Ministry of Road Transport
and Highways
National Highways and
Infrastructure Development
Corporation Limited

Japan International
Cooperation Agency (JICA)

Preparatory Study for North East Road Network Connectivity Improvement Project (Phase 2)

Draft Final Report
- NH40 -

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Nippon Engineering Consultants Co., Ltd.

【Note】

The information related to bidding has been deleted.

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List of Abbreviations and Acronyms

AADT	Average Annual Daily Traffic
AC	Asphalt Concrete
ADB	Asian Development Bank
AH	Asian Highway
BOT	Build-Operate-Transfer
BRDB	Border Roads Development Board
BRO	Border Roads Organization
CAGR	Compound Annual Growth Rate
CBR	California Bearing Ratio
CC	Cement Concrete
CPCB	Central Pollution Control Board
CCEA	Cabinet Committee on Economic Affairs
CRF	Central Road Fund
CTCS	Classified Traffic Count Survey
DBFO	Design-Build-Finance-Operate
DBST	Double Bituminous Surface Treatment
DPR	Detailed Project Report
ESC	Environment and Social Consideration
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rates of Return
EMMP	Environmental Mitigation and Monitoring Plan
EMP	Environment Management Plan
EPC	Engineering-Procurement-Construction
F/S	Feasibility Study
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GOI	Government of India
GOJ	Government of Japan
GQ	Golden Quadrilateral
GSDP	Gross State Domestic Product
GS Road	General Staff Road (for defense requirements)
HFL	High Flood Level
IAHE	Indian Academy of Highway Engineers
ICB	International Competitive Bidding
IEE	Initial Environmental Examination
INR	Indian Rupee
IPP	Indigenous Peoples Plan
IRC	Indian Road Congress
IRI	International Roughness Index
ISC&EI	Inter State Connectivity and Economic Importance
IWAI	Inland Waterways Authority of India
IWT	Inland Water Transport

JICA	Japan International Cooperation Agency
KP	Kilo Post
LCV	Light Commercial Vehicle
MDONER	Ministry of Development of North Eastern Region
MDR	Major District Road
MDB	Multilateral Development Bank
MEA	Ministry of External Affairs
MOEF	Ministry of Environment and Forests
MOEFCC	Ministry of Environment, Forests and Climate Change
MORTH	Ministry of Road Transport and Highways
NE	North-East
NEC	North-East Council
NER	North-Eastern Region
NH	National Highway(s)
NHAI	National Highways Authority of India
NHDP	National Highways Development Project
NHIDCL	National Highways and Infrastructure Development Corporation
NHIIP	National Highway Interconnectivity Improvement Programme
NITHE	National Institute for Training of Highway Engineers
NSDP	Net State Domestic Product
OD	Origin Destination
PAP	Project Affected Person
PCI	Per Capita Income
PCU	Passenger Car Units
PHF	Peak Hour Factor
PM	Penetration Macadam
PPP	Public-Private-Partnership
PWD	Public Works Department
RAP	Resettlement Action Plan
RO	Regional Office
R&IPDP	Resettlement and Indigenous People Development Plan
ROW	Right of Way
RSI	Roadside Interview
RSMP	Road Sector Modernization Program
SARDP-NE	Special Accelerated Road Development Programme for North-East
SBST	Single Bituminous Surface Treatment
SDP	State Domestic Production
SEIA	Summary Environmental Impact Assessment
SEZ	Special Economic Zone
SH	State Highway
SIA	Social Impact Assessment
SPCB	State Pollution Control Board
ST	Scheduled Tribe
STR	Strategic Road
SVF	Seasonal Variation Factors

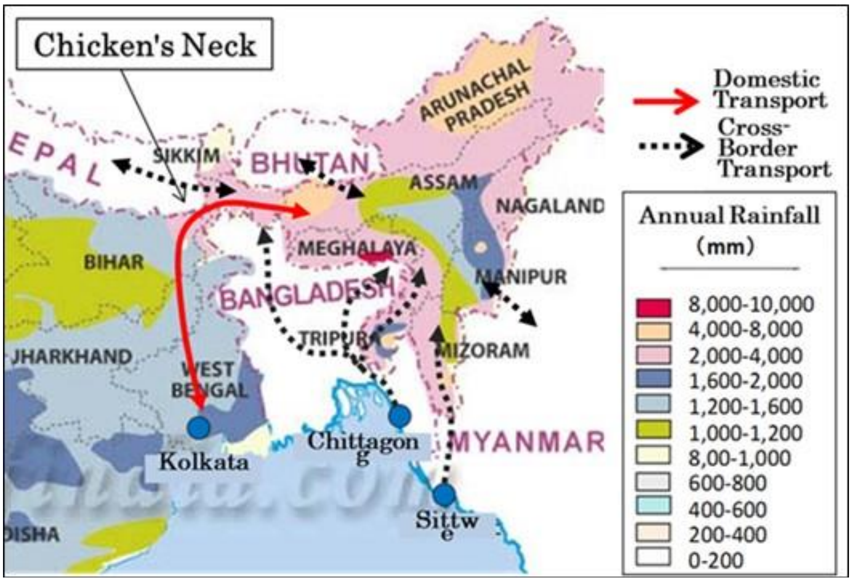
TA	Technical Assistance
TOR	Terms of Reference
TTC	Travel Time Cost
UN ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
V/C	Vehicle Capacity Ratio
VGF	Viability Gap Funding
VOC	Vehicle Operating Cost
WB	World Bank

CHAPTER 1 INTRODUCTION

1.1 Background of Study

The development of the road network in North-East (NE) states of India is of utmost importance in the country. The NE states (Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, and Arunachal Pradesh) are located far from the mainland of India, connected by a “chicken’s neck” surrounding Bangladesh. Cross-border trade agreements with Bangladesh and Myanmar have yet to be enacted. Therefore transit cargoes must change trucks and go through import/export procedures at the border, which increases the freight cost.

In India, the development of National Highways (NH) in the mainland has been progressing while those in NE states have been stagnant due to insufficient budget and technical difficulty. Only 28.5% of the road is paved (national average is 63.4%) and only 53% of the NH has more than 2 lanes (national average is 77.9%). Some parts of the area have a yearly precipitation of more than 10,000 mm that results in frequent landslides and road blocks, hindering smooth cargo transportation and economic development of the area.



Source: JICA Study Team

Figure 1-1: North-East States Annual Rainfall

In order to improve the present situation, the Government of India (GOI) has set a Special Accelerated Road Development Programme for North-East (SARDP-NE) under the 12th five year plan (April 2012-March 2017), aiming to develop the national road network between the major cities in the area. It is also considered one of the important policies by the Modi administration.

Japan International Cooperation Agency (JICA) has conducted “the Information Collection Survey on Cross Border Transport Infrastructure Improvement in South Asia” in 2013, and made recommendations to strengthen the connectivity in the region and improve the relevant infrastructure. In light of many existing difficulties on the trade routes between the northeastern states and other regions, road developments of several routes are proposed.

Under these circumstances, GOI has requested loan assistance to the Government of Japan (GOJ) for improvement of eight existing roads (total length of 1,242 km), and rehabilitation of two existing bridges, and one new bridge in the NE states. JICA conducted the Preparatory Study for Road Network Improvement in NE States of India (hereinafter referred to as Phase 1) including 1) prioritization of the proposed projects for Japanese ODA loans by analyzing the current conditions, 2) collection and analysis of data for top two priority projects and review of F/S conducted by India, and 3) examination of the top two priority projects as candidates for Japanese Official Development Assistance (ODA) loans.

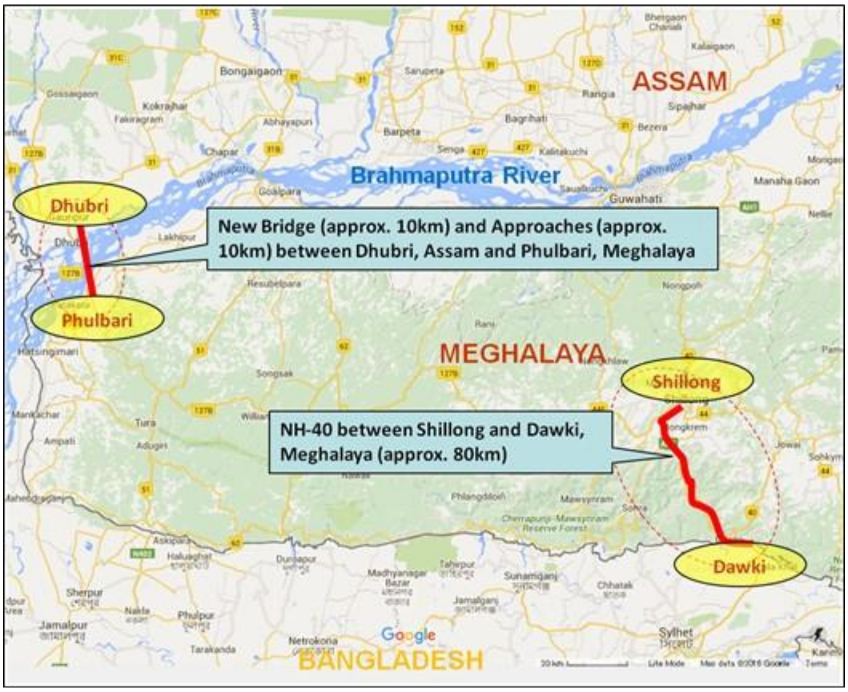
Nh54 and NH51 have been selected as the top two priority projects to conduct study. As the result it was identified that NH54 contained sections that might suffer huge social environment impact from the road expansion. Four bypassed for built-up sections with pavement improvement (10 m width) for the existing sections have been proposed and the additional study was conducted.

This preparatory study is a phase 2 (hereinafter referred to as Phase 2) following the Phase 1 targeting NH40 and Dhubri Bridge as the candidates to conduct a necessary study for loan evaluation as Japanese ODA including project costs, implementation plan, maintenance and operation structures, environmental and social considerations, etc.

It is expected that the first loan evaluation package will include NH54 and NH51, the second NH54 bypasses and Nh40, to be followed with Dhubri Bridge.

1.2 Outline of the Project

The locations and outline of the Project are shown below.



Source: JICA Study Team

Figure 1-2: Project Locations

Table 1-1: Tentative Outline of the Project

Project Name	Road Network Improvement in North-East States of India (Phase 2) (hereinafter referred to as "the Project")
Project Objectives	The Project aims at improving the road connectivity within the North-East region of India and with other areas by improving and constructing national highways (including bridges) in the region, thereby contributing to the economic development in the region.
Project Overview	① Improvement of the national highway 40 (approx. 80km) between Shillong and Dawki in Meghalaya ② Construction of a new bridge connecting Dhubri, Assam and Phulbari, Meghalaya (bridge length: approx. 10km, approaches: approx. 10km)
Project Area:	North-East States of India
Counterpart (C/P) Agencies	Ministry of Road Transport and Highways (MoRTH) National Highways and Infrastructure Development Corporation Limited (NHIDCL)

Note: Phase 2 does not include construction of a new bridge connecting Dhubri, Assam and Phulbari, Meghalaya.
Source: JICA Study Team

1.3 Objectives of Study

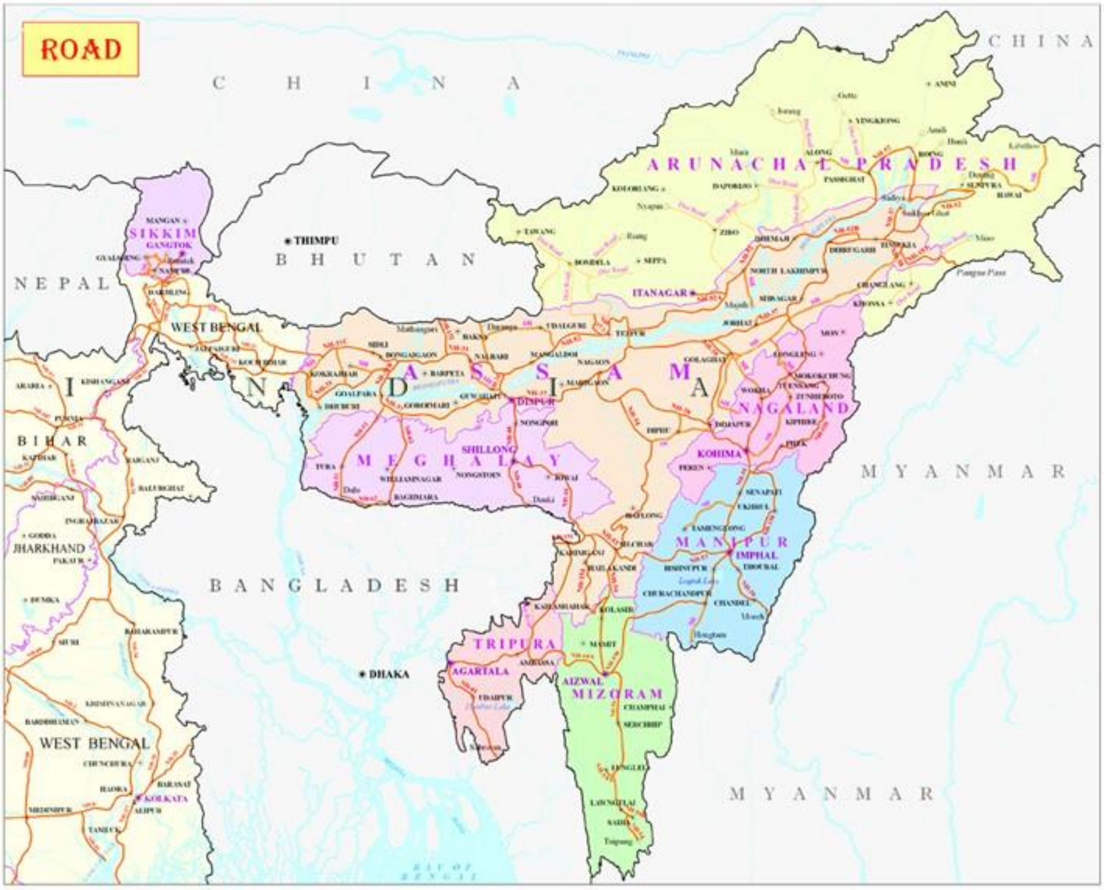
The objectives of the study are to develop a project plan including the project purpose and outline, project costs, implementation plan, maintenance and operation structures, environmental and social considerations, etc. This will provide the GOJ with the basis for loan evaluation as Japanese Official Development Assistance (ODA), in response to the GOI's loan request.

CHAPTER 2 PRESENT CONDITION OF STUDY ROADS

2.1 Present Status of Roads and Transport in Study Area

2.1.1 National Highway Network in NE States

The total length of NH in NE is 13,258 km and these are being developed and maintained by the state Public Works Department (PWD), Border Roads Organization (BRO), National Highways Authority of India (NHAI) and National Highways and Infrastructure Development Corporation (NHIDCL) under the Ministry of Road Transport and Highways (MORTH). Of the total length of 13,258 km, about 12,476 km is with the NHIDCL and respective state's PWD. The remaining length of 782 km is with NHAI. The Ministry has been paying special attention to the development of NH in the North-East region (NER) and 10 % of the budget allocation is earmarked for NER. The NH network mainly connects state capitals and major districts, as well as the international cross border network as shown in Figure 2-1.



