunj Bypass	7,713	5,100	11,703	21,918	656	434	996	1,865	7 m	4 L divided (BLT-up)	4 L divided (BLT-up)
Gandaki Canal - Parwanipur	7,867	5,201	13,877	26,190	669	443	1,181	2,228	7 m	4 L divided (BLT-up)	4 L divided (BLT-up)
Parwanipur - Pathlaiya	8,869	11,728	33,175	62,858	727	962	2,720	5,154	4 L divided	6 L divided	6 L divided - LOS C
Pathlaiya - Hetauda	10,102	13,359	29,204	54,801	878	1,161	2,538	4,763	4 L divided	6 L divided	6 L divided - LOS C
Hetauda - Narayanghat	13,307	17,597	32,685	60,510	1,057	1,398	2,596	4,806	4 L divided (BLT-up)	6 L divided (BLT-up)	6 L divided (BLT-up) - LOS C

Notes:

1. All the roads should comprise of shoulders at least 1.8 m wide.
2. Asian highway Class II denoted here comprise 2.5 m wide shoulder with climbing lane.
3. Capacity for six-lane carriageway are calculated based on observed conditions along the Project Road Corridor
4. Capacity for six-lane carriageway in built-up areas pertains to conditions similar to built-up areas in the municipalities.
5. Shoulders 2.5 m wide assumed for four and six lane divided carriageways.
6. Design capacities for single to two lane roads based on Draft Nepal Road Standard 2062 4th Revision, 2005.
7. Design capacities for four and six lane are Consultant's estimate based on US HCM 2000 methodology with suitable adjustment based on IRC Research Paper 566: Critical Evaluation of Roadway Capacity for Design Service Volume for Multi-lane High-Speed Corridor" by Velmurgan-Errampalli et al; IRC Journal; India; Dec. 2010.

10 PRELIMINARY ENGINEERING DESIGN

10.1 Data Entry and Calculation

All the data collected during field surveys/visit were entered in a tabulated format and grouped in separate headings, such as SDI (surface distress index), road inventory, inventory of bridges/cross drainage structures, existing and proposed retaining structures, etc., and analysed using typical sections for different kinds of structures the quantities were computed.

10.2 Design Standards

Following design standards are proposed for the project road sections.

Nos. of Lanes

As per traffic studies the project road requires 4 lane facility from the base year 2016. This shall be sufficient for the initial 10 years of operations.

Design Speed

The design speeds shall be as given in **Table 2.3** for the **Class I** type roads (Asian Highways) i.e. 100 kmph for level terrain and 80 kmph for rolling terrain.

Cross Section

The proposed facility shall be a limited access road. From traffic considerations it shall have 4-lane divided carriageway with a 3-4m wide raised median. **New Hetauda bypass** shall be **2-lane** as the traffic can also use existing 2-lane road. For turning traffic breaks in the median shall not more frequent than at 2km interval. To cater for the local traffic service roads shall be provided on either side in congested markets, industrial areas etc. at sections listed in **Table 10.1**. Typical cross sections are given in **Figure 10.1**.

Table 10.1: List of Sections with Provision of Service Roads

List of Settlement along Hetauda - Narayanghat Road Section				
S. No.	Chainage		Length	Settlement
	From	To	(m)	
1	394+850	395+520	670.0	Hetauda
2	398+600	399+400	800.0	Nawalpur
3	409+800	410+100	300.0	Newarpani
4	419+500	420+000	500.0	Jyamire
5	420+600	421+200	600.0	Simpani
6	422+000	422+500	500.0	Beluwa
7	423+900	425+000	1100.0	Manahari
8	433+100	433+300	200.0	Churachuri
9	435+000	435+500	500.0	Lother, Makawanpur
10	435+650	435+740	90.0	Lother, Bharatpur
11	439+300	440+550	1250.0	Gadaule
12	440+800	441+400	600.0	Pipletar
13	442+900	443+800	900.0	Dadhuwa
14	444+600	445+000	400.0	Bhandara
15	451+600	452+700	1100.0	Parsa

List of Settlement along Hetauda - Narayanghat Road Section				
S. No.	Chainage		Length	Settlement
	From	To	(m)	
16	454+000	454+900	900.0	Chainpur
17	457+000	459+000	2000.0	Ratnanagar
18	465+580	471+500	5920.0	Bharatpur
		Total	18330.0	
Hetauda - Birgunj Road Section				
SN	Chainage		Length	Settlement
	From	To	(m)	
1	0+000	7+500	7500.0	Hetauda bypass
2	137+370	138+900	1530.0	Ratomate
3	143+240	151+800	8560.0	Churiya
4	152+200	153+850	1650.0	Amlekhgunj
5	161+900	162+700	800.0	Pathlaiya
6	164+950	166+350	1400.0	Simra
7	169+250	172+450	3200.0	Jitpur
8	177+135	182+195	5060.0	Parwanipur-birgunj bypass
9	183+550	189+740	6190.0	Pratima chowk,Birgunj bypass section
10	10+065	10+780	715.0	Dryport
		Total	36605.0	

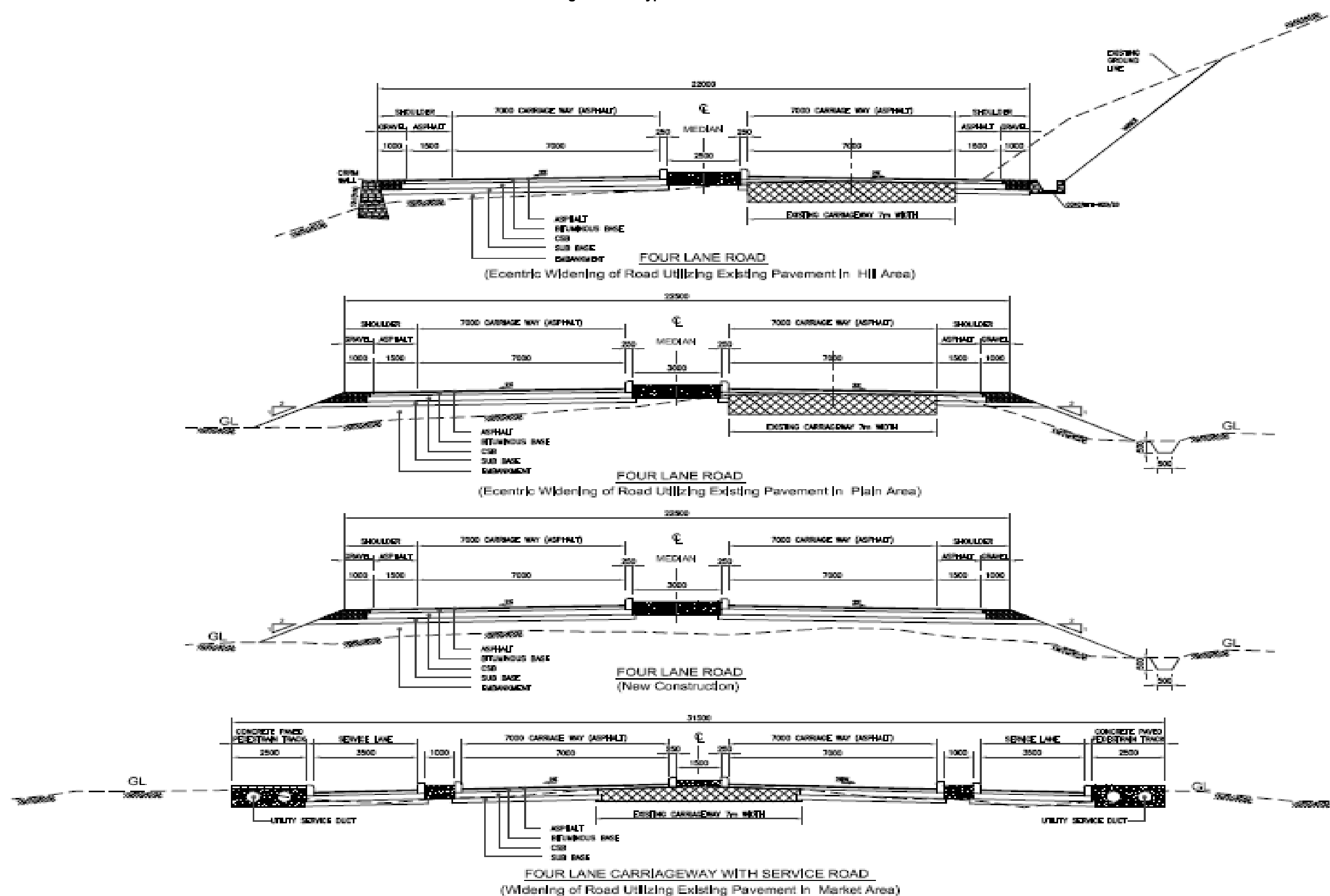
As mentioned in **Chapter 2**, the study road has a common section from Aaptari – Simra and thereafter following 3 links are studied for improving to the Asian Highway Standards. Locations of these links are shown in **Figure 1.1**.

Link-1: Simra- Parwanipur- ICD

Link-2: Simra- Parwanipur- Pratima Chauk- Raxaul / Birgunj border

Link-3: Simra- Milan Chauk- Jagan Nathpur- ICD

Figure 10.1: Typical Cross Sections



10.3 Pavement Design

10.3.1 General

Existing road has bituminous surfacing with varying traffic volume at various sections (ref Chapter 7, Traffic Studies). Considering arterial road carrying long distance and international cargo traffic from dry port, it is required to design asphalt road surfacing with 4-lane divided carriageway formation width. The road shall be upgraded to the Asian Highway Standards class I.

To achieve the Asian Highway Standards (Class I) minimum formation width required shall vary from 22.0m to 31.5m as shown in cross section (Figure 10.1). Minimum width of median should be 3.0m and shoulder 2.5 – 3.0m. Existing road width is generally varying from 6-7m with upto 11m in market areas. In Jitpur, service roads are also provided on both sides of 2-lane road resulting on overall width of 25-30m.

10.3.2 Existing Pavement Structure

The existing pavement composition is of granular sub-base, gravel base and asphalt surfacing. Thickness of pavement is varying from 200 - 600mm with 30 to 80mm bituminous surfacing, 100 - 300mm granular base-course and 100 - 300mm granular sub-base course.

10.3.3 Existing Pavement Condition

The Consultant has carried out a visual pavement condition survey (Surface Distress Index, SDI) where the different distress modes have been assessed at 100 m representative section at every kilometre throughout the alignment.

The survey includes recording of the following features:

- Surface description (rich/ hungry/ open/ close surface)
- Rut depth divided into 3 categories (<10 mm/ 10-20 mm/ >20 mm)
- % cracked area
- % area covered by pot holes, ravelling and patching
- Edge break and Shoulder condition
- Drain Condition

SDI survey data is presented in **Annexure - 4**

10.3.4 Pavement Structural Strength

The Benkelman Beam Rebound Deflection Technique was used for determining the rebound deflections of the existing road. The deflection measurements were carried out along the entire length of project road as per Canadian Good Road Association (C.G.R.A.) procedure indicated in Indian Road Congress guidelines (IRC-81:1997). Benkelman beam deflections were recorded at every 200m along the road.

The pavement temperature and seasonal variation in climate influence deflections measured by the Benkelman Beam. At any deviation of the pavement temperature during measurements from the standard temperature of 35 °C, correction has been applied to the deflection measured in accordance with the procedure described in IRC: 81-1997.

Seasonal correction was carried out using the factors suggested by DoR Central Laboratory. The deflection measurements and the rebound deflection are given as **Annexure - 4** and graphical plot of same is given in **Figure 10.2, 10.3 and 10.4**.

10.3.5 Design Traffic Loads

Traffic volume counts and forecasting have been carried out as at various locations described in **Chapter 9**. For calculation of traffic loads for pavement design in terms of cumulative equivalent standard axle loads is considered based on equivalence factors worked out from Axle load surveys carried out by Consultants at Aptari in June 2010. The data collected from these surveys are used to calculate the mean number of equivalent standard axles for a typical vehicle in each class. These values are then used in conjunction with traffic forecasts to determine the predicted cumulative equivalent standard axles that the road will carry over its design life.

Table 10.2: Equivalent Standard Axles Observed at Aptari, NMH

Vehicle	North to South	South to North
Multi-axle Truck	0.92	15.72
Heavy Truck	1.22	5.68
Light Truck	1.85	0.5
Bus	0.21	0.85
Mini Bus	0.09	0.11
Micro Bus	0.07	0.06
Utility Vehicle	0.02	0.0003
Tractor & Power Tiller	0.03	0.01
Car/Taxi	0.000	0.000
Motor Cycle	0.000	0.000
Four Wheel Drive	0.12	0.12

Source: Consultant's survey & analysis, July 2010.

The ESA values shown shaded are assumed values based on experience as they have negligible impact to axle-loads. Though the ESA value for the multi-axle trucks along the loaded direction (south to north) is very high, it is still consistent with the corresponding values of the axle survey under SWRP in 2007.

For the design of pavement, the design life is defined in terms of the cumulative number of standard axles that can be carried before strengthening of the pavement is necessary. Design life of pavement is taken as 10 years. Considering 4 years duration for construction of road after completion of detailed design, 2016 is considered as the year of completion of construction for estimation of initial traffic.

The projected cumulative ESA for the year 2026 is indicated in **Table 10.3** for different road sections based on consideration of growth in the existing volume of commercial vehicles. With a provision of 4 years for completion of construction the consultants have designed the thickness pavement layers for overlay and widening for a ten-year design period, using the projected cumulative ESA for the year 2026 and the sub-grade CBR. . This design load does not take into consideration the damage factor during the construction phase i.e. 2011 to 2015.

Table 10.3: Cumulative Equivalent Standard Axles (ESA)

Road Section for Traffic Loading	Cumulative ESAs in millions (MSA)
Hetauda - Narayanghat	49.19
Pathlaiya - Hetauda	37.32
Parwanipur - Pathlaiya	32.77
Gandaki Canal - Parwanipur	14.53
Birganj Bypass	14.25
Raxaul - Pratima Chowk/ Bypass Jn	18.61
Pokhariya -Parwanipur ICD Bypass	21.77

10.3.6 Subgrade CBR

Major width of road formation is in cut having good subgrade of granular soil or boulder mixed soil of low plasticity properties, falling within A1 and A2 group of AASHTO classification. Average subgrade CBR is 10 falling in subgrade strength class S4 as per the guidelines contained in Table 3.2 of TRL Overseas Road Note 31 (ORN 31). Subgrade strength class (S4) covers a wide band of CBR range of 8-14. Detailed investigation will be made in detailed engineering phase to make subsection of uniform subgrade strength to optimize the thickness design and the costs thereof.

10.3.7 Design Methodology

It is proposed to use the existing pavement as far as possible. In many locations the existing pavement shall be strengthened and used as one carriageway. Accordingly project shall involve strengthening of existing pavement with asphalt overlay and widening by providing a new pavement. Thickness of asphalt overlay on existing pavement and new pavement for widening has been determined by the following methods.

Pavement Type	Design Method
Overlay Design	• IRC: 81-1997
Pavement Widening & Pavement Reconstruction	• TRL Overseas Road Note 31
	• IRC: 37-2001

10.3.8 Homogeneous Sections:

A pre-requisite for successful economic comparison of different pavement alternatives is that the road is divided into homogeneous sections. Homogenous sections are sections, which would be expected to have uniform pavement construction costs and uniform deterioration performance throughout the length of each section. The major parameters influencing pavement construction costs and future pavement performance (and related user costs) include:

- Traffic loading in terms of ESALs
- Crust details
- Subgrade strength
- Benkelman Beam deflections
- Roughness and surface condition

The project road is divided into homogeneous sections primarily based on traffic loading and pavement deflection / pavement crust. The resulting design values for subgrade CBR, Benkelmann Deflections and existing pavement crust are given in **Table 10.4**.

Table 10.4: Details of Homogenous Sections

Section No.	From	To	Deflection Avg+2xδ _{st} (mm)	Sub-grade CBR (min)	Existing Crust thickness (avg)			Design Traffic (8.2 t ESAs x10 ⁶) 10 Yrs Msa
					BIT (avg). (mm)	Gravel (avg) (mm)	GSB (avg) (mm)	
	(km)	(km)	(mm)		(mm)	(mm)	(mm)	Msa
1	4+520 (Aptari)	467+640 (Narayanghat Chowk)		8				
2	467+640 (Narayanghat Chowk)	395+520 (Hetauda Chowk)	3.04	8				49.19
3	395+520 (Hetauda Chowk)	137+370 (Pathlaiya)	1.80	8				37.32

Section No.	From	To	Deflection Avg+2x δ_{st}	Sub-grade CBR (min)	Existing Crust thickness (avg)			Design Traffic (8.2 t ESAs x10 ⁶) 10 Yrs
					BIT (avg).	Gravel (avg)	GSB (avg)	
4	137+370 (Pathlaiya)	177+135 (Parwanipur)	1.92	8				21.77
5	177+135 (Parwanipur)	187+915 (Birganj ICD)	1.68	8				21.77
6	177+135 (Parwanipur)	189+740 (Birganj Border)		8				14.25
5	Simara	Jagannathpur		8				21.77

10.3.9 Overlay design by IRC-81:1997

Overlay thickness has been worked out in terms of Bituminous Macadam overlay from the design charts of IRC-81:1997 based on characteristic deflection and cumulative standard axle loads. The results are shown in **Table 10.5**.

Table 10.5: Overlay Thicknesses in Homogenous Sections

Section No.	From	To	Characteristic Deflection Avg+2x δ_{st}	Cumulative Equivalent Axle Load (MSA)	Overlay thickness (BM) as per IRC-81:1997
	(km)	(km)	(mm)		mm
1	467+640 (Narayanghat Chowk)	395+520 (Hetauda Chowk)	3.04	49.19	240
2	395+520 (Hetauda Chowk)	137+370 (Pathlaiya)	1.80	37.32	190
3	137+370 (Pathlaiya)	177+135 (Parwanipur)	1.92	21.77	170
4	177+135 (Parwanipur)	187+915 (Birganj ICD)	1.68	21.77	150

The worked out thickness is to be multiplied by 0.7 as the overlay material provided shall be DBM or AC.

10.3.10 New Pavement Design

Design of new pavement has been carried out following TRL Overseas Road Note 31 and IRC:37-2001. Required pavement thickness are given in **Tables 10.6** and 10.7.

Table 10.6: New Pavement Design as per TRL-Overseas Road Note 31 (ORN-31)

Section No.	From	To	Sub-grade CBR (min)	Design Traffic (8.2 t ESAs x10 ⁶) 10 YRS	TRL Overseas Road Note-31 Structural Catalogue		Pavement thickness as per TRL Overseas Road Note-31, Chart 5		
					Subgrade Class	Traffic Class	Bituminous Surface	Granular Road Base	Granular Sub-Base (GSB)
	(km)	(km)	%	msa			mm	mm	mm
1	4+520 (Aptari)	467+640 (Narayanghat Chowk)	8	49.19	S4	T8	150	250	175
2	467+640 (Narayanghat Chowk)	395+520 (Hetauda Chowk)	8	49.19	S4	T8	150	250	175
3	395+520 (Hetauda Chowk)	137+370 (Pathlaiya)	8	37.32	S4	T8	150	250	175

Section No.	From	To	Sub-grade CBR (min)	Design Traffic (8.2 t ESAs x10 ⁶) 10 YRS	TRL Overseas Road Note-31 Structural Catalogue		Pavement thickness as perTRL Overseas Road Note-31, Chart 5		
					Subgrade Class	Traffic Class	Bituminous Surface	Granular Road Base	Granular Sub-Base (GSB)
4	137+370 (Pathlaiya)	177+135 (Parwanipur)	8	21.77	S4	T8	150	250	175
5	177+135 (Parwanipur)	187+915 (Birganj ICD)	8	21.77	S4	T8	150	250	175
6	177+135 (Parwanipur)	189+740 (Birganj Border)	8	14.25	S4	T7	125	225	175
7	Simara	Jagannathpur	8	14.25	S4	T7	125	225	175

Table 10.7: New Pavement Design as per IRC:37-2001

Section No.	From	To	Sub-grade CBR (min)	Design Traffic (8.2 t ESAs x10 ⁶) 10 YRS	Pavement thickness as per IRC:37-2001			
					Bituminous Concrete (BC)	Dense Bituminous Macadam (DBM)	Wet-Mix Macadam Base (WMM)	Granular Sub-Base (GSB)
	(km)	(km)		msa	mm	mm	mm	mm
1	4+520 (Aptari)	467+640 (Narayanghat Chowk)	8	49.19	40	120	250	200
2	467+640 (Narayanghat Chowk)	395+520 (Hetauda Chowk)	8	49.19	40	120	250	200
3	395+520 (Hetauda Chowk)	137+370 (Pathlaiya)	8	37.32	40	95	250	200
4	137+370 (Pathlaiya)	177+135 (Parwanipur)	8	21.77	40	85	250	200
5	177+135 (Parwanipur)	187+915 (Birganj ICD)	8	21.77	40	85	250	200
6	177+135 (Parwanipur)	189+740 (Birganj Border)	8	14.25	40	70	250	200
7	Simara	Jagannathpur	8	14.25	40	70	250	200

10.3.11 Recommended Pavement Composition

Based on the designs described above, it is found that the bituminous overlay thickness on existing pavement and bituminous surfacing thickness for new composition from IRC method are consistent and economical than the thickness worked out from ORN-31. It is therefore proposed to adopt the following thicknesses.

Table 10.8: Recommended Overlay Thickness

Section No.	From (km)	To (km)	Overlay thickness Based on IRC-81:1997)	
			Bituminous Concrete (BC) Mm	Dense Bituminous Macadam (DBM) mm
1	467+640 (Narayanghat Chowk)	395+520 (Hetauda Chowk)	40	120
2	395+520 (Hetauda Chowk)	137+370 (Pathlaiya)	40	95
3	137+370 (Pathlaiya)	177+135 (Parwanipur)	40	85
4	177+135 (Parwanipur)	187+915 (Birganj ICD)	40	70

Table 10.9: Recommended New Pavement Thickness

Section No.	From (km)	To (km)	Pavement thickness as per IRC:37-2001			
			Bituminous Concrete (BC) Mm	Dense Bituminous Macadam (DBM) mm	Wet-Mix Macadam Base (WMM) mm	Granular Sub-Base (GSB) mm
1	4+520 (Aptari)	467+640 (Narayanghat Chowk)	40	120	250	200
2	467+640 (Narayanghat Chowk)	395+520 (Hetauda Chowk)	40	120	250	200
3	395+520 (Hetauda Chowk)	137+370 (Pathlaiya)	40	95	250	200
4	137+370 (Pathlaiya)	177+135 (Parwanipur)	40	85	250	200
5	177+135 (Parwanipur)	187+915 (Birganj ICD)	40	85	250	200
6	177+135 (Parwanipur)	189+740 (Birganj Border)	40	70	250	200
7	Simara	Jagannathpur	40	70	250	200

10.3.12 Pavement Design on Steep Grades

It is noted that on the sections with steep grades and on sharp curves the pavement on Birgunj – Kathmandu side lane has deformed much more than the other side lane. On level sections the two pavement are not much different. It is therefore recommended that during the detail design this aspect should also be looking into detail and suitable special design provided.

10.4 Horizontal Alignment

For the purpose of feasibility study of widening and upgrading of road, the Consultants have generally accepted the horizontal alignment from satellite imagery. Sharp curves for realignment and Hetauda bypass have been identified by visual observation and/or hand-held GPS coordinates. Except for proposing widening at some sharp curves and new alignments. A plan of the road is presented based on available topo-sheets in 1:25000 scale.

10.5 Vertical Alignment

Height of embankment/Vertical alignment of road is assessed by visual observations. Majority of road pass through plain/rolling terrain. In hilly area near Hetauda, contours from topographical survey sheets (1:25000 scale) were referred to estimate earthwork cutting/filling.

10.6 Design of Retaining and Cross Drainage Structures

The locations of both existing and proposed retaining structures and cross drainage structures were identified during the road inventory survey. Highway engineers proposed the type and size of the structures during the field visit. A summary of the existing and proposed structures is given in **Table 10.10**.

Table 10.10: Number of Existing & Proposed Structures

Type of Structures	Unit	Existing	Proposed	Total
Gabion Wall	No	89	620	
Stone Masonry Wall	No	48	315	
Culvert	No	371	76	
Causeway	No	9	-	
Half Bridge	No	-	-	
Cantilever slab	No	-	-	
Bridges (not proposed now)	No	26		
Longitudinal Drain Lined	RM	42,415	54,935	

10.6.1 Retaining Structures

Most of the retaining structures are on the valley side of the road. The structures are proposed:

- to support road formation fill;
- to support the toe of a slope that has failed, or is likely to fail;
- to support cut material for disposal purpose;
- to widen the formation width;
- to make landslide stable along with bioengineering work
- where there are constraints on permissible plan extent of earthworks, as on hairpin bends or hairpin stacks;
- as revetments to prevent erosion on steeply sloping cut faces

Details of the updated existing and proposed retaining structures are given in the **Annex 2.**

10.6.2 Bridges

The alignment crosses 25 Bridges and for the smooth movement of traffic, widening of the bridges is also necessary, as the road has been widening to the sufficient formation width. Widening of the bridges are not considered due to high cost involvement/economical consideration.

10.6.3 Longitudinal Side Drains

It is proposed to construct trapezoidal type side drain at hilly areas and RCC side drain in urban areas with cover slab where required. The proposed drain will be helpful to widen the road.

10.6.4 Cross Drainage

The alignment crosses a number of cross drainage structures and most of them facilitating appropriately. Cross drainages structure are proposed for extending as the road has been widening appropriately. Typical flows in the cross drainage are given in the hydrology section of this report.

10.6.5 Typical Drawings

As a part of documentation for the design, a standard set of typical drawings have been attached with cross drainage and other associated structures. These drawings are based on low cost structures that have been used in Nepal in different road projects.

11 COST ESTIMATES

11.1 General

Updates of cost estimates for the upgrading of the road are based on an evaluation of the unit rates and quantities obtained from the preliminary designs, drawing and inventory. Costing has been carried out in the format using District rates and approved Norms.

11.2 Costing Details

11.2.1 Unit Rates

The unit rates of various components, such as labour and construction materials, are based on the rates provided by the Chitwan, Makwanpur, Bara and Parsa District Development Committee (DDC) for the fiscal year 2010/2011 (B.S 2067/068). For the unit rates which are not available from District rates, market/factory rates are used. The hiring charge of equipment is based on DoR's approved rates. Unit rates take into account the haulage of materials from the prospective quarry sites or factory to the construction site. The basic rates were used without VAT to avoid double counting and to derive a cost for economic analysis. Fifteen percent Contractor's overhead was included in the derived unit item rates.

11.2.2 Rate Analysis

Rate analysis is based on approved Norms "NORMS for RATE ANALYSIS as per Standard Specifications for Road and Bridge Works-2008" (Approved by Ministry of Physical Planning and Works, Department of Roads) and District rates/market rates. Estimated rate analysis has done for those items which is not available in the approved norms.

Cost calculated based on the contractor's rates in the immediately preceeding section has also been provided.

11.2.3 Quantities

The quantities of earthwork, retaining structures and drainage structures are obtained from the preliminary design drawings & inventory. The quantities of pavement are based on road length, carriageway and design thickness of the pavement layers. Estimation of quantities for civil works has been estimated by from the design drawing and inventory reports.

11.3 Cost Estimates

The total estimated cost has been calculated by unit item rate of individual items based on rate analysis multiplied by quantities estimated from the design & drawings. The total estimated construction cost of the road including VAT & Contingencies has been submitted separately in **Annex 3**.

The Consultants have worked out project cost for different options:

The costs estimates for all discussed options are presented in **Tables 11.1 to 11.5** below.

Table 11.1: Summary of Cost Estimate for Various Options of Links between Birgunj and Pathlaiya

Item No.	Description	Cost Estimate Amount (NRs.)			
		Narayanghat-Hetauda bypass-Pathlaiya	Pathlaiya-Parwanipur-ICD	Pathlaiya-Parwanipur - Birgunj bypass-Raxual	Pathlaiya - Simara-Jagannathpur-ICD
		(Common Section) NP	(L-1)	(L-2)	(L-3)
A	Road Works	9,84,96,45,988.16	1,74,07,28,630.60	2,15,97,86,818.40	1,37,56,38,771.80
B	Bridge Works	3,91,99,50,000.00	19,68,75,000.00	35,43,75,000.00	1,89,00,000.00
	Sub Total without Contingencies & VAT	13,76,95,95,988.16	1,93,76,03,630.60	2,51,41,61,818.40	1,39,45,38,771.80
	Physical Contingencies @10%	1,37,69,59,598.82	19,37,60,363.06	25,14,16,181.84	13,94,53,877.18
	Price Contingencies @10%	1,37,69,59,598.82	19,37,60,363.06	25,14,16,181.84	13,94,53,877.18
	Sub Total with Contingencies & without VAT	16,52,35,15,185.79	2,32,51,24,356.72	3,01,69,94,182.08	1,67,34,46,526.16
	VAT @ 13% of (A)	2,14,80,56,974.15	30,22,66,166.37	39,22,09,243.67	21,75,48,048.40
	Grand Total (Including VAT)	18,67,15,72,159.95	2,62,73,90,523.09	3,40,92,03,425.75	1,89,09,94,574.56
	Cost per Km	17,18,19,013.16	10,09,95,215.19	12,24,79,016.55	7,72,46,510.40
	Cost of Land & Houses	40,25,00,000.00	20,00,000.00	65,50,000.00	53,62,00,000.00
	Total Project Cost	19,07,40,72,159.95	2,62,93,90,523.09	3,41,57,53,425.75	2,42,71,94,574.56
1 \$= NRs	72	\$26,49,17,668.89	\$3,65,19,312.82	\$4,74,41,019.80	\$3,37,11,035.76
	Project Cost without Bridges (\$)	\$19,10,91,943.89	\$3,28,11,500.32	\$4,07,66,957.30	3,33,55,085.76
	Cost of Bridges (\$)	\$7,38,25,725.00	\$37,07,812.50	\$66,74,062.50	\$3,55,950.00
	Length (Km)	108.67	26.015	27.835	24.48
Bridge Detail: 1 no. -4 lane new bridge (over Karra River in Hetauda bybass), 9 nos. - 4 lane new bridges (in place of Causeway) , 3 nos. - 4 lane new bridges (in place of choked bridges), 23 nos. - 2 lane new bridges (Parallel to existing bridges for widening)					