Source: Ministry of Development of North Eastern Region

Figure 2-1: National Highway Network in NER

The details of NH and their development and maintenance works taken up under various schemes during the Fiscal Year 2014-15 in NER are as follows:

(i) Length under National Highway Development Project (NHDP) Phase-III 110 km

(ii) Length of NH, state roads under SARDP-NE, Phase A: 4,099 km, Phase B: 2,392 km, Arunachal Pradesh package of Roads and Highways: 2,319 km

The current status of NH in each state in NE is shown in Table 2-1.

Table 2-1: Numbers and Lengths of National Highways in NE States

No.	Name of State	National Highway No.	Total Length (km)
1	Arunachal Pradesh	52, 52A, 153, 229, 52B Ext, 37 Ext, 315 New, 713 New, 513 New, 313 New, 113 New, 713A New	2513.05
2	Assam	6 New, 31, 31B, 31C, 36, 37, 37A, 37E, 38, 39, 44, 51, 52, 52A, 52B, 53, 54, 61, 62, 117A New, 127B New, 127E New, 151, 152, 153, 154, 315A New, 127C New, 127D New, 329 New, 427 New, 627 New, 702 New, 702B New, 702C New, 702D, 715A New	3811.67
3	Manipur	39, 53, 102 New, 102A New, 102B New, 102C New, 129A New, 108A New, 129 New, 137 New, 137A New, 150, 155, 702A New	1545.74
4	Meghalaya	40, 44, 51, 62, 127B New	1204.36
5	Mizoram	6 New, 44A, 54, 54A, 54B, 102B New, 150, 154, 302 New, 306A New, 502A New	1381.00
6	Nagaland	36, 39, 61, 129 New, 150, 155, 702 New, 702A New, 702B New, 702D	1150.09
7	Tripura	44, 44A, 108A, 208 New, 208A New, 108B New	805.0

Source: MORTH Annual Report 2015-16

2.1.2 Transport Infrastructure Development Projects in NER

The GOI has focused on time-bound completion of critical transport infrastructure of NER, viz. road, rail, inland water transport (IWT), airport and air connectivity. Some of the critical ongoing projects are; (i) East West Corridor (Srinampur to Silchar), (ii) SARDP-NE, (iii) Bogibeel Bridge, (iv) Railway gauge conversion (Lumding-Silchar and Rangia-Murkong selek), (v) New railway lines (Jiribam-Tupul-Imphal), (vi) Airport hangers in the Lokapriya Gopinath Bordoloi International Airport (Guwahati). The GOI has also proactively taken initiatives for promoting linkages with other parts of the country and for close bilateral relations with the neighboring countries and other South East Asian countries in pursuance of the ‘Act East Policy’. Establishing closer ties between India and Bangladesh will also go a long way in promoting peace and development in the NER.

2.2 Present Status of National Highway Development

2.2.1 Organizations Related to National Highway Development

(1) Ministry of Road Transport and Highways (MORTH)

The MORTH was formed in 2009 by bifurcating the erstwhile Ministry of Shipping, Road Transport and highways into two independent Ministries. The MORTH encompasses construction and maintenance of NH, administration of Motor Vehicles Act, 1988 and Central Motor Vehicles Rules 1989, formation of broad policies relating to road transport, environmental issues, automotive norms, fixation of use fee rate for use of NH, etc., in addition to making arrangements for cross-border movement of vehicular traffic with neighboring countries.

(2) National Highways Authority of India (NHAI)

Source: NHAI

Figure 2-2: NHAI Logo

The NHAI was set up through an Act of Parliament, namely the National Highways Authority of India Act, 1988. It is responsible for the development, maintenance and management of NH entrusted to it by MORTH and for matters related or incidental thereto. The NHAI became operational in February, 1995. As on March 31, 2015, out of total 55,561 Km. of national highway that are planned to be developed/ upgraded by NHAI, 32,620 Km. (excluding terminated contracts) of national highway have been awarded, of which 23,866 Km. have been completed and 8,754 Km. are in progress. Projects for 18,012 Km. is to be awarded in due course.

(3) Indian Academy of Highway Engineers (IAHE)

Source: IAHE

Figure 2-3: IAHE Logo

Indian Academy of Highway Engineers (IAHE) is a registered society under the administrative control of MORTH. It changed the name from National Institute for Training of Highway Engineers (NITHE) in 2010. It is a collaborative body of both central and state governments and was set up in 1983 with the objective of fulfilling the long-felt need for training of highway engineers in the country, both at the entry level and during the service period. IAHE offers about 80 traiing cources for about 1,700 trainees on wide area s related to roads from planning, construction, maintenance, quality control, road safety, contract management, ITS, etc. A new training building and facilities were built in Noida, UP, on 1st October 2001. The training facilities include an air-conditioned lecture hall, lecture rooms, a library, a conputor room, a material testing training room, lodgings with a canteen and a leisure room, a faculty rooms, etc. IAHE has been adding facilities according to the growing demand of training.

(4) National Highways & Infrastructure Development Corporation LTD (NHIDCL)

Source: NHIDCL

Figure 2-4: NHIDCL Logo

In February 2014, the Cabinet approved the set up and operation of a new corporate entity under MORTH to exclusively carry out the task of construction / up-grading / widening of NH in parts of the country, which share international boundaries with neighboring countries so as to promote regional connectivity with neighboring countries on a sustainable basis. An approximate aggregate length of 10,000 kms has been identified to begin with for development through this company. The company also proposes to improve road connectivity and efficiency of the international trade corridor, by expanding about 500 KMs of roads in the North Bengal and Northeastern region of India to enable efficient and safe transport regionally with other South Asia Sub-regional economic Cooperation (SASEC) member countries. These projects are being funded by ADB (Asian Development Bank).

(5) Indian Roads Congress (IRC)

Source: IRC

Figure 2-5: IRC Logo

Indian Roads Congress (IRC) is the apex body of road sector engineers and professionals in India. IRC was formally registered as a society in 1937. IRC has more than five million associates (direct/indirect) and over 16,700 registered members comprising of engineers & professionals of all Stakeholders of road sector. IRC have published Codes of Practices for Specifications & Standards, Special Publications on Guidelines and Manuals, publications on behalf of MORTH, and other informative publications for road-related public organizations. In December 2015, IRC 76th Annual Session was held in Indore, which had about 2,000 people attendances from public and private sector in the road industry.

2.2.2 Development Programs for National Highways

(1) Outline of Road Network in India

India has one of the largest road networks in the world with over 5,232,000 km of roads. It is comprised of NH, expressways, state highways (SH), Major District Roads (MDR), Other District Roads and Village Roads. Historically, investments in the transport sector have been made by the Government. However, to encourage private sector participation, the Ministry has laid down comprehensive policy guidelines for private sector participation in the development of NH. Categories of roads and corresponding lengths of overall road network of India are shown in Table 2-2.

Table 2-2: Categories and Lengths of Road Network of India

No.	Category	Length (km)
1	National highways / Expressways	100,475
2	State highways	148,256
3	Other Roads	4,983,579
	Total	5,232,310

Source: MORTH Annual Report 2015-16

(2) Present Status of Each NH Development Programs

The MORTH has been entrusted with the responsibility of the development of road transport and highways in general, and construction and maintenance of NH in particular. All roads other than NH in the states fall within the jurisdiction of respective state governments. In order to assist the state governments in the development of state roads, MORTH provides financial assistance out of the Central Road Fund (CRF) and Inter State Connectivity and Economic Importance (ISC&EI) scheme. Besides National Highways Development Project (NHDP) and National Highway Interconnectivity Improvement Programme (NHIIP), MORTH is implementing SARDP-NE and Development of Roads in Left Wing Extremism (LWE) schemes, which includes NH and state roads. The MORTH is also responsible for evolving standards and specifications for roads and bridges in the country besides acting as a repository of technical information on roads and bridges. The present status of each NH development programs is shown in Table 2-3 below.

Table 2-3: Present Status of NH Development Program 31st December, 2015 (km)

Program Name	Total Length	Completed	Completed In 2015
NHDP	54,478	24,324	1233
I: GQ,EW-NS Corridors, Port Connectivity, Others	7,522	7,521	1
II: 4/6-laning North South-East West Corridor, Others	6,647	5,903	48
III: Upgrading, 4/6-laning	12,109	6,734	252
IV: 2-laning with Paved Shoulders	20,000	1,825	709
V: 6-laning of GQ and High Density Corridor	6,500	2,319	223

VI: Expressways	1,000	0	0
VII: Ring Roads, Bypasses, Flyovers, Others	700	22	0
SARDP-NE	6,190	1,829	82
LWE	5,422	3,904	334
NHIIP	1,120	239	157

Source: MORTH Annual Report 2015-16

(3) National Highways Development Project (NHDP)

NHDP Phase I and II comprise of the development of NH to 4/6 lane standards. The developments are (a) Golden Quadrilateral (GQ) connecting 4 major metropolitan cities viz. Delhi-Mumbai-Chennai-Kolkata, (b) North South & East West Corridors (NS-EW) connecting Srinagar to Kanyakumari and Silchar to Porbandar with a spur from Salem to Cochin, (c) Road connectivity of major ports of the country to NH, and (d) Other NH stretches.

NHDP Phase I, which was approved by the Cabinet Committee on Economic Affairs (CCEA) in December 2000 at an estimated cost of Rs. 303 million (1999 prices) comprises 5,846 km of GQ, 981 km of NS-EW Corridor, 356 km of Port Connectivity and 315 km of other NH, a total of 7,522 km. This was completed in 2015.

NHDP Phase II, which was approved in December 2003 at an estimated cost of Rs. 343 million, comprises mostly NS-EW Corridor (6,151 km) and other NH of 486 km length, the total length being 6,647 km. Out of the balance, 48 km was completed in 2015.

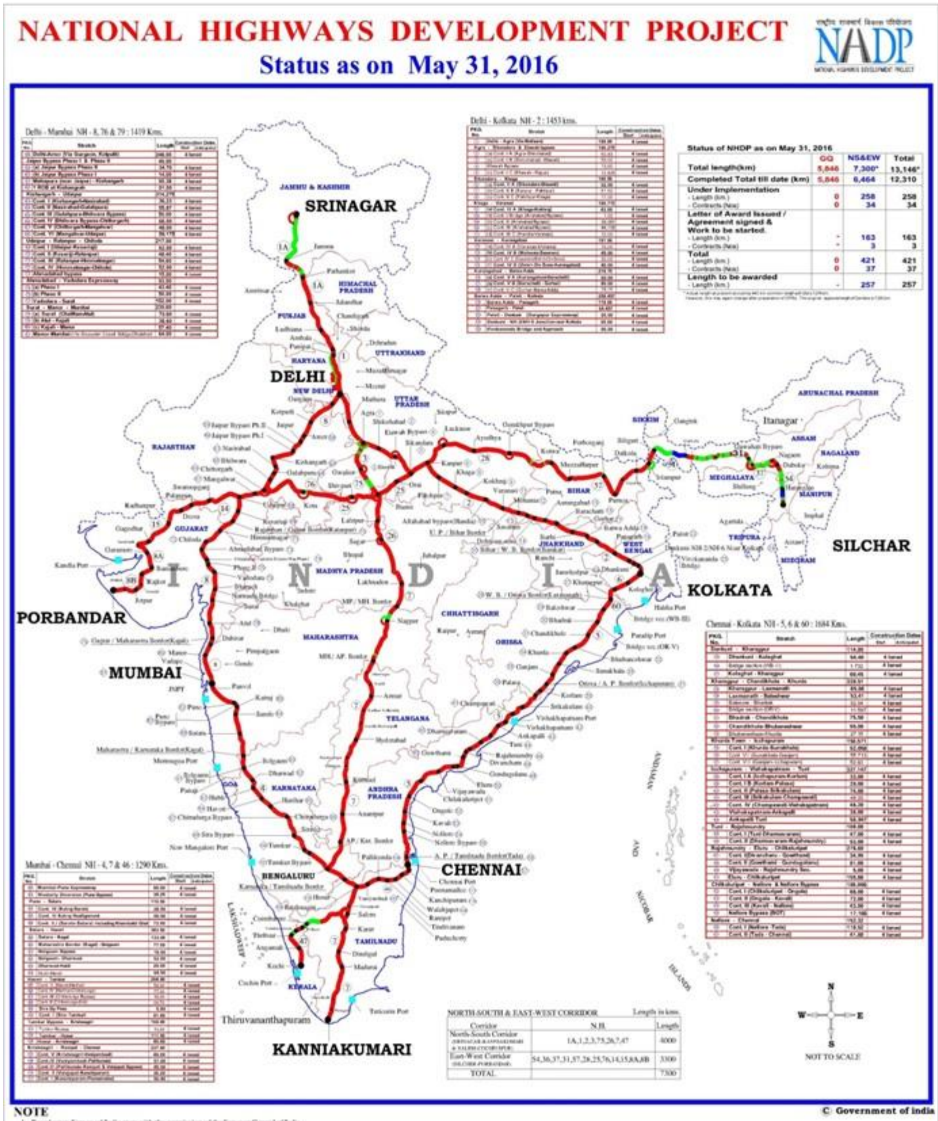
NHDP Phase III covers the 4-laning of 4,000 km of NH on Build-Operate-Transfer (BOT) basis and was approved in March 2005. Additional sections have been added in the following years and so far 12,109 km has been identified at an estimated cost of Rs. 806 million. By December 2015, 6,734 km of the 12,109 km has been four laned and an additional 3,313 km is under implementation. During the year of 2015, 252 km has been completed.

NHDP Phase IV envisages upgrading of about 20,000 km of NH to 2-lane paved shoulder at an estimated cost of Rs. 850 million. This phase was approved in July 2008. Out of the total, 13,203 km is entrusted to NHAI. A length of 1,825 km has already been four/two laned up to the end of 2015 and 4,704 km is under implementation. During the year 2015, 709 km have been completed.

NHDP Phase V comprises 6-laning of 6,500 km of existing 4-lane NH with approval in October 2006 at an estimated cost of Rs. 4,121 million. Six laning of 6,500 km includes 5,700 km of GQ and 800 km of other stretches. Of the 6,500 km, a length of 2,319 km has already been 6-laned by the end of 2015 and a length of 1,756 km is under implementation. During the year of 2015, total length of 223 km has been completed.

NHDP Phase VI envisages development of 1,000 km of fully access-controlled expressways under the Public Private Partnership (PPP) model following a Design-Build-Finance-Operate (DBFO) approach. This phase was approved at an estimated cost of Rs. 1,668 million in November 2006. It is planned that Rs. 900 million will come from private sector and the balance Rs. 768 million will be government funding for bridging the viability gap as well as meeting the cost of land acquisition, utility shifting, consultancy, etc.

NHDP Phase VII covers the construction of standalone ring roads, bypasses, grade separators, flyovers, elevated roads, tunnels, road over bridges, underpasses, service roads, etc., with a BOT (Toll) model. This phase was approved in December 2007 at an estimated cost of Rs. 1,668 million.