Table 11.2: Summary of Cost Estimate for Full Road Length with Various Options

Item No.	Description	Cost Estimate Amount (NRs.)			
		Common Section Narayanghat-Hetauda bypass-Pathlaiya (Common Section) Entire length 4-lane, 6-lane in market with full asphalt	Option 1 Narayanghat-Hetauda bypass-Pathylaiya- Simara-Parwanipur-ICD Entire length 4-lane, 6- lane in market with full asphalt	Option 2 Narayanghat-Hetauda bypass-Pathylaiya-Simara- Parwanipur-Birgunj bypass-Raxual Entire length 4-lane, 6-lane in market with full asphalt	Option 3 Narayanghat-Hetauda bypass-Pathylaiya- Simara-Jaganathpur-ICD Entire length 4-lane, 6- lane in market with full asphalt
1	General Items	5,13,98,360.00	6,27,78,937.00	6,36,30,970.00	6,27,00,553.00
2	Site Clearance	8,85,99,102.00	9,53,24,423.00	9,55,51,629.00	9,78,84,190.00
3	Earthwork	1,32,29,68,035.40	1,36,38,56,829.00	1,37,02,94,624.80	1,36,09,08,781.20
4	Pavement Works	5,54,15,40,628.00	6,63,47,67,105.00	6,80,41,89,062.00	6,52,38,72,738.00
5	Structures	2,59,93,11,461.76	3,11,04,65,548.76	3,34,74,46,794.76	2,88,84,17,517.76
6	Road Furniture and Traffic Safety Measures	14,28,80,883.00	20,27,95,259.00	19,76,27,804.00	17,08,49,586.00
7	Environmental Mitigation (Including Bio-engineering)	2,98,06,597.00	3,11,86,597.00	3,11,86,597.00	3,11,86,597.00
8	Day works	31,40,921.00	41,99,920.00	45,05,325.00	44,64,797.00
9	Relocation of Services including Market/Passenger shades	7,00,00,000.00	8,50,00,000.00	9,50,00,000.00	8,50,00,000.00
A	Road Works	9,84,96,45,988.16	11,59,03,74,618.76	12,00,94,32,806.56	11,22,52,84,759.96
10	1-New Bridge over Karra River at Hetauda bypass, L=130m @ Rs.150,000/m2	39,00,00,000.00	39,00,00,000.00	39,00,00,000.00	39,00,00,000.00
11	New Bridges parallel to Existing Bridge	2,30,89,50,000.00	2,50,58,25,000.00	2,66,33,25,000.00	2,32,78,50,000.00
12	3-New Bridges in place of choked bridge,L=54m, W=20m	16,20,00,000.00	16,20,00,000.00	16,20,00,000.00	16,20,00,000.00
13	9-New Bridges in Place of CW, L=353M, W=20m	1,05,90,00,000.00	1,05,90,00,000.00	1,05,90,00,000.00	1,05,90,00,000.00
B	Bridge Works	3,91,99,50,000.00	4,11,68,25,000.00	4,27,43,25,000.00	3,93,88,50,000.00
	Sub Total without Contingencies & VAT	13,76,95,95,988.16	15,70,71,99,618.76	16,28,37,57,806.56	15,16,41,34,759.96
	Physical Contingencies @10%	1,37,69,59,598.82	1,57,07,19,961.88	1,62,83,75,780.66	1,51,64,13,476.00
	Price Contingencies @10%	1,37,69,59,598.82	1,57,07,19,961.88	1,62,83,75,780.66	1,51,64,13,476.00
	Sub Total with Contingencies & without VAT	16,52,35,15,185.79	18,84,86,39,542.51	19,54,05,09,367.87	18,19,69,61,711.95
	VAT @ 13% of (A)	2,14,80,56,974.15	2,45,03,23,140.53	2,54,02,66,217.82	2,36,56,05,022.55
	Grand Total (Including VAT)	18,67,15,72,159.95	21,29,89,62,683.04	22,08,07,75,585.70	20,56,25,66,734.51
	Cost per Km	17,18,19,013.16	15,81,39,085.15	16,17,57,998.50	15,44,31,593.95
	Cost of Land & Houses	40,25,00,000.00	40,45,00,000.00	40,90,50,000.00	93,87,00,000.00
	Total Project Cost	19,07,40,72,159.95	21,70,34,62,683.04	22,48,98,25,585.70	21,50,12,66,734.51
	Length (Km)	108.67	134.685	136.505	133.15
1 \$ = NRs	72	\$26,49,17,668.89	\$30,14,36,981.71	\$31,23,58,688.69	\$29,86,28,704.65
	Project Cost Without Bridges	\$19,10,91,943.89	\$22,39,03,444.21	\$23,18,58,901.19	\$22,44,47,029.65

Bridge Detail: 1 no. -4 lane new bridge (over Karra River in Hetauda bybass), 9 nos. - 4 lane new bridges (in place of Causeway),
3 nos. - 4 lane new bridges (in place of choked bridges), 23 nos. - 2 lane new bridges (Parallel to existing bridges for widening)

Table 11.3: Summary of Cost Estimate for Various Options for ICD- Parwanipur- Pathlaiya Road Section

Length 26.015 Km		Cost Estimate Amount (NRs.)					
Item No.	Description	Option L1.1 (P-P: 4+2 Lane, P-ICD: 4 Lane, AC Surfacing)		Option L1.2 (P-P & P-ICD: 4 lane with AC surfacing)		Option L1.3 (P-P: 4 lane, AC surfacing, P-ICD: 4 lane, DBST)	
			%		%		%
1	General Items	1,13,80,577.00	0.60%	79,80,577.00	0.77%	74,80,577.00	0.81%
2	Site Clearance	67,25,321.00	0.35%	65,38,694.00	0.63%	65,38,694.00	0.70%
3	Earthwork	4,08,88,793.60	2.15%	2,83,65,994.00	2.72%	2,85,11,696.00	3.07%
4	Pavement Works	1,09,32,26,477.00	57.39%	68,57,71,334.00	65.81%	49,68,89,337.71	58.11%
5	Structures	51,11,54,087.00	26.84%	13,66,69,721.00	13.12%	13,66,69,721.00	14.71%
6	Road Furniture and Traffic Safety Measures	5,99,14,376.00	3.15%	2,82,37,376.00	2.71%	2,82,37,376.00	3.04%
7	Environmental Mitigation (Including Bio-engineering)	13,80,000.00	0.07%	12,05,000.00	0.12%	12,05,000.00	0.13%
8	Day works	10,58,999.00	0.06%	10,58,999.00	0.10%	10,58,999.00	0.11%
9	Relocation of Services including Market/Passenger shade	1,50,00,000.00	0.79%	1,50,00,000.00	1.44%	1,50,00,000.00	1.61%
10	4 nos. new Bridge, L=125m, W=10.5m @ Rs.125,000/m2	16,40,62,500.00	8.61%	16,40,62,500.00	15.26%	16,40,62,500.00	12.60%
A	Sub Total without Contingencies & VAT	1,90,47,91,130.60	100.00%	1,07,48,90,195.00	100.00%	88,56,53,900.71	100.00%
B	Physical Contingencies @10%	19,04,79,113.06		10,74,89,019.50		8,85,65,390.07	
C	Price Contingencies @10%	19,04,79,113.06		10,74,89,019.50		8,85,65,390.07	
D=A+B+C	Sub Total with Contingencies & without VAT	2,28,57,49,356.72		1,28,98,68,234.00		1,06,27,84,680.85	
E	VAT @ 13% of (A)	29,71,47,416.37		16,76,82,870.42		13,81,62,008.51	
F=D+E	Grand Total (Including VAT)	2,58,28,96,773.09		1,45,75,51,104.42		1,20,09,46,689.36	
G	Cost per Km	16,12,79,848.46		5,60,27,334.40		4,61,63,624.42	
H	Cost of Land & Houses	20,00,000.00		20,00,000.00		20,00,000.00	
I=F+H	Total Project Cost	2,58,48,96,773.09		1,45,95,51,104.42		1,20,29,46,689.36	
1 \$ = NRs	72	\$3,59,01,344.07		\$2,02,71,543.12		\$1,67,07,592.91	
	Project Cost Without Bridges	\$3,13,51,157.83		\$1,62,92,321.10		\$1,37,85,081.14	

NB: P-P: Pathlaiya - Parwanipur Section, P-ICD: Parwanipur - ICD Sectio, AC: Asphalt Concrete

WC-40, DBM-50

Table 11.4: Summary of Cost Estimate with Various Options for Pathlaiya – Ratomate – Hetauda bypass Road Section

Item No.	Description	Cost Estimate Amount (NRs.)													
		Pathlaiya - Ratomate Section (PR)						Hetauda bypass		Pathlaiya - Ratomate - Hetauda bypass Section (PRH)					
		Option PR 1		Option PR 2		Option PR 3		HB		Option PRH 1		Option PRH 2		Option PRH 3	
		4+6 lane, BC surfacing	%	4-lane, BC pavement	%	4-lane, BC pavement CURTAILED	%	2-lane, DBST Surfacing	%	Option 2.1 + HB	%	Option 2.2 + HB	%	Option 2.3 + HB	%
1	General Items	4,43,55,027.00	1.47%	1,01,55,027	0.42%	1,01,55,027	0.42%	42,30,710	0.72%	4,85,85,737	1.37%	1,43,85,737	0.48%	1,43,85,737	0.50%
2	Site Clearance	2,63,32,824.00	0.87%	2,62,29,483	0.98%	2,62,29,483	1.08%	5,21,575	0.09%	2,68,54,399	0.76%	2,67,51,058	0.90%	2,67,51,058	0.94%
3	Earthwork	22,82,62,465.80	7.55%	22,49,76,210	8.45%	21,42,23,758	9.22%	1,55,32,195	2.63%	24,37,94,661	6.86%	24,05,08,405	8.09%	22,97,55,953	8.03%
4	Pavement Works	1,06,25,65,392.00	35.16%	66,48,02,763	32.75%	66,48,02,763	27.25%	12,95,14,891	32.02%	1,19,20,80,283	33.54%	79,43,17,654	26.73%	79,43,17,654	27.76%
5	Structures	53,03,17,938.76	17.55%	38,56,47,041	15.12%	28,59,99,382	15.81%	4,69,33,083	7.94%	57,72,51,022	16.24%	43,25,80,124	14.56%	33,29,32,465	11.64%
6	Road Furniture and Traffic Safety Measures	1,83,35,499.00	0.61%	1,59,92,499	0.69%	1,59,92,499	0.66%	2,83,95,460	4.80%	4,67,30,959	1.31%	4,43,87,959	1.49%	4,43,87,959	1.55%
7	Environmental Mitigation (Including Bio-engineering)	71,23,905.00	0.24%	71,23,905	0.27%	71,23,905	0.29%	1,11,50,029	1.89%	1,82,73,934	0.51%	1,82,73,934	0.62%	1,82,73,934	0.64%
8	Day works	12,59,174.00	0.04%	11,99,674	0.04%	11,99,674	0.05%	26,80,125	0.45%	39,39,299	0.11%	38,79,799	0.13%	38,79,799	0.14%
9	Relocation of Services including Market/Passenger shade	7,00,00,000.00	2.32%	7,00,00,000	2.62%	7,00,00,000	2.87%	50,00,000	0.85%	7,50,00,000	2.11%	7,50,00,000	2.52%	7,50,00,000	2.62%
10	1-New Bridge over Karra River at Hetauda bypass 115m @ Rs.125,000/m2	-	0.00%	-	0.00%	-	0.00%	28,75,00,000	48.63%	28,75,00,000	8.09%	28,75,00,000	9.68%	28,75,00,000	10.05%
11	11-New Bridges parallel to Existing Bridge, L=596m, W=10.50m	71,12,43,750.00	23.53%	71,12,43,750	26.60%	71,12,43,750	27.32%	-	0.00%	71,12,43,750	20.01%	71,12,43,750	23.94%	71,12,43,750	24.86%
12	3-New Bridges in place of choked bridge, L=54m, W=20m	13,50,00,000.00	4.47%	13,50,00,000	5.05%	13,50,00,000	5.19%	-	0.00%	13,50,00,000	3.80%	13,50,00,000	4.54%	13,50,00,000	4.72%
13	3-New Bridges in Place of CW, L=75M, W=20m	18,75,00,000.00	6.20%	18,75,00,000	7.01%	18,75,00,000	7.20%	-	0.00%	18,75,00,000	5.28%	18,75,00,000	6.31%	18,75,00,000	6.55%
A	Sub Total without Contingencies & VAT	3,02,22,95,975.56	100.00%	2,67,35,03,553	100.00%	2,32,94,70,241	100.00%	53,14,58,069	100.00%	3,55,37,54,044	100.00%	2,97,13,28,421	100.00%	2,86,09,28,309	100.00%
B	Physical Contingencies @10%	30,22,29,597.56		26,73,50,355		23,29,47,024		5,31,45,807		35,53,75,404		29,71,32,842		28,60,92,831	
C	Price Contingencies @10%	30,22,29,597.56		26,73,50,355		23,29,47,024		5,31,45,807		35,53,75,404		29,71,32,842		28,60,92,831	
D=A+B+C	Sub Total with Contingencies & without VAT	3,62,67,55,170.67		3,20,82,04,263		2,79,53,64,289		63,77,49,682		4,26,45,04,853		3,56,55,94,105		3,43,31,13,971	
E	VAT @ 13% of (A)	47,14,78,172.19		41,70,66,554		36,33,97,358		8,29,07,459		55,43,85,631		46,35,27,234		44,63,04,816	
F=D+E	Grand Total (Including VAT)	4,09,82,33,342.86		3,62,52,70,817		3,15,87,61,646		72,06,57,141		4,81,88,90,484		4,02,91,21,338		3,87,94,18,788	
G	Cost per Km	16,70,70,254.50		14,77,89,271		12,87,71,368		9,60,87,619		15,04,49,281		12,57,92,112		12,11,18,289	
	Land and house cost	9,07,61,000.00		9,07,61,000		9,07,61,000		2,77,50,000		11,85,11,000		11,85,11,000		11,85,11,000	
	Total Project Cost	4,18,89,94,342.86		3,71,60,31,817		3,24,95,22,646		74,84,07,141		4,93,74,01,484		4,14,76,32,338		3,99,79,29,788	
1 \$ = NRs	72	\$5,81,80,476.98		5,16,11,553		4,51,32,259		1,03,94,544		6,85,75,021		5,76,06,005		5,55,26,803	
	Project Cost Without Bridges	\$3,69,32,942.54		3,03,03,959		2,59,18,362		52,52,095		4,16,32,401		3,05,36,623		2,84,27,574	
	Length, km	24.53		24.53		24.53		7.50		32.03		32.03		32.03	

Pavement Works

Pavement: WC-40mm, DBM-95mm, CSB-250mm, Subbase-200mm

Pavement: WC-40mm, DBM-75mm, CSB-250mm, Subbase-200mm

Pavement: WC-40mm, DBM-50mm, CSB-250mm, Subbase-200mm

Pavement: DBST, CSB-250mm, Subbase-200mm

Table 11.5: Summary of Cost Estimate with Various Options for ICD - Pathlaiya – Ratomate – Hetauda bypass Road Section

Item No.	Description	Engineer's Estimate Amount (NRs.)									
		Option L1.3		Option PR 3		Option PRH 3		Option 4		Option 5	
		ICD-Pathlaiya	%	Pathlaiya - Ratomate	%	Pathlaiya-Ratomate - Het bypass	%	Option L1.3 + Option PR 3		Option L1.3 + Option PRH 3	%
1	General Items	74,80,577.00	0.84%	1,01,55,027.00	0.44%	1,43,85,737.00	0.50%	1,76,35,604.00	0.55%	2,18,66,314.00	0.58%
2	Site Clearance	65,38,694.00	0.74%	2,62,29,483.00	1.13%	2,67,51,058.00	0.94%	3,27,68,177.00	1.02%	3,32,89,752.00	0.89%
3	Earthwork	2,85,11,696.00	3.22%	21,42,23,758.00	9.20%	22,97,55,953.20	8.03%	24,27,35,454.00	7.55%	25,82,67,649.20	6.89%
4	Pavement Works	49,68,89,337.71	56.10%	66,48,02,763.00	28.54%	79,43,17,654.46	27.76%	1,16,16,92,100.71	36.13%	1,29,12,06,992.17	34.46%
5	Structures	13,66,69,721.00	15.43%	28,59,99,381.76	12.28%	33,29,32,464.76	11.64%	42,26,69,102.76	13.15%	46,96,02,185.76	12.53%
6	Road Furniture and Traffic Safety Measures	2,82,37,376.00	3.19%	1,59,92,499.00	0.69%	4,43,87,959.00	1.55%	4,42,29,875.00	1.38%	7,26,25,335.00	1.94%
7	Environmental Mitigation (Including Bio-engineering)	12,05,000.00	0.14%	71,23,905.00	0.31%	1,82,73,934.00	0.64%	83,28,905.00	0.26%	1,94,78,934.00	0.52%
8	Day works	10,58,999.00	0.12%	11,99,674.00	0.05%	38,79,799.00	0.14%	22,58,673.00	0.07%	49,38,798.00	0.13%
9	Relocation of Services including Market/Passenger shade	1,50,00,000.00	1.69%	7,00,00,000.00	3.00%	7,50,00,000.00	2.62%	8,50,00,000.00	2.64%	9,00,00,000.00	2.40%
10	4 nos. new Bridge, L=125m, W=10.5m @ Rs.125,000/m2	16,40,62,500.00	18.52%	-	0.00%	-	0.00%	16,40,62,500.00	5.10%	16,40,62,500.00	4.38%
11	1-New Bridge over Karra River at Hetauda bypass 115m @ Rs.125,000/m2	-	-	-	0.00%	28,75,00,000.00	10.05%	-	0.00%	28,75,00,000.00	7.67%
12	11-New Bridges parallel to Existing Bridge,L=596m, W=10.50m	-	-	71,12,43,750.00	30.53%	71,12,43,750.00	24.86%	71,12,43,750.00	22.12%	71,12,43,750.00	18.98%
13	3-New Bridges in place of choked bridge,L=54m, W=20m	-	-	13,50,00,000.00	5.80%	13,50,00,000.00	4.72%	13,50,00,000.00	4.20%	13,50,00,000.00	3.60%
14	3-New Bridges in Place of CW, L=75M, W=20m	-	-	18,75,00,000.00	8.05%	18,75,00,000.00	6.55%	18,75,00,000.00	5.83%	18,75,00,000.00	5.00%
A	Sub Total without Contingencies & VAT	88,56,53,900.71	100%	2,32,94,70,240.76	100%	2,86,09,28,309.42	100%	3,21,51,24,141.47	100%	3,74,65,82,210.13	100%
B	Physical Contingencies @10%	8,85,65,390.07		23,29,47,024.08		28,60,92,830.94		32,15,12,414.15		37,46,58,221.01	
C	Price Contingencies @10%	8,85,65,390.07		23,29,47,024.08		28,60,92,830.94		32,15,12,414.15		37,46,58,221.01	
D=A+B+C	Sub Total with Contingencies & without VAT	1,06,27,84,680.85		2,79,53,64,288.91		3,43,31,13,971.30		3,85,81,48,969.76		4,49,58,98,652.15	
E	VAT @ 13% of (A)	13,81,62,008.51		36,33,97,357.56		44,63,04,816.27		50,15,59,366.07		58,44,66,824.78	
F=D+E	Grand Total (Including VAT)	1,20,09,46,689.36		3,15,87,61,646.47		3,87,94,18,787.57		4,35,97,08,335.83		5,08,03,65,476.93	
G	Cost per Km	4,61,63,624.42		12,87,71,367.57		12,11,18,288.72		8,62,53,998.14		8,75,24,601.20	
H	Cost of Land & Houses	20,00,000.00		9,07,61,000.00		11,85,11,000.00		9,27,61,000.00		12,05,11,000.00	
I=F+H	Total Project Cost	NPR 1,20,29,46,689.36		NPR 3,24,95,22,646.47		NPR 3,99,79,29,787.57		NPR 4,45,24,69,335.83		NPR 5,20,08,76,476.93	
1 \$ = NRs	72	\$1,67,07,592.91		\$4,51,32,258.98		\$5,55,26,802.61		\$6,18,39,851.89		\$7,22,34,395.51	
	Project Cost Without Bridges	\$1,36,12,603.48		\$2,51,04,018.30		\$2,98,83,223.68		\$3,88,01,189.05		\$4,35,97,575.85	