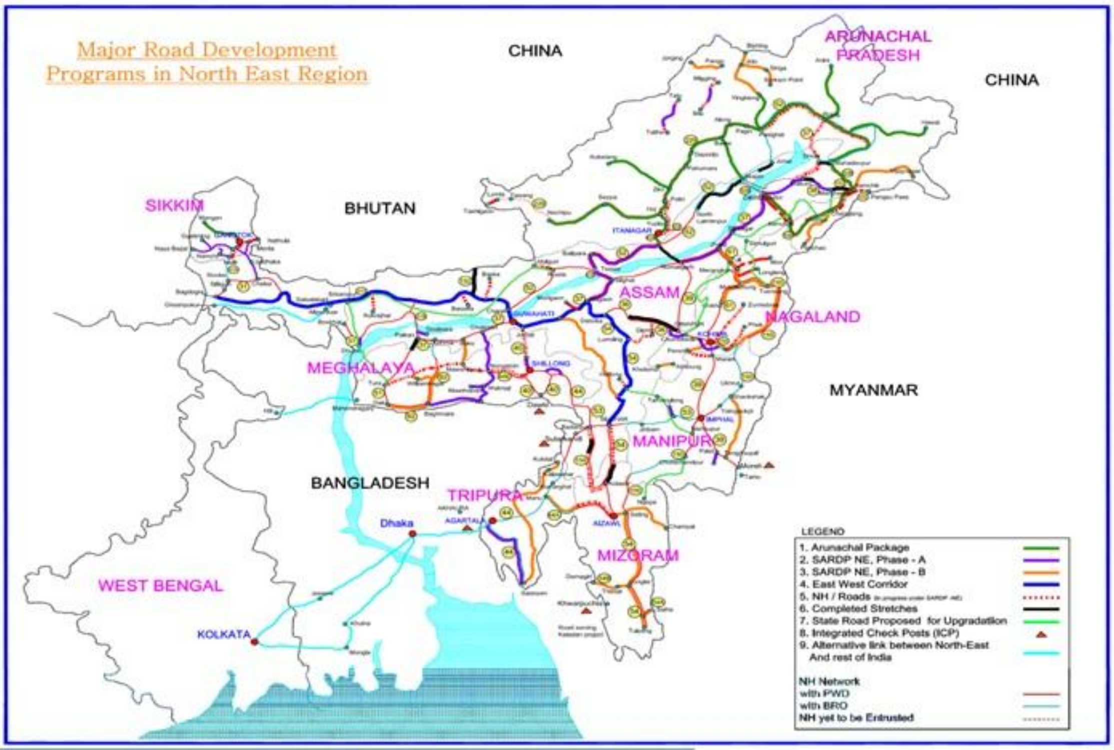


Source: NHAI

Figure 2-6: National Highway Development Project (as of May 31, 2016)

(4) Special Accelerated Road Development Programme for the North Eastern Region (SARDP-NE)

SARDP-NE aims at improving road connectivity of district headquarters and remote places of NER with state capitals. It envisages 2/4-laning of about 7,530 km of NH and 2-laning/improvement of about 2,611 km of state roads. This will ensure the connectivity of 88 district headquarters in NE states to the nearest NH by at least a 2-lane road. The programme has been divided into Phase A, Phase B, and Arunachal Pradesh Package of Roads and Highways.



Source: Ministry of Development of North Eastern Region (MDONER)

Figure 2-7: Major Road Development Programs in North East Region

Phase A is the improvement of 4,099 km of roads consisting of 3,014 km of NH and 1,085 km of state roads at an estimated cost of Rs. 2,177 million. Out of 4,099 km, BRO, state PWD and NHIDCL have been assigned with the development of 3,213 km of roads at an estimated cost of Rs. 1,282 million. Of the remaining length of 886 km, 112 km is to be implemented by NHAI on BOT (annuity) basis, 20 km by Arunachal Pradesh PWD and 752 km by NHIDCL. The works are in various stages of progress and the likely date of completion for Phase A is March, 2017.

Phase B involves 2-laning of 2,392 km of NH and 2-laning/improvement of 1,331 km state roads. Phase B is approved only for DPR preparation.

The Arunachal Pradesh Package of Roads and Highways covering 2,319 km (2,205 km NH and 114 km state/General Staff Roads (GS roads)) of road stretch was approved as part of SARDP-NE on January, 2009. Out of this, 776 km has been approved for execution under BOT (Annuity) basis and approval for tendering under EPC basis has been given for the remaining 1,543 km. By December 2015, works for a total length of 1,675 km at a cost of Rs. 1,529 million have been awarded. The remaining length of 644 km is either under estimate examination or DPRs are under preparation.

(5) Development of Roads in Left Wing Extremism (LWE) Affected Areas

The GOI approved the Road Requirement Plan for the development of 1,126 km NH and 4,351 km State Roads (total 5,477 km) to 2-laning at a cost of Rs. 730 million in Left Wing Extremism (LWE) affected 34 districts in the State of Andhra Pradesh, Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Maharashtra, Odisha and Uttar Pradesh for all-inclusive growth of these areas.

MORTH has set up the LWE Division under the Chief Engineer for sanctioning and implementing the above programme through respective state PWD. The detailed estimates for 5,422 km have been sanctioned at an estimated cost of Rs. 859 million, out of which, works on 5,263 km length costing Rs. 701 million have been awarded. Development of 3,904 km has been completed up to January, 2016 and the cumulative expenditure incurred so far is Rs. 540 million. The development of roads under the programme is scheduled to be completed by March, 2017 except for the works that are yet to be awarded.

(6) National Highways Interconnectivity Improvement Projects (NHIIP)

Rehabilitation and upgrading to 2-lane roads with paved shoulders of stretches of various NH in the states of Bihar, Karnataka, Odisha, Rajasthan and West Bengal is being taken up with loan assistance from the World Bank (WB) under Phase-I of NHIIP. Eleven stretches involving 15 civil works contracts comprising a total length of 1,120 km amounting to Rs. 519 million (WB share is US$ 500 million) is envisaged in the programme. Cabinet approved the project in April, 2013. Target completion of the project is March, 2022.

The Project components include A: Road Improvement and Maintenance, B: Institutional Development Component, and C: Road Safety. The loan is to be amortized in 18 years including a 5 year grace period.

(7) National Expressway Network Plan

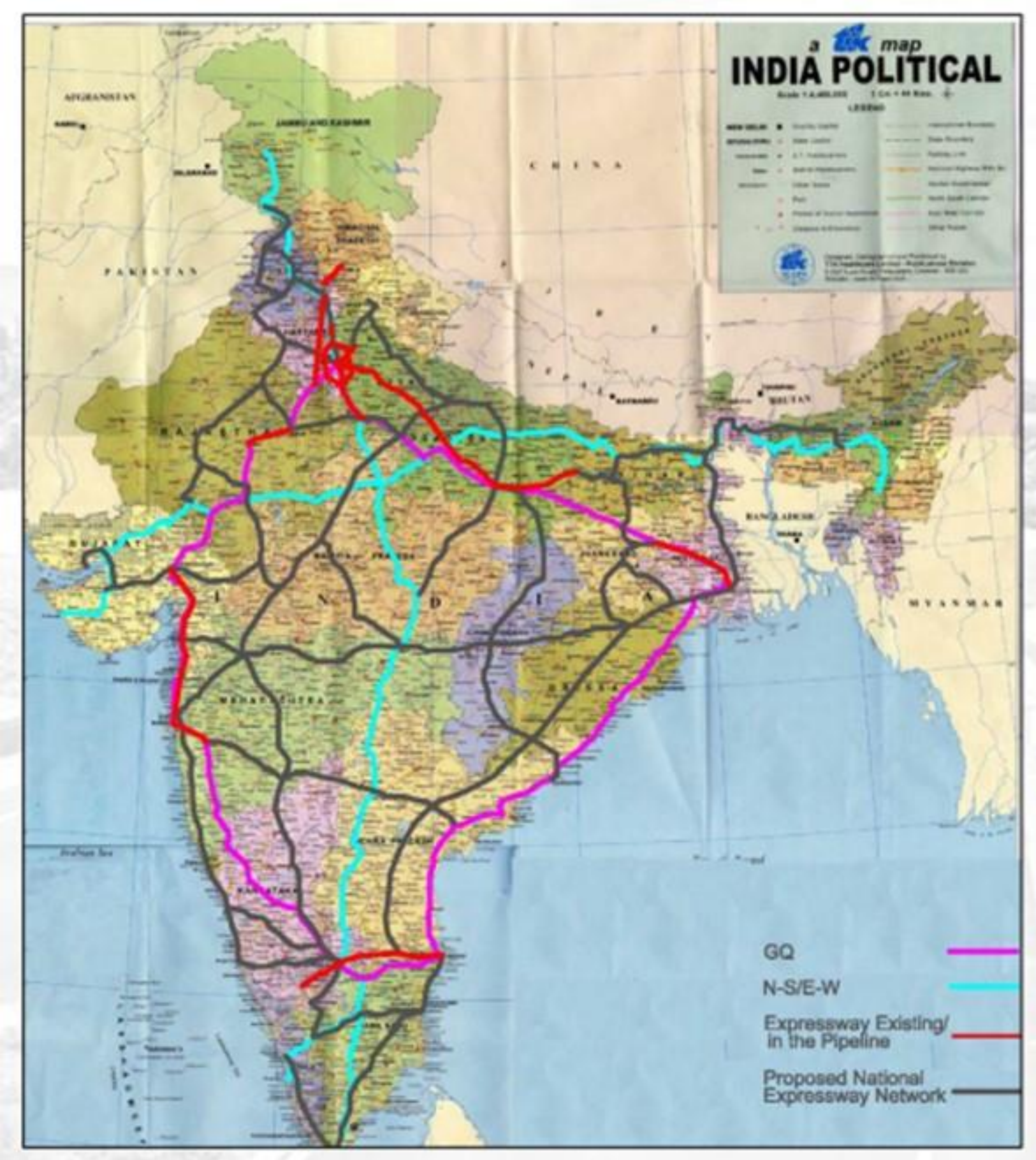
The study on the “Formation of Master Plan for Indian National Expressway Network” in 2009 highlighted the urgency of developing an expressway network in India in three phases by the year 2022. The present NH system cannot cope with the current and anticipated traffic requirements, as is already evident from the levels of congestion along the existing arterials. By all indications, roads will continue to remain the backbone of the inland transportation system.

The study having considered the existing and already proposed expressway segments in different state, revealed the need to construct 18,637 km of expressway network. The network developed shall be both supplementary and complimentary to the existing arterial network including the North - South and East - West Corridor and the GQ (beside the well-laid out network of NH).

A project is considered viable for BOT with a threshold FIRR of 12%. Results of the financial analysis have been presented in the report. The need to provide 40% Viability Gap Funding (VGF) for some segments and, the need to take up certain segments on annuity basis cannot be discounted. The study has considered the funding options of VGF of 20% with 20 years of the concession period as scenario I by adopting the Ministry’s toll rate (2008) for the purpose of prioritization of expressway segments.

Financial analysis suggests that in order to be financially viable, a link must cater to Average Annual Daily Traffic (AADT) of 25,000 passenger car units (PCU) under scenario I, while the same would be 15,000 PCU under scenario II, which has VGF of 20% with 30 years of the concession period. The expressways shall have at least 4 lane divided carriageway cross section. The Right of Way (ROW) shall be a uniform 90 m. It will be a Toll Expressway Network with toll rates as per the Ministry’s Guideline (2008).

The network shall be completed in 3 phases spanning up to 2022. In the first phase, 11 projects covering 3,530 km are awarded by 2012. In the second phase (2013-17), 4,310 km will be added. In the third phase (2018-22), another 4,310 will be added. The third phase may also see the development of an additional 5,226 km of expressways on the annuity model.



Source: MORTH

Figure 2-8: Proposed National Expressway Network

2.2.3 Cross Border Connectivity Projects in NER

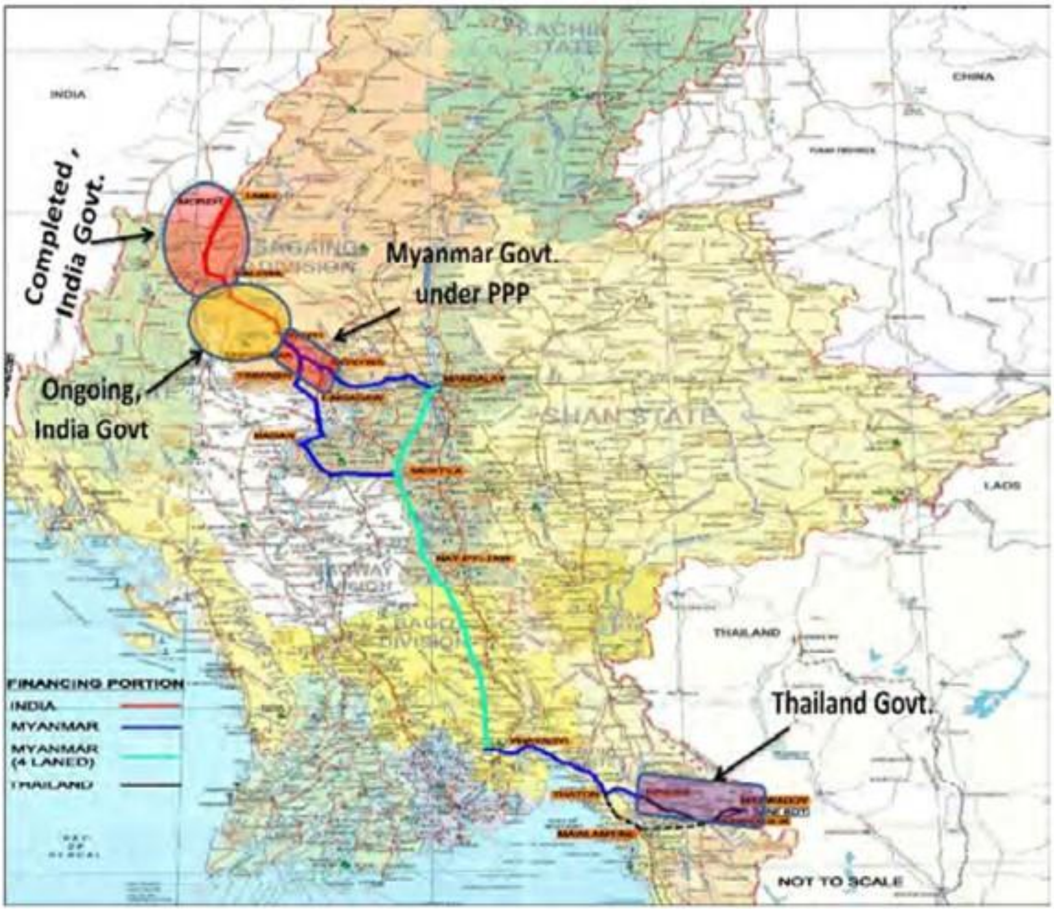
(1) Trilateral Highway Project

India has been implementing several connectivity projects in Southeast Asia to strengthen the ASEAN-India Strategic Partnership. Trilateral Highway is poised to create a new dynamic in India's multi-faceted ties with the region. With the new GOI focusing with renewed vigor on spurring the economic uplift of India's NE states, the gateway to ASEAN, enhanced connectivity promises to bring new prosperity in this region. The ASEAN-India road connectivity in the present form runs along Asian Highway (AH1) and the India-Myanmar-

Thailand Trilateral Highway.

On the Trilateral Highway, the Tamu and Kalewa friendship road is being constructed with India's assistance (Figure 2-9). About 132 km has been completed and handed over to Myanmar. Work on the other 28 km is under progress. India has also undertaken the task of repair/upgradation of 71 bridges on the Tamu-Kalewa Friendship Road, and upgradation of the 120 km Kalewa-Yargyi road segment to highway standard, while Myanmar has agreed to undertake upgradation of the Yargyi-Monywa stretch to highway standard by 2016.

This project would help in establishing trilateral connectivity from Moreh in India to Mae Sot in Thailand via Myanmar. Separately, GOI had taken initiatives to prepare DPR for construction of Chaungma-Yinmabin section (30 km); and upgradation from single lane to double lane of the Yinmabin-Pale-Lingadaw section (50 km). India has also announced the extension of the Trilateral Highway to Cambodia, Lao PDR and Vietnam.



Source: Ministry of External Affairs, GOI

Figure 2-9: Trilateral Highway Project

(2) Kaladan Multi Modal Transit Transport Project

The Kaladan Multi Modal Transit Transport Project was jointly identified by India and Myanmar to create a multi-modal mode of transport for shipment of cargo from the eastern ports of India to Myanmar as well as to the NE part of India through Myanmar. This project, which will connect Sittwe Port in Myanmar to the India-Myanmar border, is expected to contribute to the economic development of the NE states of India, by opening up the sea route for the products. It also provides a strategic link to the NE, thereby reducing pressure on the Siliguri Corridor. Since the project is of political and strategic significance, the decisions were made to execute it through India's grant assistance to Myanmar.

The Ministry of External Affairs (MEA), GOI entered into a Framework Agreement with the Government of Myanmar in April 2008 to facilitate implementation of the project. As shown in the figure below, the components of this project include (i) construction of an integrated port and IWT terminal at Sittwe including dredging; (ii) development of navigational channel along river Kaladan from Sittwe to Paletwa (158 km); (iii) construction of an IWT - Highway transshipment terminal at Paletwa; and (iv) construction of six IWT barges (each 300 tonne capacity) for transportation of cargo between Sittwe and Paletwa. The Framework Agreement and two protocols (Protocol on Transit Transport and Protocol on Maintenance) were signed by India and Myanmar on 2nd April 2008. A substantial portion of the construction of the integrated Port and IWT jetty at Sittwe is complete. Construction work of IWT terminal at Paletwa started in April 2013. The border to NH 54 (Lawngtlai) Road on the Indian side in Mizoram is in progress.

Source: IWAI

Figure 2-10: Kaladan Multimodal Transit Transport Project

(3) National Waterway-2 Brahmaputra Project

Northeast India has many large and small rivers providing facilities for water transport, especially in their plains sections. From the ancient period until roads were constructed, the Brahmaputra and Barak rivers were commonly used as the medium of transport. Especially, Brahmaputra is the life line of NER. It was declared as National Waterway-2 in 1988 for a distance of 891 km from Dhubri to Sadia. Inland Waterways Authority of India (IWAI) maintains the navigational channel at minimum 45 m width and 2.5 m depth, which is the standard for National Waterway-2.

Necessary aids for facilitating 24 hour navigation are maintained between Dhubri and Silghat while day navigation marks are provided in further upper sections of the river. Terminal facilities for loading and unloading of cargo are being maintained by IWAI at strategic locations such as Dhubri, Jogighopa, Pandu, Silghat, Neamati and Dibrugarh. Pandu (Guwahati) is being developed as a multi modal transport hub which can serve the entire NER. A permanent terminal at Dhubri in Assam is under construction with all facilities as a first important terminal on the Brahmaputra. It has been proposed to upgrade the existing temporary terminal at Jogighopa to a bulk cargo handling terminal for products like Meghalaya coal, with rail connectivity up to the terminal.

Source: MDONER

Figure 2-11: National Waterway-2 Brahmaputra Project

2.2.4 On-going Road Projects in NER by International Cooperation

There are several ongoing road projects in NER funded by international cooperation agencies as shown in Table 2-4.

Table 2-4: On-going Road Projects in NER

International Donor	Project Name
World Bank (WB)	Assam State Road Project
World Bank (WB)	Mizoram State Road Project I-II
Asian Development Bank (ADB)	North Eastern States roads Investment Program

Source: JICA Study Team

(1) Assam State Road Project (WB)

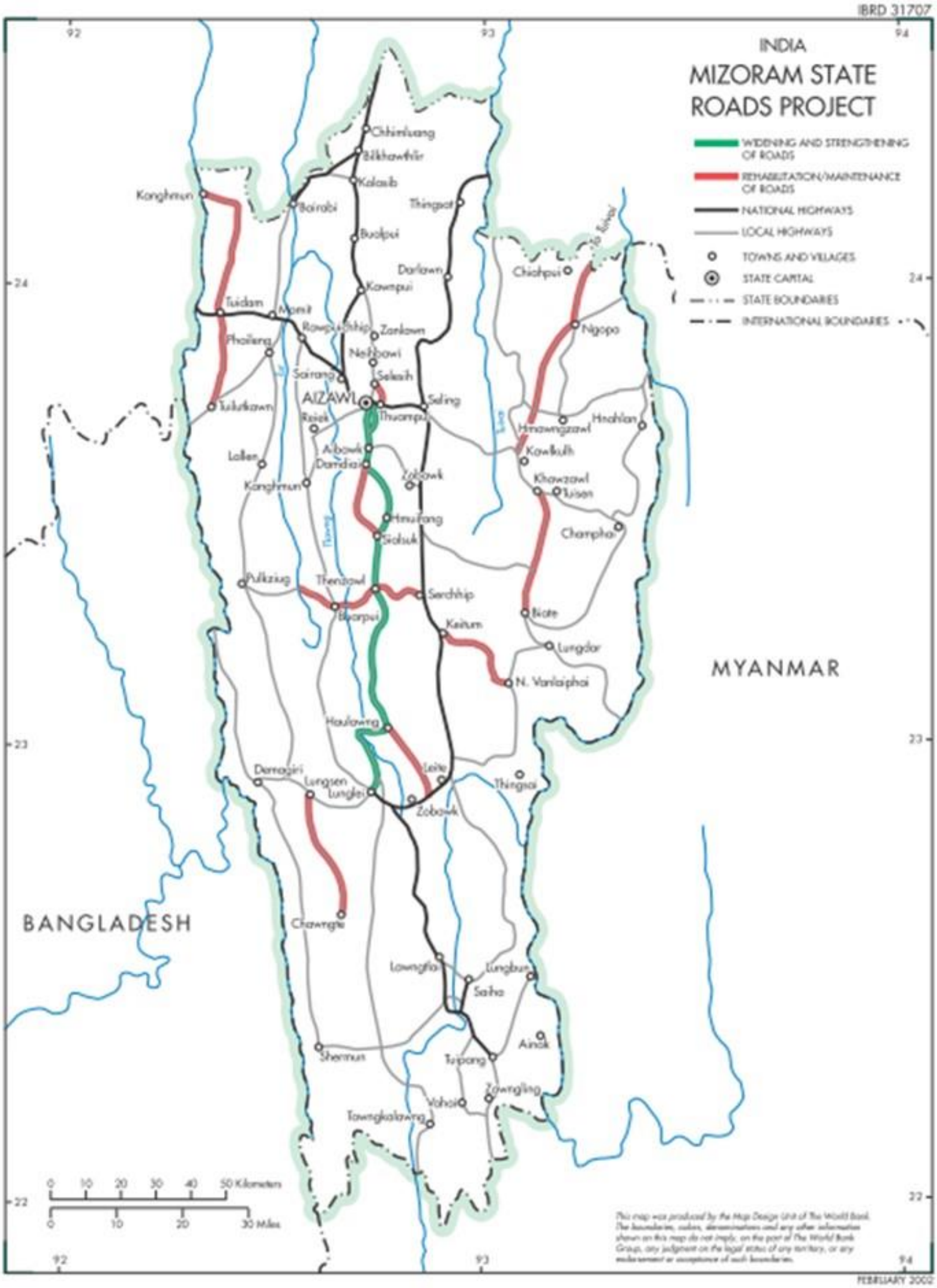
The project development objective is to enhance the road connectivity of Assam by assisting the public works roads department to improve and effectively manage its road network. There are three components to the project; (a) Improvement of priority sections of the secondary roads to improve state connectivity and facilitate regional integration, (b) Road sector modernization and performance enhancement to support implementation of the Road Sector Modernization Program (RSMP) to carry forward and deepen various institutional development initiatives already underway, (c) Road safety management to support the building of road safety management capacity of related agencies through developing and implementing a multi-sector road safety strategy.

(i) Approval Date (as of board presentation) : March 13, 2012
(ii) Closing Date : March 31, 2018
(iii) Total Project Cost : US$ 400.00 million

(2) Mizoram State Road Project I (WB)

The project's development objective is to improve the management and carrying capacity of the Mizoram core state road network. The project comprises of six components; (a) Improvement (widening and strengthening) of about 184 km SH, (b) Implementation of the Resettlement and Indigenous People Development Plan (R&IPDP), Environmental Management Plan (EMP), and land acquisition and utility relocation plan associated with the road improvement component, (c) Rehabilitation and maintenance of about 520 km of state roads, (d) Design, supervision and technical advisory services for civil works, (e) Institutional strengthening, including equipment, TA, training, and pre-investment studies, (f) Road safety engineering interventions.

(i) Approval Date (as of board presentation): March 14, 2002
(ii) Closing Date: December 31, 2010
(iii) Total Project Cost: US$ 70.00 million



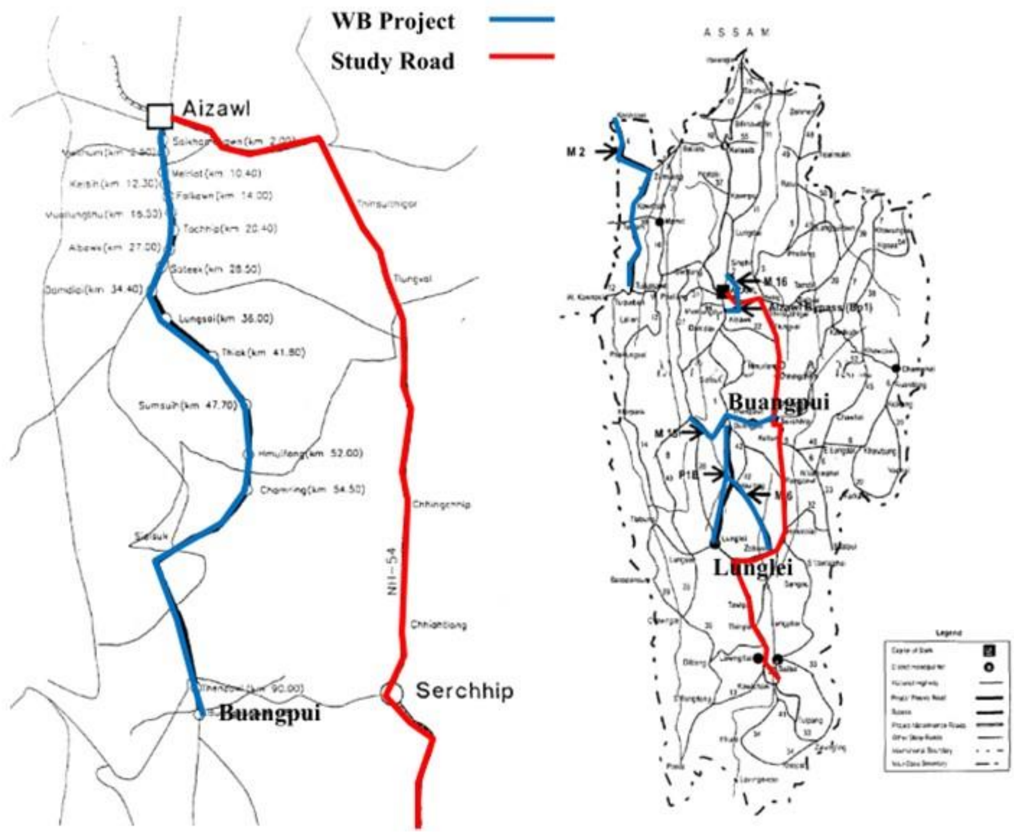
Source: World Bank

Figure 2-12: Location of Mizoram State Road Project I (WB)

(3) Mizoram State Road Project II (WB)

The objective of the Second Mizoram State Roads Regional Transport Connectivity Project is to increase transport connectivity along regional trade corridors in Mizoram. There are three components to the project; (a) Improvement of priority cross-border roads and trade-related infrastructure including widening and strengthening of 91 km of road and preparation studies for approximately 330 km of road, (b) Construction or improvement of trade-related infrastructure along project roads including market structures and a truck stop, (c) Road sector modernization and performance enhancement through institutional strengthening to support gradual transformation of PWD into a modern road agency through implementation of a Road Sector Modernization Plan, which will carry forward and deepen various institutional development initiatives, introduced under the Mizoram State Road Project I.

(i) Approval Date (as of board presentation): June 12, 2014
(ii) Closing Date: October 31, 2020
(iii) Total Project Cost: US$ 107.00 million



Source: JICA Study Team Phase 1

Figure 2-13: Location of Mizoram State Road Project II (WB)

(4) North Eastern States Roads Investment Program (ADB)

The Condition Survey of Roads in NER was conducted in October 2005, which showed that approximately 70% of roads in the region were in poor condition and barely 20% in serviceable condition. Most SH and MDR were of inadequate width. The average travel speed on these roads was found to be approximately 40 km/hour for light vehicles and about 25 km/ hour for trucks and buses.