NB: P-P: Pathlaiya - Parwanipur Section, P-ICD: Parwanipur - ICD Sectio, AC: Asphalt Concrete

26.015 Km

24.53 Km

32.03 Km

50.545 Km

58.045 Km

12 ECONOMIC ANALYSIS

12.1 Introduction

The Birgunj - Narayanghat section is one of the most important road corridor in Nepal. It has also been declared as part of the Asian Highway network. The Government of Nepal intend to be upgraded as per Asian Highway network standards. The minimum requirement of the Asian Highway is to a 2-lane road, but with the existing traffic it needs to be 4-lane. The road falls in plain to rolling terrain. Near to Birgunj road bifurcates into three roads / links requiring considering multiple options. The economic analysis provided in this chapter for various options.

12.2 Project Costs

a) Engineering costs

For engineering and analysis purposes the length of common sections and 3 links near Birgunj is as below.

Section	Location	Project Chainage
Common Section	Aaptari (Start point)	0+000
	Narayanghat Chowk (EWH km 467+640)	4+520
	Hetauda bypass (start)	76+640
	Hetauda bypass (end) / Ratomate Bazaar	84+140
	Pathlaiya	108+670
Link 1	Pathlaiya	108+670
	Parwanipur	123+905
	ICD (End point, Option 1)	134+685
Link 2	Pathlaiya	108+670
	Parwanipur	123+905
	International Border (End point, Option 2)	136+510
Link 3	Pathlaiya	108+670
	Simra	111+720
	Jaganathpur – ICD (End point, Option 3)	133+150

Economic costs of various sections / links have been worked out with 4-lane, 4-lane + service roads and in certain cases with 2-lane links.

The engineering costs for these sections / links are shown below (see Chapter 11 for full details).

Table 12.1: Engineering cost

Code	Section	Length Km	Economic costs \$m	
			Constr.	Land
NP	Naryanghat-Hetauda bypass-Pathlaiya	108.67	178.67	5.223
A	Pathlaiya-Jaganathpur-ICD (bypass ext'n) 4 lanes	24.48	18.10	6.958
B	Pathlaiya-Parwanipur-ICD (4-lane)	26.02	25.14	0.028
C	Pathlaiya-Birgunj bypass-Border	27.84	32.62	0.085

For economic analysis purposes, design & supervision costs were added at 4 percent.

b) Land costs

There are no economic costs for land associated with the widening and improvement project in general. For the bypasses i.e. Hetauda bypass and Simra – Jagan Nathpur new road cost of 50m right-of-way (ROW) is included in above shown cost.

12.3 Traffic data summary in 2011 and forecast

12.3.1 Traffic Volumes Estimated in 2011

Normal Traffic

A summary of traffic volumes, as AADT estimated in 2011, is given in the table below, for each traffic section, resulting from the March 2011 classified traffic counts (see Chapter 9).

Table 12.2: Traffic (AADT) in 2011

Vehicle type	ICD Bypass	Jitpur (South)	Pathalaiya (S)	Karra Bridge Hetauda (S)	Narayanghat East (Tikauli)
Multi & 3axle trucks	167	892	121	1,235	295
Medium 2axle truck	172	986	1,372	1,141	2,715
Light truck /tractor	152	984	404	521	466
Large Bus	1	423	268	869	1,193
Medium Bus 25 seat	2	402	119	342	640
Minibus Hiace	1	126	94	98	342
Car/Jeep	12	442	110	268	742
Utility (pickup)	451	3,256	1,569	3,842	5,858
Motorbike	16	404	155	507	441
3 wheel taxi	6	570	43	553	163
4 wheel drive	23	385	176	727	437
Total Motorized	1,003	8,870	4,431	10,103	13,308
Total non-motorized	1,028	9,049	1,326	10,237	1,770
- bicycles %	99%	99%	79%	99%	92%

Source: Consultants Traffic Surveys 2011

Traffic composition

Table 12.3: Motorized traffic compositions used in HDM analyses

Vehicle type	ICD Bypass	Jitpur (South)	Pathalaiya (S)	Karra Bridge Hetauda (S)	Narayanghat East (Tikauli)
Multi & 3axle trucks	16.7%	10.1%	2.7%	12.2%	2.3%
Medium 2axle truck	17.1%	11.1%	31.0%	11.3%	20.4%
Light truck /tractor	15.2%	11.1%	9.1%	5.2%	3.5%
Large Bus	0.1%	4.8%	6.0%	8.6%	9.0%
Medium Bus 25 seat	0.2%	4.5%	2.7%	3.4%	4.8%
Minibus Hiace	0.1%	1.4%	2.1%	1.0%	2.6%
Car/Jeep	1.2%	5.0%	2.5%	2.7%	5.6%
Utility (pickup)	44.9%	36.7%	35.4%	37.9%	44.0%
Motorbike	1.6%	4.6%	3.5%	5.0%	3.3%
3 wheel taxi	0.6%	6.4%	1.0%	5.5%	1.2%
4 wheel drive	2.3%	4.3%	4.0%	7.2%	3.3%
Total Motorized	100.0%	100.0%	100.0%	100.0%	100.0%

12.3.2 Traffic forecast

Traffic growth rates

Growth of the active vehicle fleet might be employed as a proxy for overall annual traffic growth on main roads, since vehicle utilization (km/year) is expected to vary only fractionally over time. Vehicle fleet growth in 2008-2009 is shown in the table below, by vehicle type.

Table 12.4: Vehicle fleets in 2008 and 2009, and change (%)

Vehicle type	2007/8	2008/9	Δ percent
Buses	26,679	27,182	1.9%
Trucks	36,794	40,437	9.9%
Tractors	40,104	44,767	11.6%
Cars, jeeps	93,266	100,123	7.4%
Motorcycles	489,686	573,020	17.0%
Total fleet	686,529	785,529	14.4%
excluding motorcycles	196,843	212,509	8.0%

Source: DOTM (Department of transport management)

Table 12.5: Traffic growth rates for HDM analyses

Vehicle type	2012-16	2017-21	2022-26	2027-36
Car/Jeep	4.8%	5.0%	5.5%	5.8%
Motorbike	4.8%	5.0%	5.5%	5.8%
4 wheel drive	4.8%	5.0%	5.5%	5.8%
Multi & 3axle trucks	6.2%	6.3%	6.5%	6.6%
Medium 2axle truck	6.2%	6.3%	6.5%	6.6%
Light truck /tractor	6.2%	6.3%	6.5%	6.6%
Utility (pickup)	6.2%	6.3%	6.5%	6.6%
Light truck /tractor	6.2%	6.3%	6.5%	6.6%
3 wheel taxi	6.2%	6.3%	6.5%	6.6%
Large Bus	7.3%	7.4%	8.0%	8.3%
Medium Bus 25 seat	7.3%	7.4%	8.0%	8.3%
Minibus Hiace	7.3%	7.4%	8.0%	8.3%

Source: Chapter 9, table 9-6

Non-motorized traffic, almost entirely consisting of bicycles, is assumed to grow at 1.8 percent per year, in concert with the average expected population growth rate.

Generated traffic

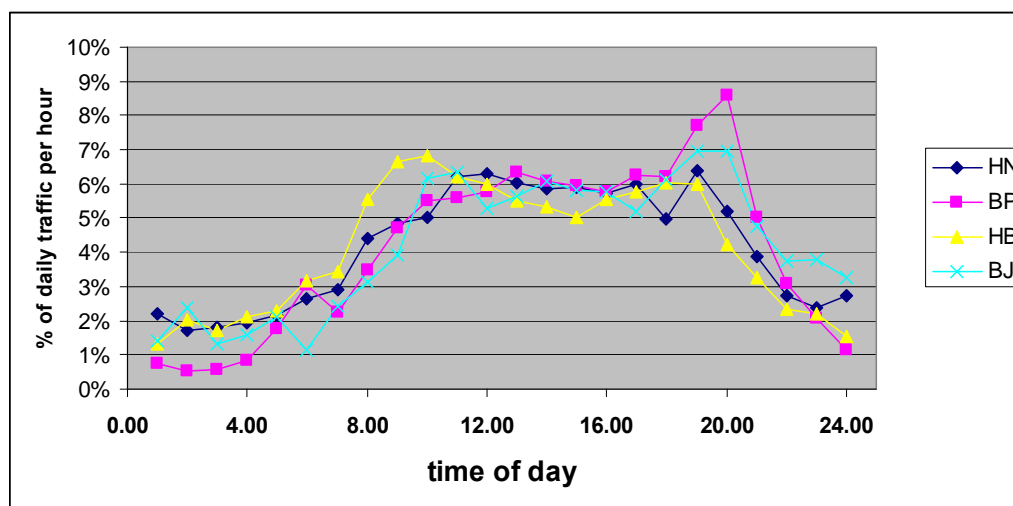
As a result of industrial developments expected in the area of influence of the improved highway, generated and diverted traffic is estimated as 25 percent of the normal traffic volume from 2016 onwards. The additional traffic is expected to grow at the same rate as estimated for normal traffic (see Chapter 9).

12.3.3 Daily Traffic profile for HDM modeling

Using the motorized traffic data from the March 2011 counts, a check was made on the daily 'profile' or histogram, since this parameter is included in the HDM-4 for modeling road congestion effects, important in the case of upgrading from 2 to 4 lanes. HDM-4 contains default histograms for different types of road use, namely: 'inter-urban', 'commuter', and 'seasonal'. In principle the 'inter-urban' profile would be selected for this analysis, however experience elsewhere in Asia has shown it necessary to check that the default histogram represents actual conditions on subject roads.

Daily traffic levels (% of daily volume) by hour of the day for the four main sections of the Birgunj-Naryanghat corridor are shown in the graph below.

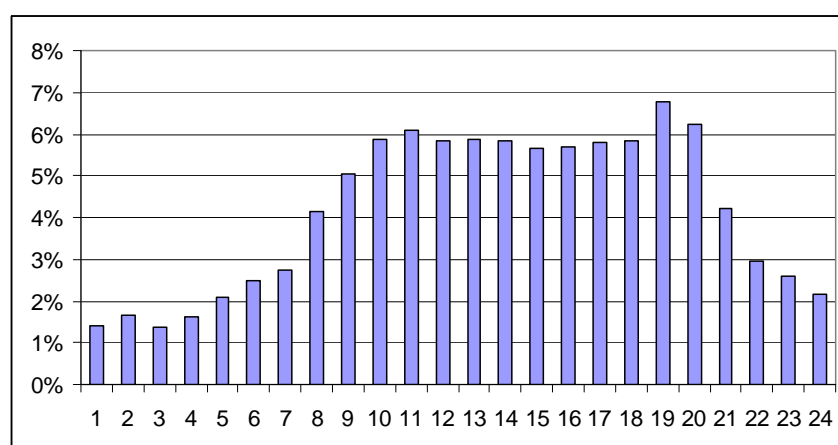
Figure 12.1: Daily traffic profiles by section (March 2011)



Key: HN Hetauda-Naryanghat
BP Birgunj-Pathalaya
HB Hetauda-Birgunj
BJ Birgunj-Jeetpur

Combining the four sections to one 24-hour profile or histogram gave the overall result for the link as shown in the bar chart below.

Figure 12.2: Daily traffic histogram Birgunj-Naryanghat road (2011)



As shown above the maximum hourly value is nearly 7% of daily flow, at around 18.00-19.00 hours, mainly from commuter traffic concentration. There is a long period throughout the day, from about 09.00 to 18.00, when hourly flows are fairly equal at about 6 percent of the daily total per hour. There is very little traffic during the night hours: from 22.00 until 06.00 hourly flows are quite low, at less than half (about 2%) the 24 hour average.

For HDM-4 modeling purposes the hourly flows as given above (graph) are condensed into four flow-groups, shown in the table below. The 8670 hours in a year are divided into flow-groups each representing the main levels of flow intensity. Also shown in the table below is the average annual hourly traffic (AAHT) expressing the intensity of flows for each group as a ratio of the simple 24 hour average, or $[1/24 = 4.167\%]$.

Table 12.6: Flow-group data input to HDM-4

hours/day	% traffic	hours/year	% per hour	AAHT
9	54.2%	3,285	6.02%	1.44
5	24.8%	1,825	4.95%	1.19
6	15.1%	2,190	2.51%	0.60
4	6.0%	1,460	1.51%	0.36
24	100%	8,760	4.17%	1.00

This traffic profile clearly shows a more 'peaked' pattern than for the Naryanghat-Mugling section where the highest AAHT ratio¹³ (for 1460 hours/year) was 1.27. However in both cases, they are quite unlike the default values included in HDM-4, which appear more suitable for inter-urban conditions in Europe.

The HDM categories for maximum capacity by road type are shown below. Capacity is given in PCSE¹⁴ per lane per hour. Jam speed (km/h) is the value defined in the HDM 3-zone speed-flow model for average speed at maximum capacity.

Table 12.7: Capacity by road type in HDM-4

Road type	CAPACITY	JAMSPEED
Single Lane Road	600	10.0
Intermediate Road	1,200	20.0
Two Lane Narrow	1,350	23.0
Two Lane Standard	1,400	25.0
Two Lane Wide	1,450	27.0
Wide 2 Lane Road	1,600	30.0
Four Lane Road	2,000	40.0

For HDM analysis purposes the 'two lane standard' road (1,400 PCSE/lane/hour) is used for the 'without project' case and the 'four lane road' (2,000 PCSE/lane/hour) in the 'with project' case.

12.4 Road User Costs

Vehicle operating costs (VOC) and values of travel time (VOTT) were completely revised (i.e., not updated from previous work) for the present study. A brief review of recent studies indicated that revision would be beneficial. Road accident¹⁵ costs were also revised, since the existing study examined appears to be rather limited in scope. The economic cost-benefit analysis input is in US dollars, primarily because the larger units of the American currency are more convenient to use for inputs to the HDM-4; and for comparability purposes, since the rupee tends to devalue over time. The devaluation has been slight in recent years; but possible changes in government monetary policy (apparently under discussion) will create some uncertainty in the outlook for the rupee. The current (end-August 2010) exchange rate is assumed as 75 rupees per dollar. However, the HDM-4 output report results (cost-benefit streams, and all reports showing money values) are shown in rupees.