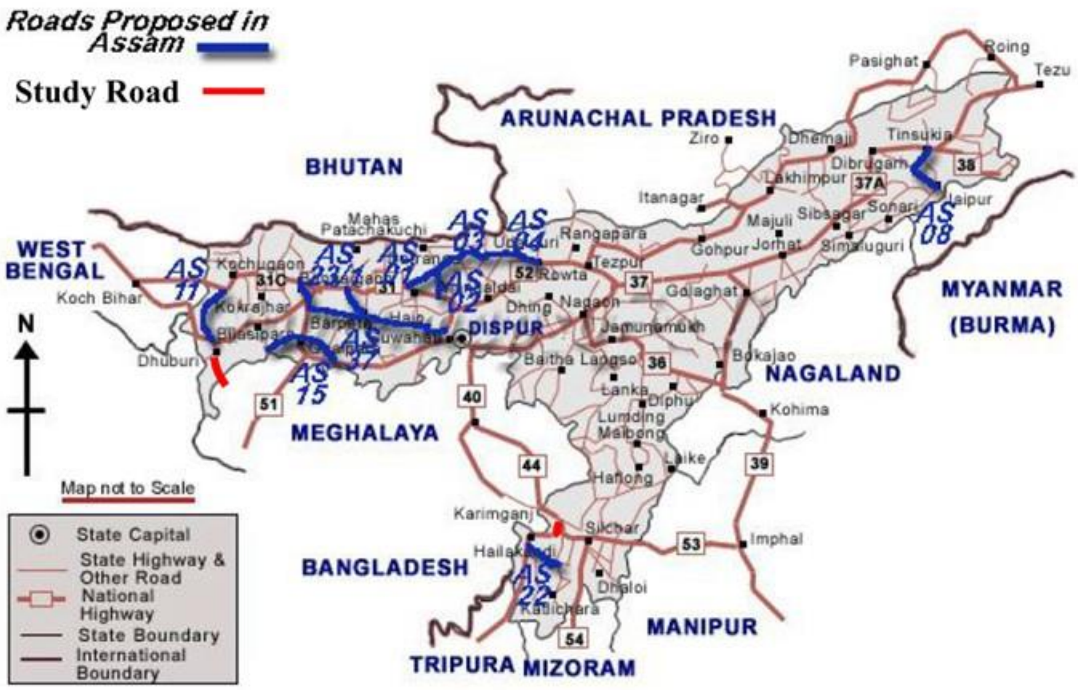
GOI approached the Asian Development Bank (ADB) for assistance in its effort to improve the condition of some of the most trafficked state highways and district roads in various states in NER. The ADB approved a Project Preparatory Technical Assistance towards preparing a Feasibility Study (F/S) for up-gradation and reconstruction of state highways and district roads and institutional development and capacity building of state PWDs in NE states. Eventually, a total length of 433.7 km of roads was selected for the proposed scheme covering the states of Assam, Manipur, Meghalaya, Mizoram, Sikkim and Tripura.

(i) Approval Date (as of board presentation): May 19, 2011
(ii) Closing Date: May 31, 2016
(iii) Total Project Cost: US$ 298.2 million

Table 2-5: North Eastern States Roads Investment Program (ADB)

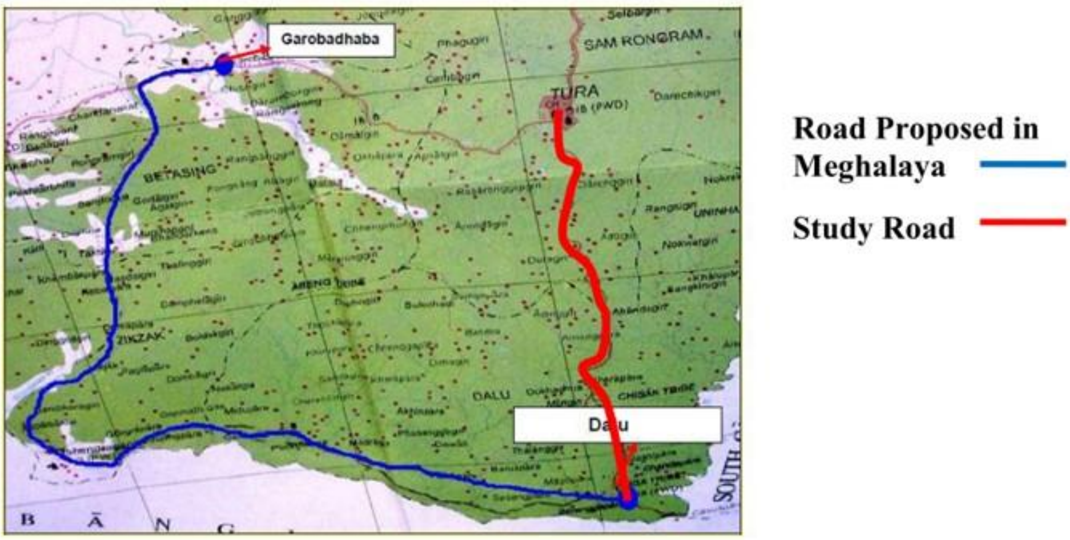
State	Name of Road	Length (km)	Cost (Rs. cr)
Assam	Kalikuchi - Barpeta	58.5	169.94
	Bilaspara - Fakiragram (NH-31)	16.2	
	Tamulpur - Paneri	43	292.57
	Paneri - Udalguri	18.6	
	Major Bridges	1.3	
Meghalaya	Garobada - Dalu	93.4	196.82
Sikkim	Meli - Nayabazar	9.5	95.39
	Nayabazar - Namchi	19.7	
Manipur	Tupul - Kasom Khullen	93.2	277.01
Mizoram	Serchhip - Buarpui	55	167.9
Tripura	Udaipur - Melaghar	20.3	69.16

Source: MDONER



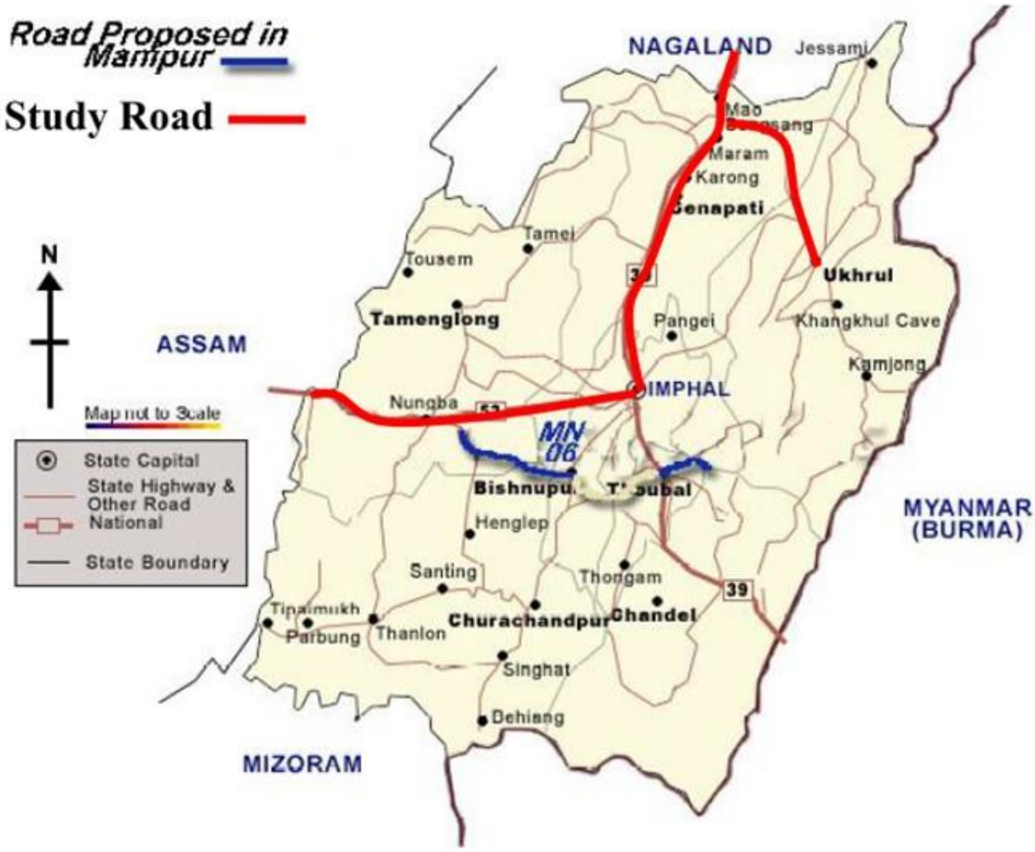
Source: JICA Study Team Phase 1

Figure 2-14: North Eastern State Roads Investment Program (Assam)



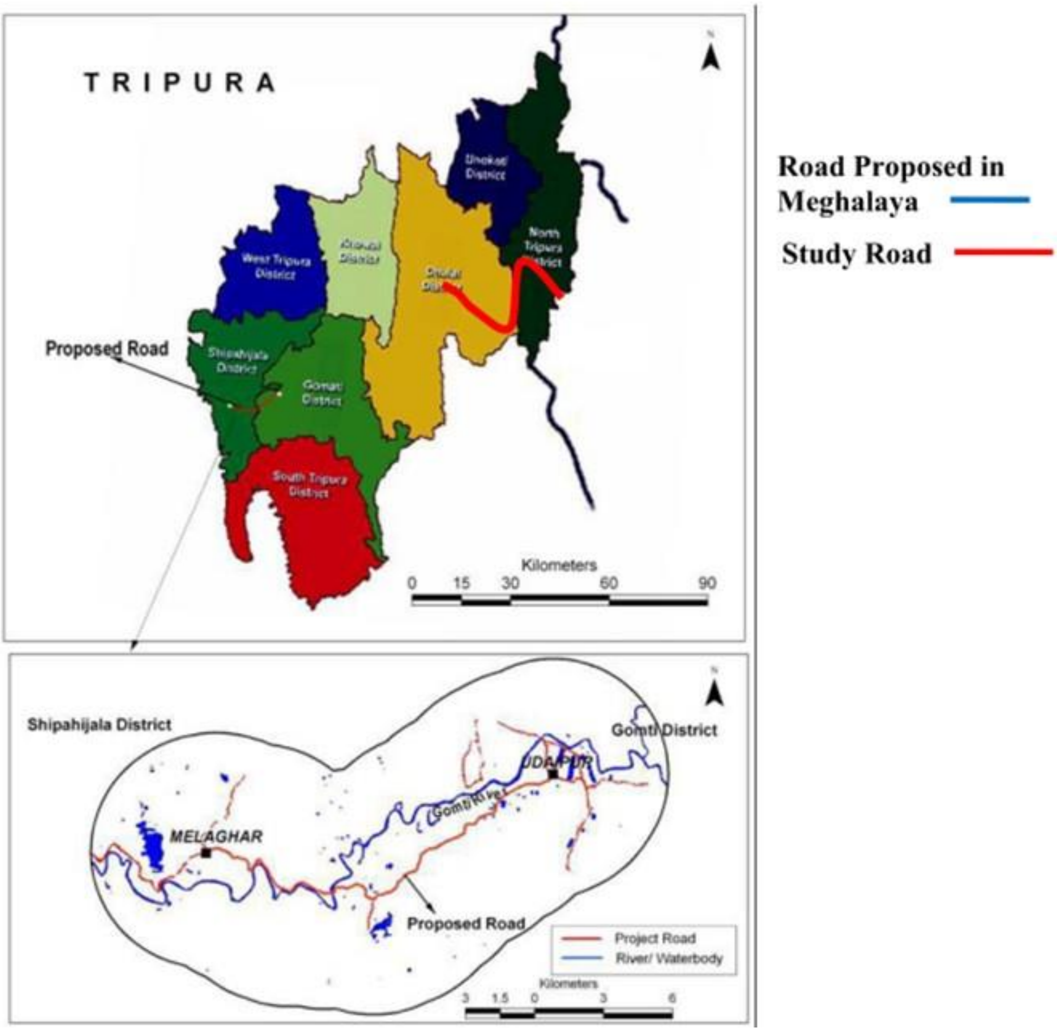
Source: JICA Study Team Phase 1

Figure 2-15: North Eastern State Road Investment Program (Meghalaya)



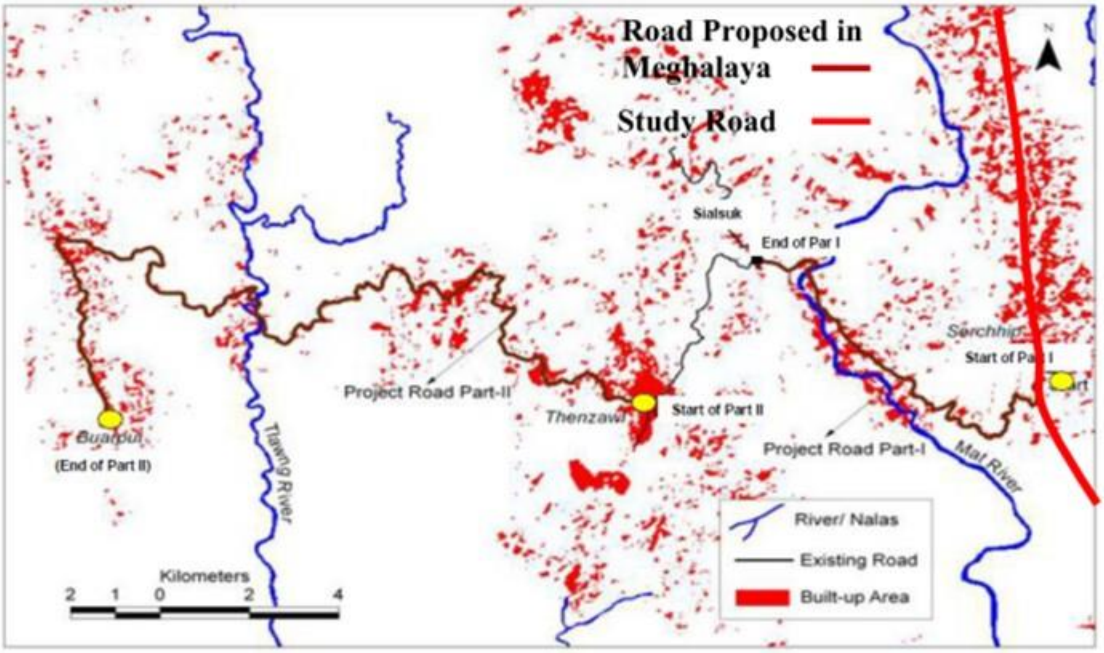
Source: JICA Study Team Phase 1

Figure 2-16: North Eastern State Roads Investment program (Manipur)



Source: JICA Study Team Phase 1

Figure 2-17: North Eastern State Roads Investment program (Tripura)



Source: JICA Study Team Phase 1

Figure 2-18: North Eastern State Roads Investment program (Mizoram)

2.3 Socioeconomic Conditions

2.3.1 Meghalaya

(1) Area and Social Framework

The area and population along with other social indicators are presented in Table 2-6. The figures on population, sex ratio, and literacy rate are based on the 2011 Census.

Among the states, the population density in Assam and Tripura states is more than three times the other 4 states. Meghalaya, study area of NH40, has the population density of 132 person/ sq.km, almost half of the average of NE states and one third of the average of all of India.

The literacy rate in all the six states is above 70%. Mizoram has the highest literacy rate at 91.33% and Assam the lowest at 72.19%. Meghalaya has the literacy rate at 74.43, almost equal to the average of "All India."

Table 2-6: Area, Population and Social Indicators of NE States

Items	Unit	Assam	Manipur	Meghalaya	Mizoram	Nagaland	Tripura	Total	All India
Area	Sq. Km	78,438	22,327	22,429	21,081	16,579	10,486	171,340	3,287,263
Districts	Nos.	27	9	7	8	11	4	66	640
Population	thousands	31,169	2,722	2,964	1,091	1,981	3,671	43,598	1,210,193
Sex Ratio	Females per 1000 Males	958	992	989	976	931	960	962	940
Population Density	Person/ Sq. Km	398	115	132	52	119	350	254	368
Literacy Rate	%	72	79.21	74.43	91.33	79.55	87.22	74.86	74.04

Source: Census 2011

(2) Regional Economy and Industrial Structure

Gross State Domestic Product (GSDP) and share of GSDP by industry are presented in Table 2-6. While GSDP per capita of NE states are lower than "All India," GSDP of Meghalaya State is rather close to "All India." Dependency on agriculture and allied in NE states, 21.51%, is much higher than in "All India," 14.37%. Dependency on agriculture and allied in Meghalaya, however, is 15.58% in 2012-13, the lowest amongst the six NE states. Share of industry is 31.51% in Meghalaya, the highest amongst the NE states.

Table 2-7: GSDP and Share of GSDP by Industry

Items	Unit	Assam	Manipur	Meghalaya	Mizoram	Nagaland	Tripura	Total	All India
2012-13									
Gross State Domestic Product (GSDP)*	Rs. Million	836,300	76,250	119,780	52,030	106,710	169,970	1,361,040	54,821,110
Population	thousands	31,169	2,722	2,964	1,091	1,981	3,671	43,598	1,210,193
GSDP per capita*	Rs	26,831	28,012	40,412	47,690	53,867	46,301	31,218	45,299
Agriculture and Allied	%	21.53	19.53	15.58	19.46	26.01	24.33	21.52	14.37
Agriculture	%	18.01	15.4	11.74	14.13	20.22	17.32	17.25	12.26
Industry	%	21.59	27.7	31.51	16.44	13.49	20.29	21.81	28.22
Mining	%	5.32		5.5	0.22	0.12	1.69	3.98	2.11
Manufacturing	%	7.61	0.6	6.69	1.58	1.74	4.62	6.07	16.28
Services	%	56.88	52.77	52.91	64.09	60.51	55.37	56.67	57.42
2013-14									
Gross State Domestic Product (GSDP)*	Rs. Million	885,370	N/A	134,650	N/A	113,670	N/A	N/A	57,417,910
Population	thousands	31,169	2,722	2,964	1,091	1,981	3,671	43,598	1,210,193
GSDP per capita*	Rs	28,405	N/A	45,428	N/A	57,380	N/A	N/A	47,445
Agriculture and Allied	%	21.27	N/A	14.56	N/A	25.39	N/A	N/A	13.95
Agriculture	%	17.77	N/A	11.1	N/A	19.78	N/A	N/A	11.85
Industry	%	21.27	N/A	31.37	N/A	13.64	N/A	N/A	27.27
Mining	%	5.13	N/A	4.96	N/A	0.11	N/A	N/A	1.98
Manufacturing	%	7.44	N/A	6.75	N/A	1.7	N/A	N/A	15.76
Services	%	57.47	N/A	54.07	N/A	60.97	N/A	N/A	58.79

* at Constant 2004-05 Prices

Source: Planning Commission, Government of India

CHAPTER 3 MAJOR ISSUES OF STUDY ROADS

3.1 Study Approach

3.1.1 Implementation Planning and Costing Based on the Natural Conditions

Since the Project road traverses rugged mountains with sharp curves, when terrain change points and landslide prone slopes are observed, utmost care will be paid to grasp the topographic changes as accurately as possible for adequate designing. Full field reconnaissance will be conducted by videotaping with GPS data to check the details.

The JICA Study Team will contact the DPR consultant for coordination of the work after the initial field reconnaissance and a review of the DPR. Consequently, the results will be adequately incorporated into scheduling the project implementation and costing.

3.1.2 Best mix Design of Indian and Japanese Mountain Road Technology

(1) Road Design in Rugged Topography

When the application of the standard cross section involves large-scale cut-slope protections or embankment retaining walls, the JICA Study Team will propose a practical design taking into consideration the level of traffic demand and economy. The practical design includes reduced cross sections, smaller horizontal curve radii for critical passes, separation of roadway in extremely rugged terrain, etc.

(2) Landslide Disaster Countermeasures

After identifying landslide-prone locations, boring geological survey will be conducted for stability analysis to analyze the cause and generation mechanism. With due considerations of the slope gradient and greening, countermeasures will be designed. The JICA Study Team will propose Japanese e technology with full respect to the Indian guidelines on landslide.[1]

(3) Road Safety Considerations

GOI has formulated National Road Safety Policy 2015 and has been grappling with traffic accident reduction setting road safety as the highest priority of the nation. However, the death toll is still increasing year by year due to rapid increase of the number of vehicles. Road traffic deaths in India is featured as 28.2% took place on national highways, of which length accounts for only 1.91% of the total road network and 53.7% took place on rural highways. There is no need to stress the importance of road safety considerations for the design of the Project road. The Indian manual[2] published in 2015 directs engineers to provide full safety measures. The JICA Study Team will propose a road design with road safety considerations.

(4) Aesthetic Design

Shillong is famous for its picturesque scenery and a summer resort on the highland. Since the section between Shillong and Dawki of NH40 passes through highlands and mountains, Viewpoints should be planned for road users to enjoy panoramic view at locations such as right after crossing a mountain pass, where there awaits a grandeur view. It will enhance not only the tourism resources of Meghalaya but also the economic value of NH40. Road alignment design is crucial to aesthetic designing of the road. Beautiful natural landscapes of mountains and

[1] IRC:SP-106-2015 Engineering Guidelines on Landslide Mitigation Measures for Indian Roads

[2] IRC:SP:73-2015 Manual of Specifications & Standards for Two Laning of Highways with Paved Shoulder

rivers should be effectively incorporated into road landscaping. It is important for creation of comfortable landscape to minimize the damage to nature and the environment and to create scenic harmony of the road and the surrounding terrain.

(5) Utilization of Precast Structures

It is the rainy season during May and October at the project site making field construction works very hard. Shortening the field work is an effective way to avoid the influence of rain to the construction. Field Assembly Precast Method for auxiliary structures such as box culverts will be effective for reducing the period of field construction work. Many box culverts are constructed on site in India taking a long construction period and stopping during rainy days, while almost all are done by the Precast Method in Japan. Auxiliary structures will be fabricated at the factory during the rainy season and transported piece by piece to the construction site to assemble during the dry season. The JICA Study Team will conduct a survey on potential casting yards and fabrication factories in the Project site.

(6) Utilization of Locally Available Materials

There are many boulder rocks in alluvial layers at the foot of mountains and road earthwork often excavates a huge amount of boulder rocks. Japan, which has rugged topography and complex geography, similar to the North-East states of India, has accumulated experiences in how to utilize boulder stones for road embankment and has developed a method of Rock Mass Embankment. India also has a rich experience in landslide mitigation measures. The JICA Study Team will propose a hybrid technology combining Japanese and Indian experience after thorough coordination with relevant organizations.

3.1.3 Bridge Substructures for Strong River Flow and Work Period Constraint

The project area experiences rainy season from May through October and the high water level of the river makes construction works impossible to implement. The preferable location of bridge will be selected considering both river width and strong water flow, which tends to change not only the shape of river bed but also location of the channel. A pier type will be selected against such river conditions. DPR will be reviewed and discussion with consultant employed by the local government will be held to find the best solution.

The Bogibeel Bridge in northern Assam, longest road and railway combined bridge in India, is under construction with caisson foundations in the Brahmaputra River. The caisson foundation is considered one of the most suitable types for new bridges. The construction plan will be examined to realize shorter construction period.

3.1.4 Study on Adaptable Japanese Technology

Countermeasures against landslide disasters measures are crucial for the Project road which passes through mountains in the heavy rain region. The new bridge design needs careful consideration and selection of foundation type and construction methods to cross the river with a fast current during the rainy season. Some applicable Japanese technologies include landslide disaster measures, high-performance pavement, bridge substructure and foundation, and new construction materials.

The JICA Study Team will study applicability of Japanese technologies considering the local conditions of geological features, inclination slopes, environmental features, the nature of the river, etc., and communicate closely with relevant organizations to propose application of Japanese technology.

3.1.5 Risk Analysis of EPC Contracts and Considerations about Procurement

The JICA Study Team will discuss risks in the EPC contract for smooth implementation of the Project. EPC contract is the mainstream for road development in India these days and the JICA Study Team will follow Phase 1 for the preparation of contract documents clarifying the risk allocations between clients and contractors because they are very different from either BOT, which India has adopted so far, or FIDIC's Redbook.

The EPC contract involves an enormous amount of documents that have to be submitted for approval by clients. It may require many days for clients to approve especially in case the absence of guidelines for checking items and criteria leads to claims by contractors.

3.1.6 Traffic Demand Forecast for Road Network Connectivity in NER

The Project road is an important trade route not only for traffic between Guwahati - Shillong - Dawki but also for freight transport in a wide area on the South Asia being a part of Asian Highway AH-1. Current traffic volume observed in Phase 1 is only about 2,000 vehicles per day and 75% of them are passenger cars[3].

When the cross-border trade agreement is concluded between India and Bangladesh, those trucks currently using the long detour through the Chicken's Neck from the Kolkata port may transfer to the Chittagong port in Bangladesh. The JICA Study Team will verify the assumptions.

3.1.7 Supporting the Preparation of EIA and RAP Based on JICA Guidelines

EIA studies for road projects of this nature are exempted in environment-related regulations in India. Evaluation of Category A (EIA level) on DPR in accordance with JICA Guidelines for Environmental and Social Considerations (hereinafter referred to as "JICA Guidelines"), however, has to be implemented considering the alignment passing through the area with a wealth of biological resources.

Such supplemental EIA study is usually required since DPR is prepared purely from technical and economic viewpoints. While information disclosure (public consultations) required by JICA Guidelines is unlikely to be implemented at DPR stage, the JICA Study Team will provide necessary support for the implementing agency in order to hold public consultations for information disclosure. Specifications on information disclosure are different between JICA Guidelines and Environment Protection Act of India. At least two consultations, at scoping and draft EIA stages are compulsory in JICA Guidelines, while consultation at disclosure of draft EIA is stated in the guidelines of India. As above, the JICA Study Team would like to explain the requirement for JICA-finance projects in terms of EIA study at the beginning of this study for facilitating the understanding of the implementing agencies. Thus, their active involvement in information disclosure is materialized and smoothly implemented.

Since it is expected that the relocation of more than 200 households and land acquisition are required for the project, the JICA Study Team will study regulations and past examples about land acquisition and relocations in India and will support a local execution agency to prepare Resettlement Action Plan (RAP, commonly called Social Impact Assessment: SIA in India) in compliance with local regulations and the JICA Guidelines requirements for smooth implementation of a yen loan project.

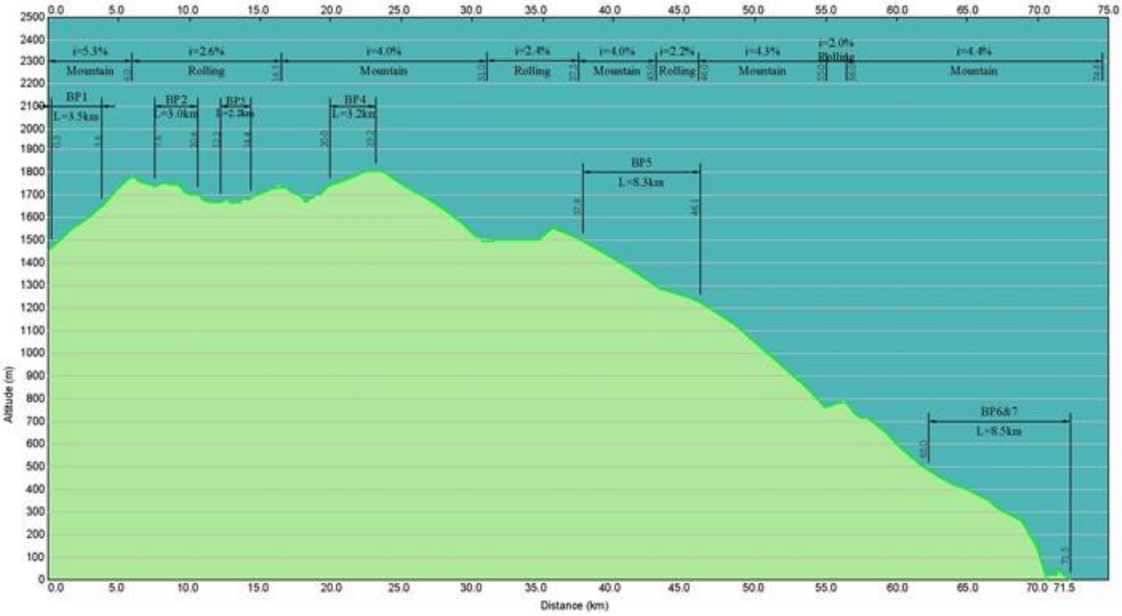
[3] The share of passenger cars is 20-40% in other roads in the Phase 1 survey

3.2 Major Issues of the DPR Design and Recommended Solutions

3.2.1 Notable Features of Design of NH40 (Shillong - Dawki)

(1) Greatly Varying Altitude of the Road

The existing NH40 (Shillong - Dawki) stretches the total length of approximately 81.26 km. The vertical alignment varies significantly starting at Shillong with the altitude of about 1500 m, crossing the highest point at about 1,700 m and ending the lowest at only about 50 m. Since the existing NH40 meanders with zigzags and sharp curves passing through mountains, the alignment improvement of horizontal curves and bypasses to avoid built-up areas shortens the total length approximately to 71.5 km.



Source: JICA Study Team

Figure 3-1: Profile of NH40

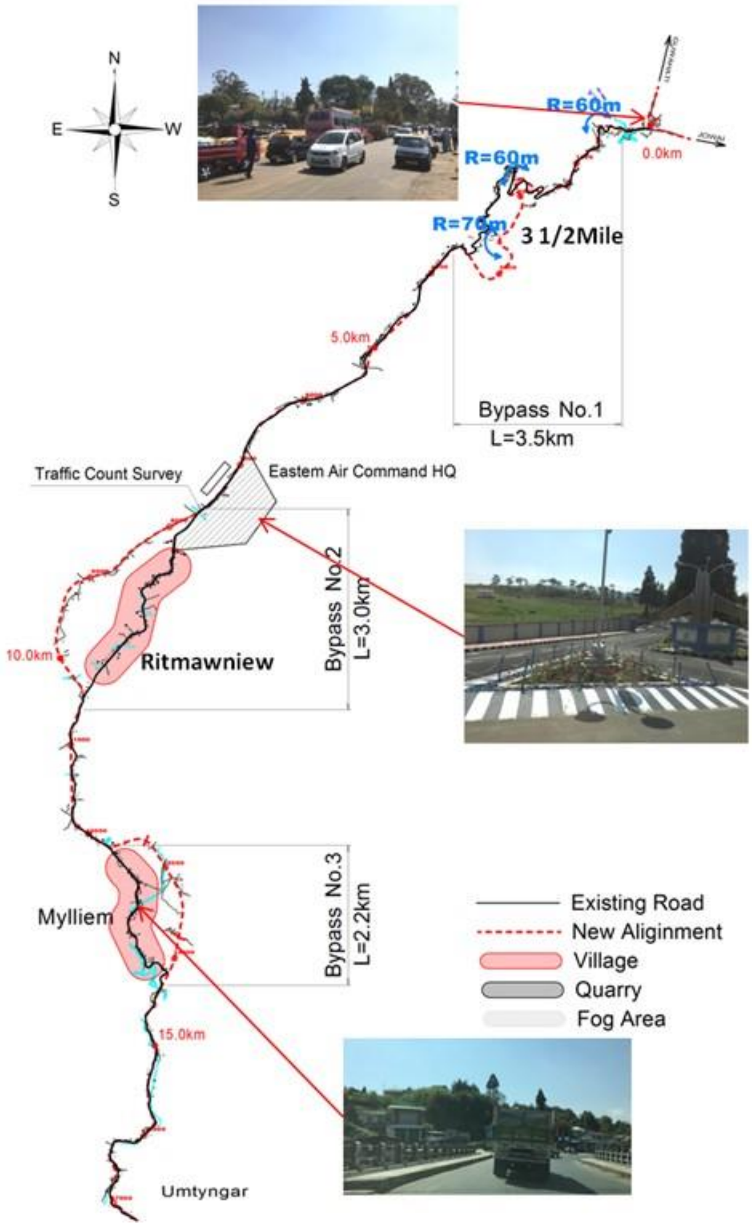
Partly due to this greatly varying altitude of NH40, the weather along the stretch is unpredictable; the higher sections have frequent dense fog, while lower sections heavy rainfall, of which the annual total reaches 10,000 mm. The lowest sections sit neighboring on Bangladesh across the Dawki River, where it boasts of beautiful and grandeur scenery attracting many tourists both from India and Bangladesh. The international border line goes along the river, which has zones called "No Man's Land" between the border line and lines on both side of 200 yards from the border line. These zones restrict some activities like a bridge construction.