12.4.1 Vehicle operating costs

Vehicle costs – including for bicycles and rickshaws - are given in US dollars in the table below. The main items, in US dollars in resource cost terms (i.e., less taxes and duties) are

¹³ The COBA (UK Govt.) AAHT concept is not used in HDM-4.

¹⁴ Passenger car space equivalents.

¹⁵ Road accident costs are sometimes regarded as an externality, i.e., tend to be imposed to a larger extent upon third parties (especially pedestrians) than on vehicle users. Statistics show that pedestrians are often the largest category of victims of death and serious injury.

shown together with other important parameters: operating weight (tonnes) annual kilometres run, annual working hours, average vehicle service life in years, and road damage factors for heavy vehicles, denoted as ESAL (equivalent standard axle load) in the HDM-4 model. More details of HDM-4 inputs are given in **Annex 9.2**.

Table 12.8: Vehicle operating costs – main parameters for HDM-4

VEH_NAME	EUC_VEH	EUC_TYRE	AKM0	HRWK0	LIFE0	WEIGHT_OP	ESAL
Large Bus	\$ 22,952	373	60,000	2,000	12.0	12.0	0.90
Minibus Hiace	\$ 14,594	139	45,000	1,500	10.0	2.2	--
Medium Bus 25 seat	\$ 19,440	160	50,000	1,700	10.0	7.5	0.50
Heavy 3axle truck	\$ 22,390	373	60,000	2,000	15.0	22.0	4.50
Medium 2axle truck	\$ 13,440	160	45,000	1,500	12.0	15.0	2.60
Car/Jeep	\$ 10,710	85	20,000	500	12.0	1.4	--
Light truck	\$ 15,440	160	40,000	1,350	10.0	6.0	0.10
4 wheel drive	\$ 17,788	128	30,000	750	15.0	1.8	--
Utility/Pickup	\$ 15,568	128	30,000	750	10.0	1.5	--
Tractor	\$ 11,932	267	25,000	1,200	10.0	5.0	0.10
Motorbike	\$ 1,466	32	10,000	300	10.0	50 kg	--
Pushbike	\$ 50	na	2,500	400	10.0	40 kg	--
Ricksha	\$ 120	na	7,200	1,000	6.0	250 kg	--

Key to headings:

EUC_VEH: Economic user cost of vehicle in US dollars

EUC_TYRE: economic cost of one tyre (US\$)

AKM0: Annual km driven

LIFE0: average service life in years

WEIGHT_OP: Average operating gross (laden) weight in tonnes (except for NMT)

ESAL: Average Equivalent Standard Axle Loading (damage effect using AASHTO 4th power formula)

Note: The vehicle cost (EUC_VEH) given above makes allowance for deduction of the economic value of OE tyres. However, the model itself makes the allowance automatically.

Cost items common to all vehicle types are given in the table below.

Table 12.9: VOC inputs common to all types

EUC_FUEL	Fuel cost US\$/litre	\$ 0.98
EUC_OIL	Engine Lubricant \$/litre	\$ 3.00
EUC_LABOUR	Workshop labour cost incl. overhead (\$/hour)	\$ 1.50
EUC_CREW	Crew costs \$ per hour	\$ 1.00
EUC_WORK	Passenger travel time \$/hour	\$ 0.27

The updating of value of travel time (VOTT) items is detailed in the section below. Two other important VOC inputs are: i) the financial rate of interest on vehicle capital, and ii) operator overhead costs. Both of these are classified as fixed costs, i.e., do not vary with number of kilometres run.

For interest costs, the validity of interest as an input in economic analysis is sometimes debated¹⁶, however, supposing it is correct, annual interest rate is taken as the difference between bank rates for long term deposits and the underlying rate of inflation. For analysis purposes this is estimated at 6 percent. The HDM-4 user manual states that the interest rate for VOC (i.e. for capital cost of vehicles) should be 'the same as the discount rate' (in this case, 12%). However there is little or no justification for this method; indeed, it is clearly

¹⁶ Some economists believe that interest on capital should not be counted in social analysis; however here it is treated as a direct business cost.

incorrect since the concepts of discounting in social cost-benefit analysis and interest on lending capital are not related.

For operating overheads (as allocated to vehicles in a transport fleet) a zero value is used in this analysis. Such items are normally allocated according to some financial accounting procedure, but it cannot be shown that overhead costs would be reduced in the 'with project' case.

12.4.2 Calibration of vehicle maintenance (spare parts) costs

Road roughness and spare parts costs:- for vehicle savings, the rate of increase of spare parts consumption with respect to road roughness is considered too high. Many analysts nowadays agree that in the HDM-4 model spare parts consumption is overestimated, however full calibration would be a time-consuming task and is well outside the scope of this study. The approach used in the 2005 road maintenance management study for Madhya Pradesh¹⁷ was adopted, and full details are given in **Annex 9.4**.

12.4.3 The value of travel time savings

It could be argued that the social value of travel time (VOTT) savings can be disregarded in road studies in developing countries, on the ground that the passenger time saved is of little value and adds virtually nothing to the gross national product. An effective rebuttal of this view is given by Nail Cengiz Yucel (World Bank review paper, 1975) as follows: *"The prevailing opinion among economists is to accept the idea that non-working travel time savings have a positive value. Some trip makers, when presented with an opportunity to substitute extra cost for time, choose cost - they are better off with shorter journey times even at higher money cost. The fact that such changes resulting from time savings are not reflected in the GDP reflects a shortcoming of national income accounting, rather than providing a valid argument for the exclusion of non-working travel time savings in the economic evaluation of alternative transport projects. The fact remains that any policy measure or project with a travel time saving will enhance total welfare of the community and therefore has a value"*.

There is a particular problem in the analysis of road improvement schemes, especially road widening schemes in low or middle income countries, in that while the vehicle (VOC) element of benefits (mainly fuel, tyres, and spare parts) may be practically equal to that in high-income countries, the attributed values of passenger travel time savings are only a small fraction of those in European countries. However, road engineering costs low income countries are often virtually the same as costs in Europe. This often means that otherwise suitable projects are postponed because they cannot meet the economic feasibility criteria. This may mean that road standards (and levels of service) are generally much lower in developing countries; and road accident rates (see above) tend to be much higher.

Value of travel time (VOTT) based on wage rates

The methodology for estimating travel time savings is derived from World Bank Transport Working Paper OT-5¹⁸ and is based on the wage rate approach. Other methods, for example the stated-preference survey, or the revealed preference method, may result in measurably higher values, but such surveys would be costly and time-consuming in this context. The OT-5 method embraces the national equity¹⁹ concept, i.e., that no one group of transport users or geographic region should be favoured above another.

¹⁷ *HDM-4 Setup in the Madhya Pradesh Road Management System* (M. Riley et al, November 2005)

¹⁸ K.M. Gwilliam, *The Value of Time In Economic Evaluation of Transport Projects - Lessons from Recent Research*. World Bank paper OT-5 (1997).

¹⁹ In the United States single values of travel time used for evaluating all types of transport investment (road, rail, air) are mandatory and published in the Congressional Record.

The main recommendations from the OT-5 paper are as follows:-

The approach is derived from the World Bank paper (OT-5) *The Value of Time in Economic Evaluation of Transport Projects, Lessons from Recent Research Transport (Professor Ken Gwilliam, Jan. 1997)*. HDM-4 allows value to be attributed to time savings of car occupants and bus passengers, but no default values are given. However, among non-OECD countries, only Chile has undertaken extensive studies. In the past, a simple lack of local information contributed to reluctance to attribute value to time savings.

The main recommendations from the OT-5 paper are as follows:-

- There are extra costs associated with employment of labour, such as social security taxes, etc. The British Ministry of Transport feasibility studies add overhead of one-third to the actual wage rate. Although high unemployment might justify the use of shadow prices (i.e., below wage rate) it is recommended that working time should normally be valued at this augmented rate.
- A common value of time should be used for all non-work journeys (unless there is strong local evidence to the contrary) with a default value of 30% of hourly income being used for the valuation, in the absence of other data.
- Business travel time should be treated in the same way as other working time savings.
- It is recommended that the value of time be treated as increasing over time in proportion to GDP per capita, unless there is local evidence to the contrary.
- It is recommended that a national "equity value of time" be used, especially where poverty alleviation or regional redistribution of income is a national objective.

The calculation of the value of travel time for this study is given in the table below.

Table 12.10: Value of travel time calculation

a	Employment 2008 million (NLFS II)	11.779
b	Population estimate 2008 million (CBS)	26.958
c	Employment ratio (b /a)	43.7%
d	per capita annual income 2008 (WB est.)	30,000
e	per capita annual income 2010 (est.)	31,000
f	per capita income 2010 (US\$)	\$ 413.33
g	average working income US\$ (f/c)	\$ 945.98
h	average hours per year (NLFS II)	2,107
j	average hourly wage (\$/hour) (g/h)	\$ 0.449
k	employer overhead costs (est.)	0%
m	working time value (\$/hour) (j+k)	\$ 0.45
n	non-work value of time (% of wage rate)	33%
--	non-work value of time (US\$/hour) (j*n)	\$ 0.15
--	Overall value of travel time 2010 (US\$/hour)	\$ 0.24
--	Overall value of travel time 2010 (NPR/hour)	17.90
--	Adjusted VOTT for HDM input US\$/hour	\$ 0.27
--	Adjusted VOTT for HDM input NPR/hour	20.4

Source: National Labour Force Survey 2007 (NLFS II), CBS, World Bank.

Note that employer overhead costs (item 'k' above) are not included here for working time, since there is evidently a great deal of informal employment (self-employed people) in Nepal. In countries like Britain or Sweden, these overhead costs (employees' social and health benefits, etc.) may typically be up to 40% of the wage rate.

12.4.4 Adjustment to Travel time inputs for HDM-4

In HDM-4 an adjustment is required to the base year value of travel time to allow for an increase in real terms of personal incomes over the period of analysis. This is because the model itself does not make allowance for real changes in values over time, e.g., for fuel cost increases, labour costs, or personal travel costs. An adjustment factor must be calculated based on i) the prevailing discount rate; ii) the period (years) of the analysis; and iii) the expected rate of increase in real terms of the input item (in this case travel time). The methodology to derive appropriate adjustment factors is given in **Annex 9**. The table below gives selected values for 15 year and 20 year analyses, at discount rate of 12 percent.

Table 12.11: Adjustment factors for Value of Travel Time input to HDM-4

Growth rate %pa	Analysis period (years)	
	15	20
1.0%	1.054	1.065
2.0%	1.113	1.137
3.0%	1.176	1.216
4.0%	1.245	1.304
5.0%	1.319	1.402
6.0%	1.400	1.510

Source: Consultants studies see Appendix 9

Based on the GDP growth scenario described in the traffic forecast, and population growth estimated at about 1.8% per year, it is estimated that the real increase in national income per capita will average about 2.0% p.a. over the next 20 years. The discount rate used is 12 percent, so the adjustment factor (from the table above) is times 1.137.

12.4.5 Fuel Costs

To estimate a value for HDM-4 resource cost purposes the U.S. Government (EIA) estimated median price between 2009 and 2016, \$110 per barrel, is used as the basis, to which is added refining, distribution and marketing costs, derived from American Petroleum Institute (API) data. The calculation of economic cost is shown in the table below.

Table 12.12: Economic cost of vehicle fuel

Crude oil long term \$ per barrel (159lt)	\$ 110.00
Manufacturing, marketing & transport	\$ 16.50
sub-total world price \$/barrel	\$ 126.50
World price \$/litre	\$ 0.796
Inland distribution & retailing \$/litre	\$ 0.185
Total economic cost (\$/litre)	\$ 0.98
Total economic cost NPR/litre	73.54

In HDM-4 the functions relating vehicle fuel consumption to average speed (speed on the x axis) are U shaped, and higher fuel resource costs in the long term will often have negative impacts on the economic case for many road upgrading projects. Road improvements usually mean higher vehicle speeds, and as a result net fuel consumption increases in the with-project (WP) case, assuming there are no distance savings. Normally, the extra cost of fuel (also tyres, which wear faster at higher speeds) is more than compensated for in the WP case by lower costs of vehicle depreciation and maintenance, and by passenger travel time savings, but even so, overall benefits will be lower than otherwise, given a 'high fuel cost' scenario.

12.4.6 Road Accidents (Social Costs)

Data were collected in April from the Traffic Police offices at Pathlaiya, Hetauda, and Birgunj. The Traffic Police assisted by providing soft copy in addition to hard copies. Data recorded, for a five month period from August-September 2010 to February-March 2011, are given in table below.

Table 12.13: Injury-accidents by district, August 2010-March 2011

Police data 13 April 2011	Injury-accidents (5 months)		
District	Fatal	Serious	Minor
Chitawan (Narayanghat)	47	20	16
Makawanpur (Hetauda)	24	42	33
Bara (Parwanipur)	30	83	109
Parsa (Birgunj)	9	9	17
Totals	110	154	175

From the existing road lengths (total approximately 131km) and the measured traffic volumes in 2011 it was estimated that 237 million vehicle-km (motorized) were run on the project roads in the districts concerned. Assuming that 90 percent of the fatalities occurred on the main road (the existing project road) then the fatal injury rate is 42 per 100 million vehicle-km (100 mvkm). This is some 35 percent lower than the estimated fatality rate for the Naryanghat-Mugling section (65/100 mvkm)²⁰ and is a credible result, given the large difference in terrain for these two roads. Since in this case the 'with project' road will be four lanes divided, additionally -in urbanized areas- with service roads, the 'with project' fatality rate is estimated as 20 per 100 mvkm, i.e., half that of the existing road.

Table 12.14: Road injuries per 100 million vehicle-km

Road type	Fatal	Serious
- two lanes (existing)	42	400
- four lanes divided	20	200

The social benefits of preventing these accidents are taken at the same values estimated for the Naryanghat-Mugling highway analysis, i.e., \$28,000 per fatal injury avoided and \$3,540 per serious injury avoided.

12.4.7 Standard Conversion Factor

Standard conversion factors (SCF) are used to convert financial (market) prices to economic costs for road construction and maintenance. Economic or resource cost equals [market price, less duties and taxes, plus subsidies]. This is in order to estimate the social worth of an investment, i.e., benefit to the society as a whole, not to any individuals or groups. For road construction costs (often a host of different cost items) the Little and Mirlees²¹ formula is generally used, employing macro-economic data (mostly from the national accounts), as follows:

SCF = (Imports plus Exports) / (Imports plus Exports plus import taxes minus export subsidies). SCF will vary from year to year according to this formula. However, in common with the DOR study *Sector Wide Road Programme & PIP Study, Narayanghat-Mugling - Feasibility Study Report* (DHV et al, 2007)²² the SC factor of 0.92 is used in this study.

²⁰ see Chapter 11 NMH final report

²¹ Ian Little & James Mirlees "Project Appraisal and Planning for Developing countries" Oxford, 1974.

²² The economic cost factor was based on analysis from the recent *Transport Sector Connectivity Project*.

12.4.8 Road Maintenance Costs

Road maintenance costs are given in the table below, economic unit values input to the HDM-4 model. In the without project (WOP) case it is assumed that the existing bitumen surfaced road will be kept in reasonably good condition. Pothole patching is assumed to take place promptly when more than 10 potholes per kilometre are observed. Other routine maintenance consists of miscellaneous work: to clean side drains and culverts, trim vegetation & maintain maximum sight distances, etc. In order to sustain project benefits over the longer term, in the WP case a correct level of routine and periodic maintenance is clearly essential. The economic analysis is unequivocally based upon this assumption; because if not, the predicted²³ user benefits would be greatly reduced, possibly to the extent that the project proposal would no longer be feasible. Road maintenance unit costs are given in the table below.