Source: JICA Study Team

Figure 3-2: Bangladesh Viewed from Dawki

(2) Features of the Road Section from KP0.000 to KP15.000

The project road starts at the intersection of NH40 and NH44, where Kilo Post (KP) is 0.000. The first few kilometers are extremely congested since this is the single major highway entering Shillong coming from the Dawki side. Bypass #1 is planned to improve the poor road alignment using the land in 3-1/2 Mile owned by the Ministry of Defense. However, the detailed survey identified that the land is mostly being owned by Ministry of Forest. Bypass #2 and #3 are planned to detour two built-up areas, namely Ritmawniew and Mylliem.

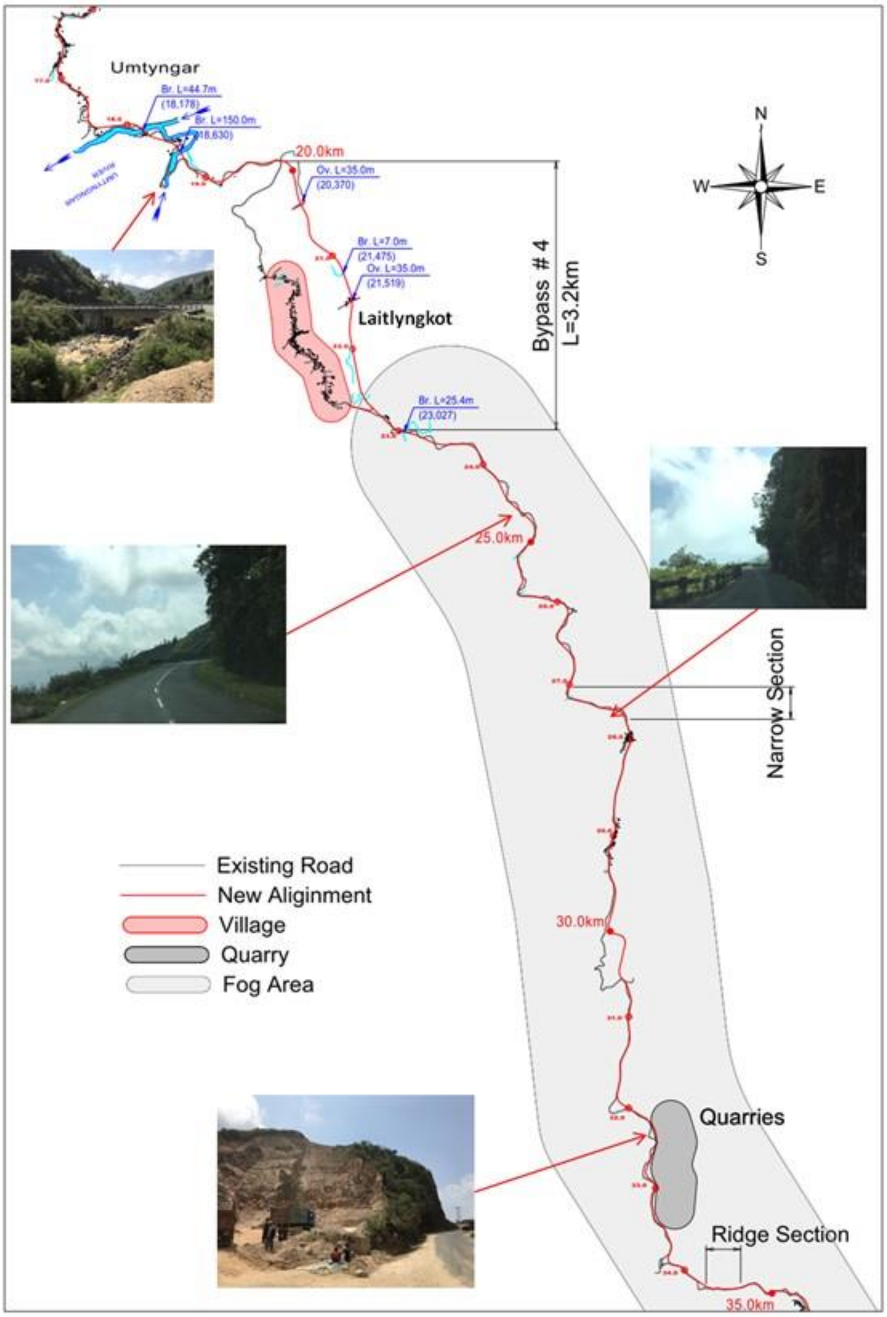


Source: JICA Study Team

Figure 3-3: Road Alignment and Condition (KP0.000 - KP15.000)

(3) Features of the Road Section from KP15.000 to KP35.000

The project road passes through the highest point of the route from KP23.000 km to KP25.000 km at the altitude of approximately 1,800 m. Massive and solid rock is exposed on the hill-side slopes along the NH40 route. There are some quarries producing rock and aggregate along the route. A few viewpoints are provided at widened shoulder areas. Bypass #4 is planned to detour the built-up area of Laitlyngkot.

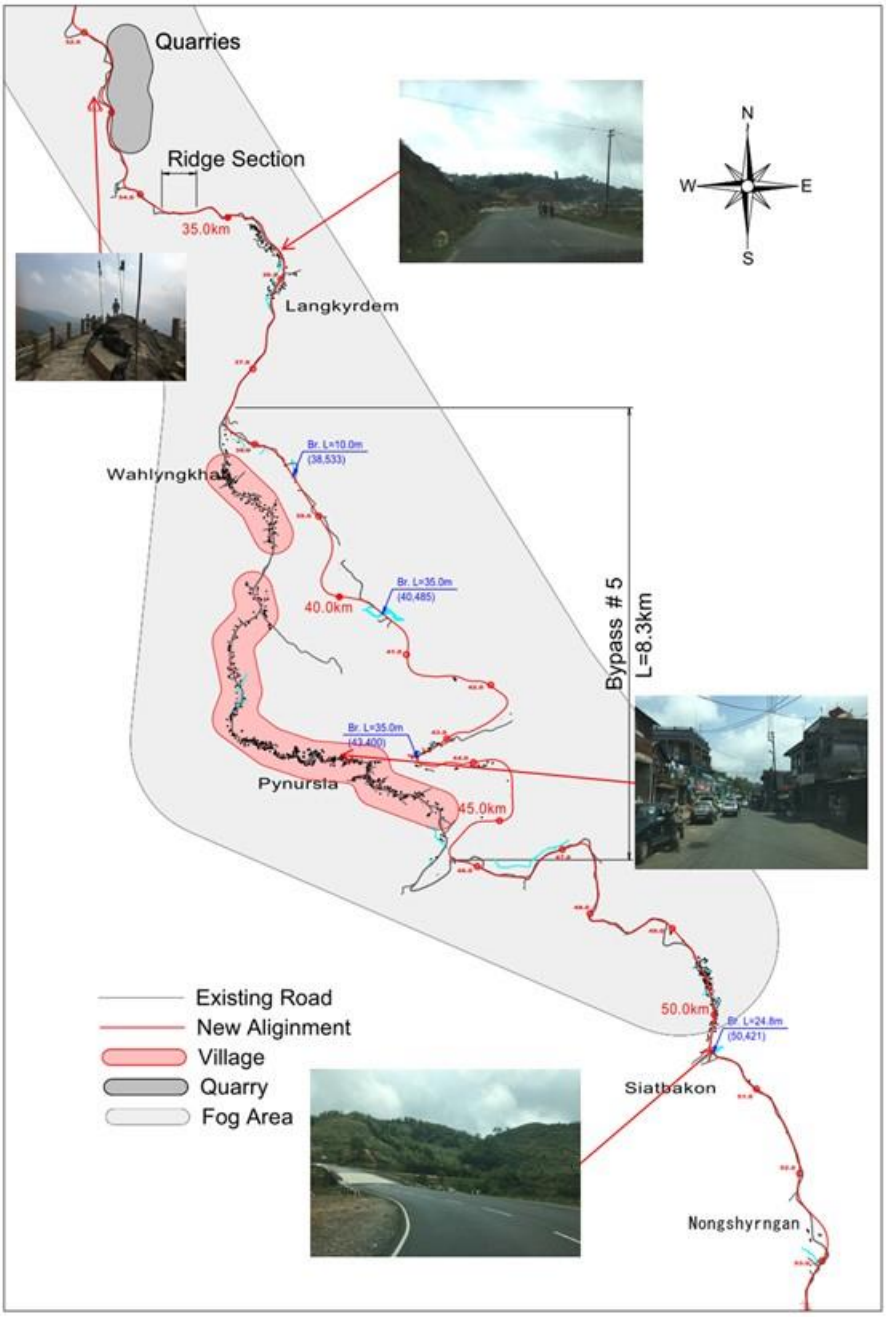


Source: JICA Study Team

Figure 3-4: Road Alignment and Condition (KP15.000 - KP35.000)

(4) Features of the Road Section from KP35.000 to KP55.000

There are some view points with a refreshment house and a small souvenir shop along the route before descending from the altitude of 1,600 m down to 1,000 m. Bypass #5 detours a relatively large town of Pynursla and then the project road passes through relatively mild rolling terrain.

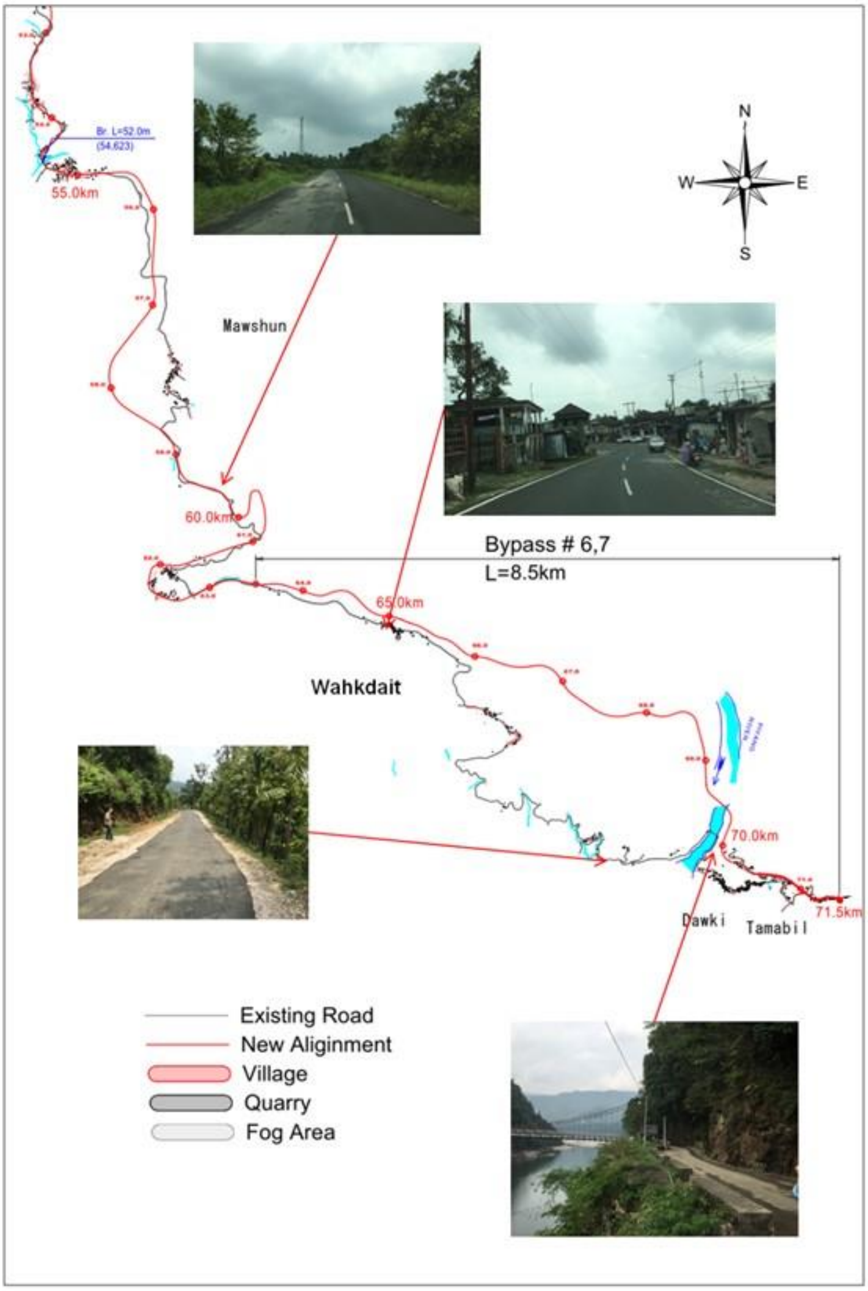


Source: JICA Study Team

Figure 3-5: Road Alignment and Condition (KP35.000 - KP55.000)

(5) Features of the Road Section from KP55.000 to KP71.500

The project road passes through a relatively mild rolling terrain from KP55.000 up to the village of Wahkdait at KP65.000 then the terrain becomes rugged and descends at the rate of 4.5% and the road width of about 5 m. Bypass #6 was planned initially to improve alignment along the existing NH40. However, it has been preplanned along the north-side of the mountain edge to avoid the restricted zones of the border line with Bangladesh. Bypass #7 detours the village of Dawki including Dawki Bridge.



Source: JICA Study Team

Figure 3-6: Road Alignment and Condition (KP55.000 - KP71.500)

(6) Features of Bridges

There are several bridges on the project road as well as short culverts. The longest bridge is the 135 m-long Dawki Bridge crossing the narrowest section of Dawki River at about 500 m upstream side from the river mouth. It is a suspension bridge constructed 85 years ago, in the year of 1931 during the colonial time. Trucks carrying stones and aggregates frequently cross the bridge. There is no appropriate detour to cross the river once the bridge is closed to traffic.