Table 12.15: Road Maintenance Costs (US\$/sq. metre)

Operation	Economic \$/m2
Inlay at rut depth 20 mm	\$ 20.00
Pothole Patching	\$ 12.00
Crack Sealing	\$ 5.00
Overlay 25mm	\$ 20.00
Edge repair	\$ 14.00

12.5 Economic Analysis

12.5.1 Section-wise Analysis

Section wise economic analysis has been carried out for various road sections using HDM 4 and the EIRR and the NPV are summarized in **Table 12.16**

Table 12.16: Cost Benefit Analysis (Section-wise)

Route	Detail	Length	Costs	Cost without Bridges	NPV	EIRR	Remarks
		Km	\$m	\$m	\$ million	(%)	
NP	Naryanghat-Hetauda bypass-Pathlaiya	108.70	264.92	191.01	72.85	15.7%	Full option
L1	Pathlaiya-Parwanipur-ICD (4-lane)	26.02	36.52	32.81	-6.65	7.9%	Full option
L2	Pathlaiya-Birgunj bypass-Border	27.84	47.44	40.76	-9.96	7.3%	Full option
L3	Pathlaiya-Jaganathpur-ICD (bypass) 4 lanes	24.48	33.71	33.35	-4.85	9.3%	Full option

As per results above Narayanghat – Pathlaiya segment of the Naryanghat - Birgunj route is considered feasible for upgrading to 4-lane road with full construction option in 2016 resulting in estimated Net Present Value (NPV) of nearly \$73 million at the 12 percent discount rate used. About 28 percent of total engineering costs are accounted for by extensive bridge works, and there is fairly high overall cost – but the project is feasible given the volume of motorized traffic already evident in 2011, about 13,300 per day west of Hetauda, and 10,100 per day on the section Hetauda to / from Pathlaiya. By year 2016, the anticipated opening year, flows are expected to be about 17,500 per day and 13,500 per day respectively, excluding any generated traffic.

²³ HDM-4 model predictions

Sections Pathlaiya-Parwanipur-ICD (4-lane), Pathlaiya - Birgunj bypass - Border, Pathlaiya-Jaganathpur - ICD (bypass ext'n) 4 lanes are having base year 2016 traffic as 7,795, 5,100 and 8,440 respectively. With full construction option and these traffic numbers, these sections are not feasible but could be feasible when the traffic grows to about 11,000 around year 2020 -2022 or with curtailed construction option. Economic analysis with curtailed construction options is provided later in this chapter.

12.5.2 Full Route Analysis

Abovementioned sections with full construction options have also been analyzed by considering combined route options and results are summarized below

Table 12.17: Cost Benefit Analysis for Full Routes

Route	Detail	Length Km	Costs \$m	Cost \$m without Bridges	EIRR % (with Bridges)
Option 1 (NP+L1)	Naryanghat-Hetauda bypass-Pathlaiya -Parwanipur-ICD (4-lane)	134.68	301.43	223.90	15.1%
Option 2 (NP+L2)	Naryanghat-Hetauda bypass-Pathlaiya - Birgunj bypass-Border	136.51	312.35	231.86	15.2%
Option 3 (NP+L3)	Naryanghat-Hetauda bypass-Pathlaiya -Jaganathpur-ICD (bypass ext'n) 4 lanes	133.15	298.63	224.45	14.8%

Economic analysis for combined route in all 3 options as per results of EIRR given in **Table 12.17** are more than 12% making the investment viable. Route Naryanghat-Hetauda bypass-Pathlaiya -Parwanipur-ICD (4-lane) provides for 4-laning of entire route from Aaptari (Narayanghat) – ICD. Route Naryanghat-Hetauda bypass-Pathlaiya - Birgunj bypass-Border also provides for entire 4-laning. Route Naryanghat-Hetauda bypass-Pathlaiya – Jaganathpur - ICD (bypass ext'n) provides for 4 lanes and but Simra – Parwanipur section remains (2-lane) as it is.

12.5.3 Analysis For Curtailed Route

To avail the available funding in a limited funding scenario economic analysis has also been carried out for first section of the road from the ICD – Parwanipur – Pathlaiya – Ratomate – Hetuada bypass, with and without bypass section. Results of the economic analysis with curtailed construction options are presented in **Table 12.18** below.

Table 12.18: Cost Benefit Analysis for Options with Curtailed Lengths

Route	Detail	Length Km	Costs \$m	Cost \$m without Bridges	EIRR % (with Bridges)
Option L1.3	Birgunj ICD- Parwanipur – Pathlaiya	26.015	16.71	13.39	15.8%
	4-Lane without service road and footpath, Bituminous Concrete Surfacing in Pathlaiya – Parwanipur Section and DBST in Parwanipur – ICD Section				
Option PRH 3	Pathlaiya – Ratomate – Hetauda bypass	32.03	55.52	28.42	14.7%
	<i>Pat – Ratomate:</i> 4-Lane without service road and footpath, with Bituminous Concrete Surfacing in entire section <i>Hetauda Bypass:</i> 2-lane DBST Surfacing				
Option 4	Birgunj ICD-Parwanipur – Pathlaiya – Ratomate (without Hetauda bypass)	50.54	61.84	38.80	16.7%
Option 5	Birgunj ICD-Parwanipur – Pathlaiya – Ratomate – Hetauda bypass	58.04	72.23	43.60	15.1%

12.5.4 Sensitivity Tests

Sensitivity tests have been carried out for all options discussed above. Net Present Value (NPV at 12% discount rate) and Economic Internal Rate of Return (EIRR) has been worked out for various cost and benefit scenarios.

Full Route Options: Sensitivity test results for full route length options are shown in the Table 12.18 below.

Table 12.18: Sensitivity tests for Various Full Length Options

Parameter	NP		NP + L1 (Option 1)		NP + L2 (Option 2)		NP + L3 (Option 3)	
	NPV \$m	EIRR %	NPV \$m	EIRR %	NPV \$m	EIRR %	NPV \$m	EIRR %
Switch Cost – construction	Plus 53%		Plus 44%		Plus 45%		Plus 42%	
Standard Result	72.85	15.7	66.2	15.1	69.2	15.2	62.9	14.8
Cost +20% VOC&VOT -20%	21.11	13.0	8.4	12.4	12.18	12.5	4.84	12.2
Accident Benefits – halved	31.08	13.6	24.9	13.1	19.4	12.9	20.78	13.0
Accident Benefit = zero	-10.69	11.4	-18.20	11.1	-30.39	10.5	-10.90	6.9
Travel Time Savings – halved	33.03	13.8	25.82	13.3	31.51	13.6	21.37	13.1
Travel Time = Zero	-6.8	11.6	10.14	11.4	-6.05	11.7	20.15	10.9
`Generated traffic = Zero	58.79	15.1	51.33	14.5	52.57	14.5	47.62	14.2

If both, costs increase by 20 percent and vehicle benefits decrease by 20 percent, the result in all cases is a drastic decrease in NPV to \$4.84 million - \$12.18 million, and EIRR to 12.2 – 12.5 percent.

The 'switch' cost -being the cost increase that would reduce the social benefit to zero- and the result of plus 42% to plus 53% (for NP, NP+L1, NP+L2 and NP+L3) indicates that there is some 'margin' for construction cost overruns, although this should be avoided if at all possible.

Curtailed Length Options: Sensitivity test results for curtailed route length options are shown in the Table 12.19 below

Table 12.19: Sensitivity tests for Curtailed Length Options

Parameter	Option 4		Option 5	
	NPV \$m	EIRR %	NPV \$m	EIRR %
Switch Cost – construction	57%		36%	
Standard Result	17.23	16.7	12.62	15.1
Cost +20% VOC&VOT -20%	4.25	13.0	0.76	12.2
Accident Benefits – halved	9.02	14.6	0.66	12.2
Accident Benefit = zero	-6.70	10.0	-11.31	9.0
Travel Time Savings – halved	7.86	14.2	5.13	13.3
Travel Time = Zero	2.24	12.7	2.37	11.3
`Generated traffic = Zero	14.98	16.2	10.38	14.6

12.6 Economic analysis – Conclusions

The HDM cost-benefit analysis, and tests of the sensitivity of outcomes to fairly major changes in important parameters, both indicate that the level of economic benefits is reasonably secure on the project.

Full Length Option

All 3 complete route options are viable, but the Option NP+L3 has a bit lower EIRR (Table 12.17). The consultant believes that the best course is to select the most preferable option from the civil engineering, traffic engineering - road safety, communities / areas benefitted - point of view.

While 'value for money' and 'cost-effectiveness' are clearly justifiable concerns, so is safety, aesthetics and appropriate geometric design, especially given that this link is part of a designated Asian Highway. Selection of the preferred shall be based on following.

- As ICP is also coming up close to the ICD, therefore it is shall be preferred that option connecting to ICD is chosen.
- Options connecting to the ICD costs less.
- Among two options connecting to the ICD, option NP+L1 has a bit higher EIRR (Table 12.17)
- NP+L1 option provides for 4-laning with service roads from Pathlaiya to Parwanipur, whereas Option NP+L3 does not.
- Option NP+L3 shall require construction of another 4-lane highway less than 2km west of existing Simra – Parwanipur section. From traffic point of view the existing highway can be 4-laned and can serve the traffic requirement. Four laning of existing highway shall save about 52 Ha of agricultural land required for new alignment through Jaganathpur.

Based on above it is recommended that Narayanghat – Pathlaiya – Parwanipur – ICD route (NP+L1) may be selected for construction under the project.

Curtailed Length Options

Both options of 4-laning from ICD-Parwanipur-Pathlaiya-Ratomate and ICD-Parwanipur-Pathlaiya-Ratomate-Hetauda bypass (Hetauda bypass 2-lane) are feasible. Any of these options may taken up in case of availability of limited funding.

13 ENVIRONMENTAL ASSESSMENT

13.1 Introduction

The main objective of the environmental assessment is to conduct environmental studies in accordance with Government Regulations and Policies as required to assess and inform decision makers about the potential environmental impacts of the proposed project and to suggest appropriate and pragmatic mitigation measures to mitigate and / or minimize the adverse impacts so that the project can be implemented in an environmentally friendly manner. The study facilitates decision making and ensure that the road upgrading / widening options under consideration were environmentally sound, sustainable and contribute to the development of the environmental assets.

Environmental screening and categorization for the upgrading / widening of Birgunj – Narayanghat road from existing 2 lane to up to 4 lane bituminous pavement with service lane as required in major built-up areas was accomplished following GoN Environmental Protection Rules (EPR) schedules 1 and 2.

As per GoN, rule 3 of EPR (1997 first amendment 1999), schedule 1 (D), Road Sector, No 6, IEE is required for the upgrading / widening of the road. Further, the proposed road section does not pass through any national park and wild life reserve area. Thus, the IEE study of the proposal becomes mandatory as per this provision and the study has been undertaken accordingly.

13.2 Methodology Adopted for this Study

The IEE study has been undertaken as per the provisions of the Environmental Protection Rules following the provisions of Rule 5, 7, 10 and 11 in compliance with schedule 1, 3 and 5 of the EPR. The study methodology is as prescribed below:

Desk Study

The desk study includes review of the EPA, EPR, PWD, Feasibility study of the project road, review of IEE reports of similar projects, Reference Manual for Environmental and Social Aspects of Integrated Road Development, and other Environmental Management Guidelines of DoR for preparation of necessary documents regarding the requirements of IEE. Questionnaire and checklist for discussion and data collection on physical, biological and socio-economic and cultural baseline environment of the project area were prepared.

Preparation and Approval of TOR

The Work Schedule (TOR) was prepared prioritizing significant environmental impacts/issues to be addressed while conducting IEE. The draft Work Schedule (TOR) was prepared and submitted for approval to MoPPW, GoN on April 07, 2011. Final TOR was submitted incorporating comments and suggestions received and approval obtained accordingly.

Publication of Public Notice

Upon approval of the TOR, a 15 days public notice was published in the **Gorkhapatra** (national level daily news paper) for consultation and collection of reactions, suggestions and comments from the project area stakeholders/local people for the purpose of IEE preparation.

Field Visit / Study

To plan the subsequent field works and to determine the depth of the study to be conducted, the Acts, Policies, Regulations and Guidelines, as listed in this ToR, was reviewed carefully. A field visit was made to conduct public consultation and to collect baseline information on

the socio-economic and cultural, physical, and biological environment of the project with regards to issues as indicated in the TOR.

Data Processing

The collected baseline data were verified by citing standard references and evaluated before assessing impacts on them. The data and information gathered from the field work were compiled and analyzed to establish the relations between the environmental impacts and their mitigation measures. The environment in conjunction with the project activity, project impacts (beneficial/adverse) was analyzed, assessed and determined as envisaged in the IEE ToR. The beneficial and adverse impacts were identified, predicted and evaluated. Corresponding mitigation measures were designed and developed including mitigation management and monitoring plans. On the basis of study analysis, conclusions were drawn on the resolution of environmental issues and enhancement of the environment of the project area.

Report Preparation

An IEE report including Environmental Monitoring and Management Plan will be prepared in accordance with the contents given in Schedule-5 of the EPR'97. Final report was prepared upon incorporating comments on the draft report. The IEE report is presented in separate volume.

13.3 Brief Description of Existing Environment

The proposed Birgung – Hetauda - Narayanghat Road (143 km) road runs along the plain terrain of terai in Chitwan District, hilly terrain from Makwanpur to Pathlaiya in Bara District and again traverses in plain terrain up to Birgunj in Parsa District and from Parwanipur Junction to ICD. Considerable vehicular traffic exists as the road forms one of the major links to neighboring India which forms gateway from India to Nepal in the Central Development Region of Nepal.

The road is rapidly being developed as urban area in most of the section and plays an important role in overall network connectivity of the nation. The proposed road upgrading section is divided into three parts. The first section starts from Hetauda (km 133+500) up to Parwanipur (km 177+090) and further to Birgunj (km189+740). Second section starts from Hetauda to Narayanghat where the chainage has been carried out according to the east-west highway (km 394+850 to km 472+160). The third Junction starts at Parwanipur Junction (km 177+135) and ends at Dry Port Junction.

The project area basically lies across the southern belt of the country below altitude of 500m and is primarily flat with fertile agricultural land consisting of river deposited alluvium and sandy/alluvium soil. Alluvium deposits of Manohari, Lothar, Rapti and Churiya Rivers will be promising quarry sites for embankment fill, sub-base, base and chipping materials.

The project area possesses sub-tropical climate with yearly average precipitation ranging from 1861mm – 2114mm with max. 24hrs record of 143mm. The mean average maximum and minimum temperatures of the project area are 30.5°C and 18.2°C with absolute extreme maximum and minimum of 38.8°C and 4.6°C respectively (VDCP, 2008).

The alignment passes through settlement areas of Jitpur, Simra, Pathlaiya, Amlekhgunj, Churiya, Ratmate, Hetauda, Nawalpur, Newarpani, Jyamere, Simpani, Beluwa, Manahari, Bijhauna, Churachuri, Lothar, Gadaule, Pipletar, Bhandara, Parsa, Ratnanagar, Tikauli and Bharatpur while rests of the alignment passes through intermixture of scattered settlements, open land bearing built-up value, cultivated and open grazing lands.

Geographically, the proposed road traverses through 4 Municipalities namely: Bharatpur, Ratnanagar, Hetauda and Birgunj Municipality; and 20 VDCs namely: Panchakanya, Chainpur, Khairahani, Birendranagar, Bhandara, Piple, Manahari, Basamadi, Churiyamai, Amlekhgunj, Pipara Simara, Jitpur Bhawanipur, Chhatta Pipara, Rampur Tokani, Limanimal, Bhauri, Chorni, Lipani Birta, and Bhawanipur.

The proposed road consists of road way structures as bridges, drainage, cross-drainage, river training structures including bus bays, working platform, delineators, traffic signs, kilometer posts etc. In general, existing services and public utilities were noted within the road right of way along the urban/settlement areas (i.e. plantation of roadside tree, roadside drains, water supply lines, electrical and telephone poles etc.). Various industries were noted within Pathlaiya – Birgunj section.

13.4 Public Consultation

A 15 days public notice shall be published in national level daily news paper for consultation and collection of reactions, suggestions and comments from the project area stakeholders / local people for the purpose of IEE preparation. A copy of public notice was displayed in the office notice board of concerned VDC, DDC, Municipality, local schools, hospitals, health posts and other relevant concerned offices and deed of public enquiry (Muchulka) of that deed was prepared. The recommendation letters from the concerned VDCs / Municipality and list of persons contacted / issues raised is kept in the IEE report. Major issues identified and raised during public consultation focuses on reinstatement, re-location and replacement of existing services and utilities like water supply system, electrical and telephone poles, bridges, irrigation crossings, drainage, cross-drainage, bus-bays, roadside trees, public temples etc.

The issue raised during public consultation were addressed in the preparation of the IEE report and incorporated accordingly in the feasibility technical design. The IEE report will be accessible to interested parties and general public through information center of MoPPW, DOR/GESU including DoR website.

13.5 Impact Identification, Prediction and Evaluation

Identification, prediction and evaluation of environmental impacts have been made for the proposed actions/activities of the proposed road upgrading / widening works during pre-construction, construction and operation stages of the project. Both beneficial and adverse impacts were analyzed. For each potential environmental impact, mitigation measures have been proposed so as to avoid or minimize the adverse environmental impacts of the project activities during pre-construction, construction and operation phases. The mitigation measures are of curative, preventive and compensatory types.

The environmental concern associated with the road sector, as a whole, most notably within Terai bordering towns, is the issue of air pollution. While the impact of the project on air quality will be positive, as a result of reductions in traffic congestion and waiting times when the vehicle engines are kept idling, the main cause of air pollution from vehicles is poor vehicle upkeep. To address this issue, Nepal has established emission standards for vehicles with facilities for enforcement of these standards. The Government has established emissions testing facilities for vehicles in the Kathmandu valley, allowing the traffic police to issue annual licenses to complying vehicles and prevent non-complying vehicles from being allowed to operate. These also need to be enforced at border crossings and other parts of the country.

Water and soil pollution is a further area of concern associated with the transportation sector caused by fuel leaks and periodic replacement of engine lubricating oil, brake fluid and battery acid. These pollutants are discarded by small workshops situated in towns and along highways throughout the country, though their concentration near border crossings

may be high. The option of including measures to foster recycling, reuse and responsible disposal of these waste products could be considered as part of the project.

Since it is the widening of existing highway where most of the section is being rapidly developed as urban area, reinstatement, re-location and replacement of existing services and public utilities forms a major concern. The cost for such work has been meticulously included in the design bill of quantity to restore and smooth functioning of such utilities.

A further potential concern is the transport of hazardous materials. The effect of the project will be beneficial in this respect, due to the construction of wider roads and the effect of erasing traffic on existing alignments. The traffic management plan and traffic control for safety measures being considered as part of the project will minimize the potential adverse impact.

13.6 Matrix for Environmental Impact

Upon full baseline documentation of environmental data of the project area, each of the environmental parameters were examined against the project activities in the different stages of project development using various methods and tools as required by the environmental parameter in question. Potential environmental impacts on Physical, Biological and Socio-economic and cultural aspects are identified and predicted based on the existing environmental condition with respect to the proposed project interventions using impact matrix in terms of **Type** (direct/indirect); **Extent** (site specific, local and regional); **Duration** (short term, medium term and long term); and **Magnitude** (low, medium and high) based on conditions of the environmental parameter at present and estimated or projected damage with the project.

13.7 Environmental Monitoring

The main objective of environmental monitoring is to detect impact in the early phase of project activity in order to provide adequate corrective action before it is too late. Other objectives of monitoring are to provide feedback on the accuracy of impact prediction, effectiveness of mitigation measures and provide guidance for readjustments during project implementation and operation. Thus, the environmental monitoring plan has been designed inclusive of monitoring indicators, period, frequency, method, location and institutional responsibility so as to ensure the effectiveness of environmental mitigation measures, compliance with environmental standards and to facilitate on changes required in project design and operation.

The Ministry of Physical Planning and Works is legally responsible for environmental monitoring works. The DoR, RSDP (AF) will carry out the monitoring of the implementation of the environmental monitoring plan by the Contractor through its Supervising Consultant during construction phase. The monitoring for compliance of recommended mitigation measures during construction and post-construction certification inspection of each completed section of road and each rehabilitated ancillary sites shall be undertaken by the Supervising Consultant. The cost for monitoring during construction and post-construction certification inspection is included in the project implementation cost.

The environmental monitoring of roads during the road operation phase shall concentrate on the major identified potential impacts of the roads, including slope stability, vegetative cover, drainage and sedimentation. The DoR, GESU shall undertake a 6-monthly inspection of the road formation and related features over the initial year following the completion of road construction. Standard report covering environmental features shall be completed by GESU following each inspection.

The cost for monitoring during construction, post-construction certification inspection, and operation phase is included in the project implementation cost.

13.8 Environmental Management Plan

This Environmental Management Plan (EMP) delineates key issues likely to arise from project implementation, and proposes mitigation measures, including monitoring schedule and responsibility. The EMP also outlines environmental management roles and responsibilities, road design and construction management of different activities, site supervision, monitoring and reporting, records, and corrective measures, improvement proposals, and cost estimates for mitigation measures. The EMP is detailed in the IEE report which shall form a part of Bidding Document.

Responsibility for environmental management associated with road construction / rehabilitation / upgrading / widening involves number of parties, each with specific responsibilities for particular activities. The five main parties responsible for the design and implementation of mitigation measures prior to, during and following road upgrading are:

- MoPPW
- DOR / GESU
- World Bank
- Design and Supervising Consultant
- Construction Contractor

The Ministry of Environment holds overall responsibility for environmental policy streamlining the existing environment improvement programs carried out by various line agencies. Within the roads sector, the Ministry of Physical Planning and Works (MPPW) has overall responsibility for environmental safeguarding. The Department of Road (DOR), as the project proponent, has the ultimate responsibility for the design/supervision of road construction and environmental management works. Geo-Environment and Social Unit (GESU) of DOR undertakes environmental assessment functions, as well as monitoring of projects and provision of advice relating to design of environmental mitigation and enhancement measures, and the setting of environmental quality standards.

The World Bank is responsible for overseeing of DOR's project management in accordance with loan conditions, the detailed road design and EMP, including periodic site visits to ensure compliance.

The design Consultant will prepare final detailed designs and conduct necessary environmental studies including EMP design recommendations. The supervising Consultant will supervise the day to day activities of the construction contractor on behalf of DoR and conduct technical supervision of road layout, overseeing contract implementation and certifying works for payment. The supervising consultant will ensure effective implementation and compliance of all aspects of work as specified in Environmental Management Plan (EMP) by the Contractor, with reporting direct to the DoR, RSDP (AF).

13.9 Summary Costs for Environmental and Social Safeguard Measures

The cost estimates for environmental mitigation measures will be included in the Environmental Management Plan and the summary of costs for environmental safeguard will be submitted separately with IEE Report.

14 SOCIAL SURVEY FINDINGS

14.1 General Background

The Government of Nepal has engaged the Consultant to undertake preparatory activities for the processing of a new loan for the proposed Road Sector Development Project Additional Financing (AF) under the currently on-going Road Sector Development Project (RSDP). This study is to identify the benefits from north-south connectivity enhancing transport facilities in the central development region, focusing primarily for poverty reduction and enhancing the economic life of the country, enhancing international as well as domestic trade through improving Birgunj-Narayanghat road which connects Kathmandu and outer parts of the country (east and west). Birgunj-Narayanghat road is one of the most important accesses to enhance international as well as domestic trade which connects Kathmandu and other parts of country with Nepal-India border at Raxaul (Birgunj).

The proposed road projects Birgunj-Narayanghat road section, additional financing of RSDP mainly concerned to improve transport system extending socio-economic services through opening up of new life chances such as new market for agriculture production, access to external markets to import goods, access to health and education services, communication and establishment of development infrastructures in Terai and hill districts of Nepal.

14.2 Description of the Project

The project covers mainly four districts viz. Parsa, Bara, Makawanpur and Chitawan. The entire road passes through built-up Terai urban settlements connecting district headquarters of all four districts and further providing access to outside markets in Terai and India. The project covers predominantly an industrial and urban society, where people have already existing highway facilities. The road alignment from Birgunj to Hetauda industrial city is an organized industrial area, further it connects Chitawan an agro based trade center. All these cities supply daily need goods, construction material and other accessories to other cities and rural areas of Nepal. Not only import and supply this road section has importance in exporting commodities to abroad.

The purpose of the study and analysis is to prepare a socio-economic profile of the potentially affected population and communities in the road influence area. The social survey was conducted through sampling of the households within the zone of influence (ZOI) of 2 km either side from the road alignment.

The social surveys were conducted in households located along the road alignment of covering Bharatpur, Ratnanagar municipalities and Chainpur, Khairahani, Birendranagar, Bhandara and Piple VDCs of Chitwan district; Manahari, Basamadi, Churiyamai VDCs and Hetauda municipality of Makawanpur district; Amalekhgunj, Piparasimara, Jitpur, Chhatapipra, Rampurtokani, Lipinimal, Bahuwari VDCs of Bara district; Chorni, Lipinibirta, Lalparsa, Ramgadhawa, Bhawanipur VDCs and Birgunj municipality of Parsa district.

14.3 Household Survey

Social Assessment of zone of influence of this road covers two km either side of the existing center line of the road. For this study both qualitative and quantitative survey methods were administered. Quantitative data were collected using structured questionnaires for household level enumeration by qualified enumerators. The qualitative information was collected through community consultation using group interview, key informant interview, open interview and focus group discussion technique by Social Development and Resettlement Specialist. Focus group discussion within the zone of influence areas were conducted during field study.

The social team carried out a detailed household survey within the 2 km either side of the road alignment which is considered as zone of influence of the road. This road section has no land and assets acquisition problem. The land within the 25 meter either side from the centre line is considered as ROW and it has already been acquired by the government. Altogether 1401 households were selected for household survey. Field study was conducted in March-April 2011.

14.4 Demographic Profile

14.4.1 Demography

Total population of the project districts is 2,521,955 with an average household size of 5.8. The population distribution between male and female is 51 and 49 percent respectively. **Table 14.1** presents the population composition of project districts.

Table 14.1: Population Distribution in the Project Districts

District	HHS	Total Population	Male		Female		Ave. HH Size
			No.	%	No.	%	
Chitawan	132,353	624,135	308,748	49.47	315,387	50.53	4.7
Makawanpur	90,101	486,390	245,045	50.38	241,345	49.62	5.4
Bara	111,534	750,231	387,469	51.65	362,762	48.35	6.7
Parsa	104,090	661,199	345,276	52.22	315,923	47.78	6.4
Total	438,078	2,521,955	1,286,538	51.01	1,235,417	48.99	5.8

Source: District Development Profile of Nepal, 2010

Combined population of the affected VDCs and municipalities is 673,508 with the average household size of 5.1. The population of male and female is 51.63 percent and 48.37 percent respectively. Population composition of affected VDCs is presented in **Table 14.2**.

Table 14.2: Population Composition of the Affected VDCs/Municipalities

VDC/Municipality	Total HH	Male	Female	Total	Ave. HH Size
Bharatpur	28,398	61,066	57,879	118,945	4.19
Ratnanagar	10,628	25,209	25,115	50,324	4.74
Chainpur	3,976	9,331	9,993	19,324	4.86
Khairahani	5,093	12,392	12,862	25,254	4.96
Birendranagar	3,622	8,490	9,180	17,670	4.88
Bhandara	3,675	9,503	9,630	19,133	5.21
Piple	3,498	8,785	8,636	17,421	4.98
Manahari	3,322	8,718	8,547	17,265	5.20
Basamadi	3,227	9,001	8,682	17,683	5.48
Hetauda	18,093	44,078	41,385	85,463	4.72
Churiyamai	2,972	8,024	8,080	16,104	5.42
Amalekhgunj	1,348	3,896	3,777	7,673	5.69
Piparasimara	4,268	11,812	11,217	23,029	5.40
Jitpur	3,423	11,276	9,789	21,065	6.15
Chhatapipra	1,169	4,009	3,991	8,000	6.84
Rampurtokani	1,133	4,165	3,865	8,030	7.09
Lipinimal	1,071	4,304	3,989	8,293	7.74
Bahuwari	733	3,013	2,790	5,803	7.92
Chhorni	1,636	5,555	5,121	10,676	6.53

VDC/Municipality	Total HH	Male	Female	Total	Ave. HH Size
Lipinibirta	1,103	4,108	3,669	7,777	7.05
Lalparsa	608	2,272	2,218	4,490	7.38
Ramgadhawa	771	2,764	2,322	5,086	6.60
Bhawanipur	1,316	4,614	4,250	8,864	6.74
Birgunj	26,092	81,360	68,776	150,136	5.75
Total	131,175	347,745	325,763	673,508	5.13

Source: District Development Profile of Nepal, 2010

14.4.2 Ethnic Composition

The project area is multi-ethnic composition. Brahmin, Chhetri, Janajati and Dalit are major groups in the districts. The ethnic composition of the project area is presented below.

Table 14.3: Ethnic Composition of Project Area (%)

Ethnic Group	Chitwan	Makawanpur	Bara	Parsa	Total
Brahmin	48.68	33.96	7.21	5.57	23.03
Chhetri	10.70	17.58	15.52	32.79	20.22
Dalit	8.85	5.15	18.85	23.97	15.21
Janajati	15.06	31.14	7.54	0.51	11.73
Newar	6.60	8.22	1.22	0.69	3.83
Muslim	1.25	2.82	24.17	14.03	10.59
Tharu	8.07	0.69	25.22	22.23	14.95
Sanyasi	0.78	0.44	0.28	0.22	0.42
Total	100.00	100.00	100.00	100.00	100.00

Source: Field Survey, 2011

14.4.3 Education and Literacy

The total number of academic institutions in Chitwan district is 990 including 511 primary, 238 lower secondary, 163 secondary, 56 higher secondary schools and 22 campuses. Likewise there are total 922 academic institutions in Makawanpur district including 511 primary 200 lower secondary, 107 secondary, 23 higher secondary and 6 campuses. The academic institutions in Bara district is 576 including 378 primary, 100 lower secondary, 65 secondary, 29 higher secondary schools and 4 campuses. Similarly, in Parsa district the numbers of academic institutions is 561 including 379 primary schools, 96 lower secondary schools, 60 secondary schools, 17 higher secondary schools and 9 campuses. **Table 14.4** presents the literacy rate of project districts.

Table 13.4: Literacy Rate of Project Districts (%)

Districts	Male	Female	Total
Chitwan	79.3	63.3	71.1
Makawanpur	60.5	39.5	55.3
Bara	61.7	33.8	49.1
Parsa	55.5	28.2	42.6

Source: District Profile of Chitwan, Makawanpur, Bara and Parsa Districts

The literacy rate of surveyed population is about 79 percent whereas about 6 percent population is graduate and above. Educational status of school going age and above of affected population is given in **Table 14.5**

Table 14.5: Educational Status of Surveyed Population (%)

Districts	Illiterate	Primary (1-5)	6-10 Class	SLC-12 Class	Graduate & Plus
Chitwan	13.6	22.94	31.87	20.54	11.05
Makawanpur	11.8	31.73	30.17	19.12	7.19
Bara	30.63	27.21	18.3	18.9	4.96
Parsa	28.1	35.82	22.32	7.51	6.25
Overall	21.23	29.6	25.81	15.8	7.56

Source: Consultants Field Survey, 2011

14.5 Settlement Patterns

Settlement patterns in the project areas generally reflect the distribution of arable land and the development of market areas. Accordingly, most of the areas exhibit a clustered and semi-clustered settlement. The study area is basically urban setting. Most of the houses are of modern and semi-modern types. About 55 percent households have modern houses while about 28 percent have semi-modern houses. Likewise about 4 percent households have traditional houses. **Table 14.6** shows the types of houses in the study area.

Table 14.6: Type of Houses (%)

Districts	Traditional	Semi-modern	Modern	Hut
Chitwan	6.68	22.91	67.06	3.34
Makawanpur	1.79	32.86	59.64	5.71
Bara	7.02	40.13	35.45	17.39
Parsa	1.74	20.10	54.09	24.07
Overall	4.35	27.77	55.10	12.78

Traditional: Stone and mud wall with straw roof; **Semi-modern:** Stone and mud wall with slate or zinc sheet roof; **Modern:** Stone or brick and cement wall with RCC roof; **Hut:** Bamboo or wood wall with straw roof.

Source: Consultants Field Survey, 2011

14.6 Migration

14.6.1 In-Migration

Migration from the hill to the Tarai is a general demographic feature in many hill/mountain districts. People of the mountain and hill region migrate to the Terai for the better economic opportunities and social services.

The road corridor of the Makawanpur is occupied heavily by the hill migrant population (52%). Similarly Chitawan is also a settlement of migrant population (48%) the highway part of Bara and Parsa also experiences little bit migrant people for better economic opportunity, which contributes for 17 percent in Bara and 10 percent in Parsa. **Table 14.7** shows the in-migration trend of the study area.

Table 14.7: In-Migration Trend (%)

Districts	Yes	No.	Total
Chitwan	48.21	51.79	100.00
Makawanpur	52.5	47.5	100.00
Bara	17.06	82.94	100.00
Parsa	9.68	90.32	100.00
Overall	31.33	68.67	100.00

Source: Consultants Field Survey, 2011

The major purpose for in-migration is employment which is about 50 percent while about 19 percent in-migration is for trade. Similarly, about 12 percent is for study purpose. **Table 14.8** shows the purpose of in-migration.

Table 14.8: Purpose of In-Migration (%)

Districts	Employment	Trade	Education	Urban Facility	Others	Total
Chitwan	54.68	10.84	10.34	18.72	5.42	100.00
Makawanpur	48.30	19.05	18.37	9.52	4.76	100.00
Bara	47.06	45.10	5.88	1.96	0.00	100.00
Parsa	40.74	33.33	22.22	0.00	3.70	100.00
Overall	50.70	19.16	13.32	12.38	4.44	100.00

Source: Consultants Field Survey, 2011

14.6.2 Out-Migration

The trend of seasonal out migration is high in this region. Household members go to Gulf, India and urban area of the country for seasonal employment, which is the main source of cash income to fulfil the household expenditure.

About 80 percent out-migrant mobility is within Nepal while 10.15 percent out-migration is in Gulf. Similarly 8.63 percent out migration is in other countries. **Table 14.9** presents the out-migration situation of the study area.

Table 14.9: Destination of Out-Migration (%)

Districts	Nepal	India	Gulf	Other Country	Total
Chitwan	13.01	12.33	54.11	20.55	100.00
Makawanpur	19.44	5.56	61.11	13.89	100.00
Bara	25.00	12.50	25.00	37.50	100.00
Parsa	54.55	22.73	22.73	0.00	100.00
Overall	18.95	11.29	52.42	17.34	100.00

Source: Field Survey, 2011

The major purpose for out-migration is employment which is 79.44 percent while 10.8 percent out-migration is for service. Similarly, 9.27 percent out-migration is for study and remaining 1.61 percent is for others purpose. **Table 14.10** presents the out-migration purpose of the study area.

Table 14.10: Purpose of Out-Migration (%)

Districts	Employment	Service	Education	Others	Total
Chitwan	83.56	7.53	6.85	2.05	100.00
Makawanpur	81.94	8.33	9.72	0.00	100.00
Bara	75.00	0.00	12.50	12.50	100.00
Parsa	45.45	27.27	27.27	0.00	100.00
Overall	79.44	9.27	10.08	1.61	100.00

Source: Consultants Field Survey, 2011

14.7 Economic Status

14.7.1 Occupation and Employment

There are different economic activities adopted by the population. The main occupation of the area population is agriculture followed by trade and labor works. Occupation status of the economically active population of the study area is given in **Table 14.11**.

Table 14.11: Occupational Status of Study Area (%)

Occupation	Chitwan	Makawanpur	Bara	Parsa	Total
Agriculture	35.04	33.36	36.06	39.91	36.39
Service	13.21	11.93	4.50	7.89	9.63
Trade	15.08	18.03	12.95	11.95	14.29
Labor	5.65	5.11	25.09	20.94	14.01
Foreign Job	6.69	6.37	0.90	0.87	3.72
Student	19.91	20.18	18.26	14.62	18.03
Others	4.42	5.02	2.25	3.83	3.93
Total	100.00	100.00	100.00	100.00	100.00

Source: Consultants Field Survey, 2011

14.7.2 Land Use

The land found in the project area is characteristically of irrigated and un-irrigated low land. The average land holding size of the area is 0.7 hectare. The domination of land use is irrigated low land. **Table 14.12** shows the land type and holding size.

Table 14.12: Land Type and Size of Study Area (Hectare)

Land Type	Chitwan	Makawanpur	Bara	Parsa	Total	Average
Irrigated Lowland	87	649	23	66	825	1.97
Unirrigated Lowland	5	3	58	71	137	0.49
Upland	12	13	3	1	29	0.10
Fallow Land	0	1	0	0	1	0.00
Total	104	666	84	138	992	0.71

Source: Consultants Field Survey, 2011

14.7.3 Landownership Status

Most of the households are owner cultivator which is about 69 percent. About 26 percent households are landless. **Table 14.13** presents tenancy pattern of the study area.

Table 14.13: Distribution of Households According to Tenancy Pattern (%)

District	Owner Cultivation	Rented-Out	Rented-In	Landless	Total
Chitwan	68.93	5.91	3.72	21.44	100.00
Makawanpur	75.91	5.61	2.97	15.51	100.00
Bara	76.00	0.33	0.33	23.33	100.00
Parsa	55.31	0.97	2.17	41.55	100.00
Overall	67.98	3.32	2.44	26.26	100.00

Source: Consultants Field Survey, 2011

14.7.4 Cropping Pattern

Paddy, wheat, maize, pulses and oilseeds are the major crops cultivated in the area. Cultivation of food grains and production of the surveyed households is given in **Table 14.14**.

Table 14.14: Production of Food Grains

Crops	Chitwan		Makawanpur		Bara		Parsa		Total	
	Area (ha)	Product ion (qtl)	Area (ha)	Product ion (qtl)	Area (ha)	Product ion (qtl)	Area (ha)	Product ion (qtl)	Area (ha)	Product ion (qtl)
Paddy	108.3	5,885	41.1	2,399	78.8	3,779	135.8	4,097	364.8	16,210
Maize	55.7	974	38.6	711	29.7	602	21.2	712	145.2	3,000
Wheat	45.3	768	14.4	180	53.9	1,156	121.1	2,247	234.6	4,351
Soybean	0.6	7	6.7	48	1.9	7	0.4	9	9.6	70
Pulses	15.0	82	2.3	7	0.3	2	22.9	44	40.5	135
Oilseeds	38.9	270	1.9	57	0.0	-	16.0	48	57.4	380

Source: Consultants Field Survey, 2011

Potato, cauliflower, tomato, onion, green vegetables are major vegetables grown in the area. Cultivation of vegetables and production of the surveyed households is given in **Table 14.15**.

Table 14.15: Production of Vegetables

Vegetable	Chitwan		Makawanpur		Bara		Parsa		Total	
	Area (ha)	Product ion (qtl)	Area (ha)	Product ion (qtl)	Area (ha)	Product ion (qtl)	Area (ha)	Product ion (qtl)	Area (ha)	Product ion (qtl)
Green Veg	5.2	135	1.9	64	0.7	27	0.5	7	8.2	233
Tomato	2.1	46	1.4	33	0.2	15	0.1	3	3.9	97
Cauliflower	3.4	180	1.0	126	0.7	94	1.8	38	6.9	437
Cabbage	3.3	67	0.5	8	0.3	39	0.2	16	4.3	130
Potato	7.3	263	36.0	47	3.1	159	2.7	134	49.1	602
Radish	2.6	59	0.7	21	0.7	36	0.1	6	4.1	121
Onion	3.5	84	0.5	9	0.2	4	0.5	13	4.7	111

Source: Consultants Field Survey, 2011

Major cash crops production in the area is chilli, ginger, garlic and turmeric. Area and production of cash crops production is presented below in **Table 14.16**.

Table 14.16: Cash Crop Production

Cash Crop	Chitwan		Makawanpur		Bara		Parsa		Total	
	Area (ha)	Product ion (qtl)	Area (ha)	Product ion (qtl)	Area (ha)	Product ion (qtl)	Area (ha)	Product ion (qtl)	Area (ha)	Product ion (qtl)
Chilli	0.4	6	0.2	3	0.1	2	1.1	3	1.7	14
Ginger	0.7	8	0.6	11	0.0	0	0.0	0	1.3	19
Garlic	1.4	15	1.0	13	0.0	0	0.1	4	2.5	33

Source: Consultants Field Survey, 2011

14.7.5 Food Sufficiency Status

A large proportion of the households reported food deficit for part of the year. About 26 percent households have year round food sufficiency and plus. Likewise about 55 percent of the households have sufficient food for less than 3 months a year from their farm products. **Table 14.17** presents the food security status.

Table 14.17: Food Sufficiency Status of Project Area Households (%)

District	12 month & Plus	9 to 12 months	6 to 9 months	3 to 6 months	Below 3 months
Chitwan	41.53	6.44	2.39	2.15	47.49
Makawanpur	17.50	10.00	5.36	5.71	61.43
Bara	24.08	7.36	4.35	4.68	59.53
Parsa	16.87	13.90	7.69	6.20	55.33
Overall	25.91	9.49	4.93	4.57	55.10

Source: Consultants Field Survey, 2011

14.8 Basic Utilities and Services

14.8.1 Drinking Water and Sanitation

Majority of the sample households in the project area have deep well/tube well and piped water supply as the major sources of drinking water. About 2 percent households have reported the use of other source as drinking water sources. **Table 14.18** shows the drinking water facility in the project area.

Table 14.18: Sources of Drinking Water (%)

Districts	Pipe Tap	Deep well/Tube well	Others	Total
Chitwan	6.68	91.89	1.43	100.00
Makawanpur	68.57	29.29	2.14	100.00
Bara	37.79	58.86	3.34	100.00
Parsa	2.23	96.77	0.99	100.00
Overall	24.41	73.73	1.86	100.00

Source: Consultants Field Survey, 2011

The status of sanitation in the region is reflected in terms of toilet facility. It is found that about 77 percent households have toilet facility. Among the total households, about 61 percent households have modern toilet where about 13 percent households have pan toilet in this road section. Still about 23 percent households are using open place for defecation. **Table 14.19** presents the toilet facility in the study area.

Table 14.19: Toilet Facility (%)

Districts	Pit	Pan	Modern	No Toilet	Total
Chitwan	3.58	11.69	80.67	4.06	100.00
Makawanpur	2.86	20.36	71.79	5.00	100.00
Bara	1.67	14.38	42.47	41.47	100.00
Parsa	0.25	8.93	48.39	42.43	100.00
Overall	2.07	13.20	61.46	23.27	100.00

Source: Consultants Field Survey, 2011

14.8.2 Energy Use

Most of the people in the project area use fuel wood for cooking and electricity for lighting purpose. Fuel wood is the major source of cooking energy for the majority of the households in the project area. About 61 percent households are depending on fuel wood for cooking. **Table 14.20** presents the sources of energy for cooking.

Table 14.20: Sources of Energy for Cooking (%)

Districts	Fuelwood	Kerosene	Bio-Gas Plant	LP Gas	Others	Total
Chitwan	36.99	0.24	11.93	50.84	0.00	100.00
Makawanpur	38.57	1.07	5.36	55.00	0.00	100.00
Bara	96.66	2.01	0.33	1.00	0.00	100.00
Parsa	77.17	1.49	1.24	18.61	1.49	100.00
Overall	60.67	1.14	5.07	31.76	0.43	100.00

Source: Consultants Field Survey, 2011

Electricity is the main source of lighting energy which contributes about 91 percent. Other sources of lighting energy are kerosene and Tukimar (Battery Lamp). Table 13.20 shows the sources of energy used for lighting purpose.

Table 14.21: Sources Energy for Lighting (%)

Districts	Kerosene	Electricity	Tukimara	Others	Total
Chitwan	2.86	94.99	1.67	0.48	100.00
Makawanpur	1.79	96.79	0.71	0.71	100.00
Bara	13.04	86.62	0.33	0.00	100.00
Parsa	12.66	87.34	0.00	0.00	100.00
Overall	7.64	91.36	0.71	0.29	100.00

Source: Consultants Field Survey, 2011

14.9 Status of Women & Disadvantaged Group

It is widely reported that women are discriminated and exploited by their own family members. Due to seasonal absence of males who out-migrate temporarily to other parts of the county and India in search of seasonal job, women carry out both household and outside farm related works. Many women of the area have no property in their name. The educational status of women is lower with comparison to male. The society also imposes restrictions on the mobility of women and their participation in the public sphere. The literacy rate of women is significantly low in the area with compare to men.

The participation of women is higher in traditional type of works such as water fetching, fodder collection, cooking, childcare etc. Much of the decision making falls within the male domain. It distinctly shows the overwhelming male dominance in terms of decision-making in the area.

The lower caste group (Dalits) is the most disadvantaged group in the area. Dalits are highly marginalized group because of lack of education, job opportunity, economic condition, health facilities as compared to other ethnic groups. Dalits are marginal landholders or landless people who mostly depend on their traditional occupation and agriculture. Among them, Dalit women become double victims, one by patriarchy and another by untouchability. Both practices are deep rooted and have significantly disadvantaged Dalit women. Most of Dalit parents, in lack of awareness and poverty, do not send their daughters to school.

14.10 Loss of Assets

Land and assets acquisition and compensation of this road section have already been settled during Road Maintenance and Development Project period. Therefore, additional assets acquisition do not need for the proposed upgrading works.

14.11 Public Consultation

The study team has visited and consulted with people living within the zone of influence, key informants and other relevant people of the project area. The concerned VDCs and Municipality person were consulted to identify the district transport status and other relevant issues. District Administration Office and District Development Office were consulted to collect relevant secondary information.



Photograph: Public consultation in Chitawan

14.11.1 Methods of Public Consultation

The task of public consultation was carried out during the project preparation. Individual consultations as well as group discussions were held in different places of the project area. The consulted persons were primarily included the VDC, Municipality personnel, political representatives and the concerned local stakeholders like common people, businesspersons, school teachers, local notables, women and social activists. Relevant issues raised in the consultations will be incorporated into the project design.



Photograph: Public consultation in Parsa

14.11.2 Scope of Consultation

The scope of consultation, especially with the local people and project affected population was focused to inform them about the nature of project and its activities. During the consultation, information was also shared about the possibilities of acquisition of private assets by paying compensation. In addition, along with information dissemination the consultation also aimed at taking people's opinion and suggestions on the project and its impact.



Photograph: Public Consultation in Bara

14.11.3 Issues Raised in Public Consultation

None of the private and public assets are located within the proposed road construction width of this road section. The major concern is that the road has to be made better. The community people are committed to support the project if they are consulted and participated

in the construction period. Local people have shown interest for employment opportunity during construction period.

One of the major and common issues raised in the consultation was the construction of overhead bridge and foot path in the major bazaar areas. Likewise participants were aware for environmental pollution and were suggesting for the green belt in the road corridor.

During the consultation another major issue was demand for the compensation of structure which was destroyed by the department of roads in 2058 BS in Piparasimara VDC of Bara district. Likely the participants of Amlekhgunj, Jitpur, Rampurtokani, Lipinimal, Bahuwari VDCs raised the issue of compensation for their previously damaged assets. In Hetauda municipality people were positive for the bypass road as there were clustered houses in the market areas. Participants of the public consultation in Bharatpur and Ratnanagar municipality suggest for the coordination with drinking water, electricity, telephone, and drainage department during construction period for the proper management of public utilities.



Photograph: Public Consultation in Makawanpur

14.12 Social Mitigation and Monitoring

14.12.1 Impact & Effect Monitoring

The Environmental Management Action Plan (EMAP) in the Initial Environmental Examination (IEE) document, referring equally to the social issues associated with the proposed road project has pre-defined a set of objectively and easily verifiable indicators against which the project's effect on the social environment will be monitored. The monitoring will use the baseline information obtained during the survey and the impact screening while conducting the IEE for the upgrading of the proposed road, and compare the data obtained during the monitoring activities carried out during the construction and the operation phase at pre-determined schedules. The Social Supervision Consultant, being responsible together with the Contractor and the Site Engineers will report to Geo-environment and Social Unit of Department of Roads on identified deviation from the determined environmental standards and safeguard measures which are incorporated in the EMAP, and ensure that corrective measures are undertaken without delays.

14.12.2 Compliance Monitoring

During the construction phase the Social Supervision Consultant will carry out a regular monitoring on all activities carried out by the Contractor. The Consultant will assess the

degree of compliance by the Contractor with all social safeguard measures that are incorporated in the clauses of the contract document. It will be also monitored whether the Contractor's performance is in line with the Environmental Code of Good Practice. The Supervision Consultant will report to the Site Engineer and to GESU/DOR on observed deviations from the determined socially acceptable standards and safeguard measures which are incorporated in the EMAP, and ensure that corrective measures are undertaken without delays. The monitoring will make the assistance particular in compliance with the assets acquisition and compensation by the DOR, as well as implementation of the proposed Vulnerable Community Development Plan to ensure the proper addressing of assistance to disadvantaged groups.