Although the importance of Dawki Bridge is undeniable the bridge has been one of the biggest bottlenecks of the road section (NH40) due to its narrow carriageway of about 5 m and the vehicle weight limit of 9 ton. Its surrounding area is scenic with steep rock cliffs and several waterfalls on both sides of the river and rich forest, and attracts many domestic and foreign tourists. The majority of traffic volume that passes Dawki Bridge is trucks carrying stones and rocks to be exported from India to Bangladesh. It is obvious that the narrow carriageway and the vehicle weight limit of the bridge results in a huge loss to the local economy and undermines the economic development in the region.

The conditions of other bridges which will be used on the new road alignment are good. The outline of these bridges is shown in Table 3-1. The results of visual inspections of bridges found no major structural distress; however, many bridges do not have sufficient carriageway width to meet the present geometric design standard.

Source: JICA Study Team

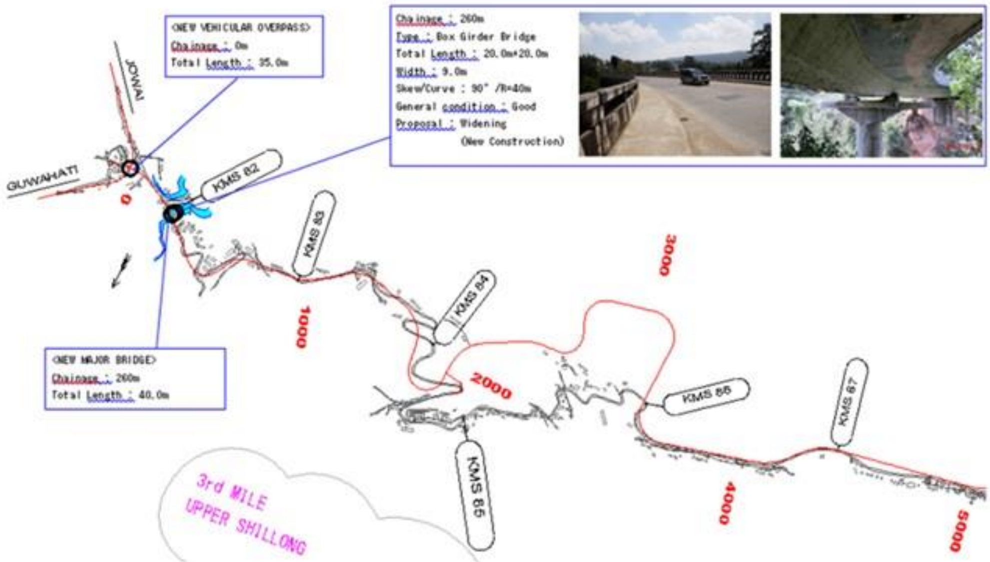
Figure 3-7: B8 Dawki Bridge (KP73.00) and Dawki River

Table 3-1: Existing Bridge Conditions

No.	Location	Type	Length(m)	Width(m)	Soundness	Measure
1	KP0.260km	PC Box Girder	40	9.0	Good	Widening
2	KP14.380km	PC Girder	25	7.5	Good	Widening
3	KP18.185km	RC+PC+ RC Girder	46	7.5	Good	Widening
5	KP23.300km	PC Girder	26	7.5	Good	Widening

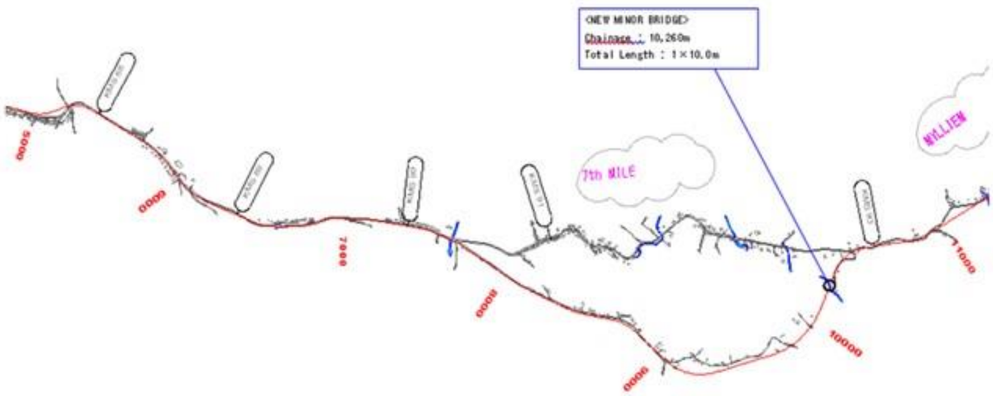
6	KP50.798km	PC Girder	25	11.0	Good	Rehabilitation
7	KP54.623	RC+PC+ RC Girder	52	7.5	Good	Rehabilitation
8	KP73.810	Slab Bridge	10	7.5	Good	Widening

Source: JICA Study Team



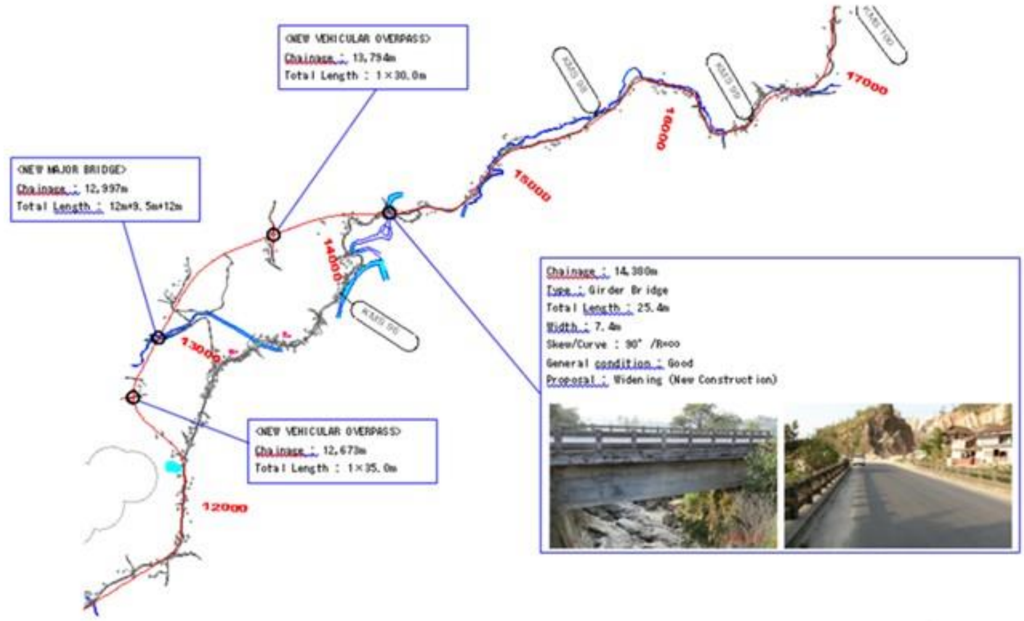
Source: JICA Study Team

Figure 3-8: KP0+000 - KP5+000



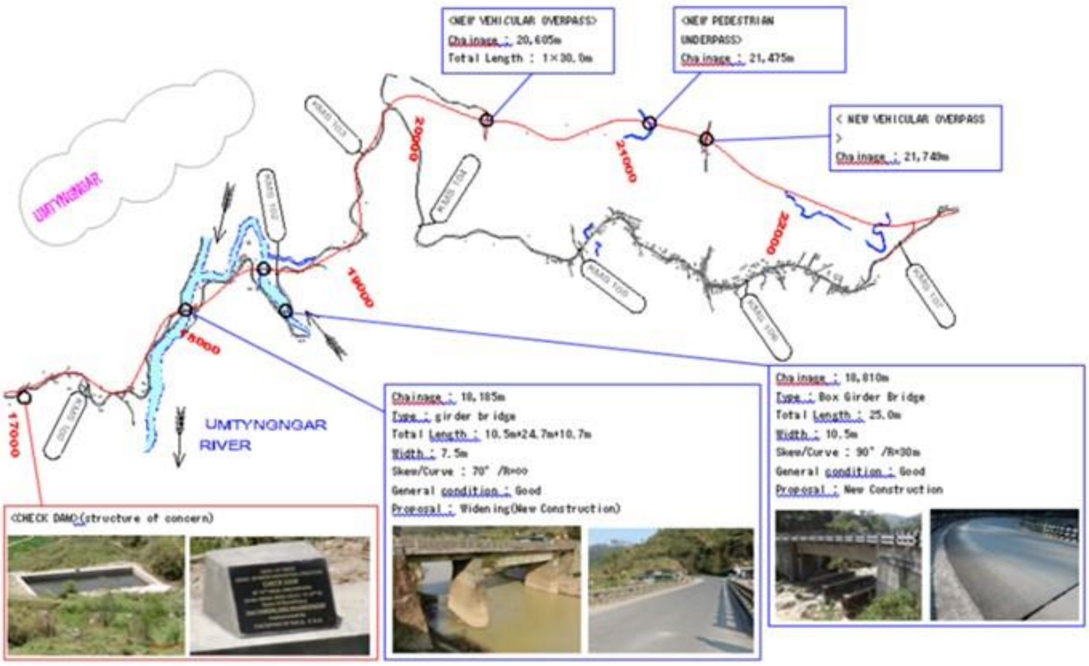
Source: JICA Study Team

Figure 3-9: KP5+000 - KP11+000



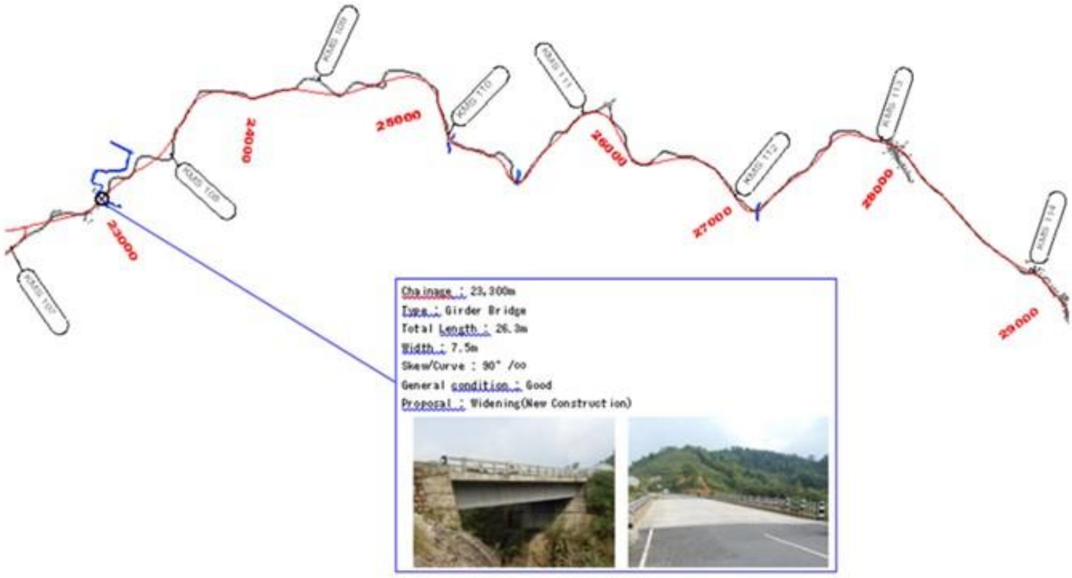
Source: JICA Study Team

Figure 3-10: KP11+000 - KP17+000



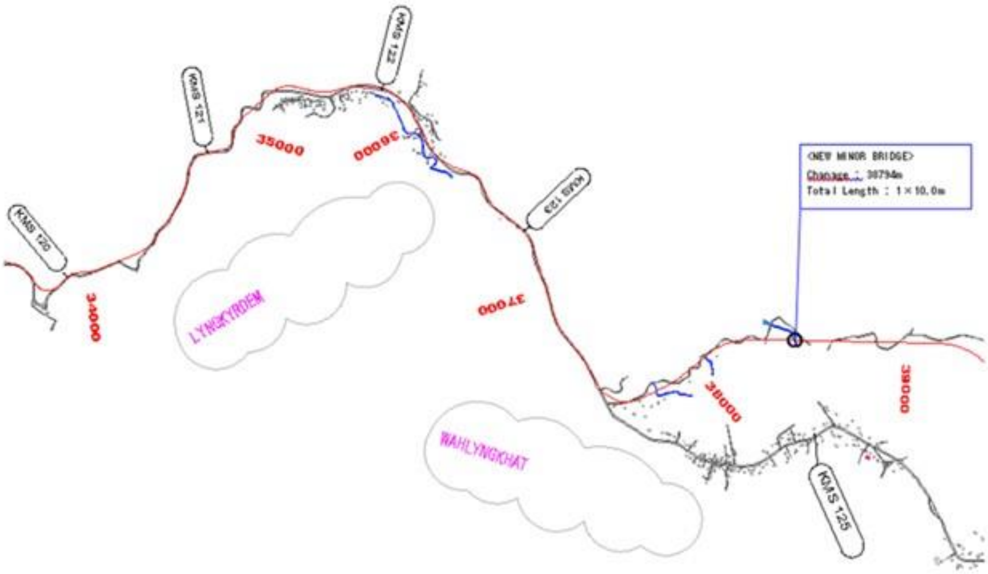
Source: JICA Stud Team

Figure 3-11: KP17+000 - KP23+000



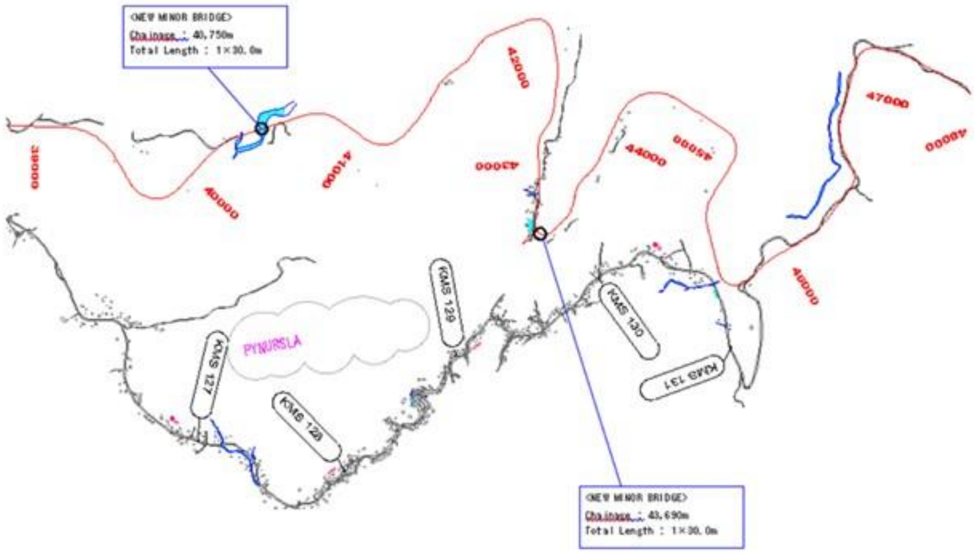
Source: JICA Study Team

Figure 3-12: KP23+000 - KP29+000



Source: JICA Study Team

Figure 3-13: KP34+000 - KP39+000

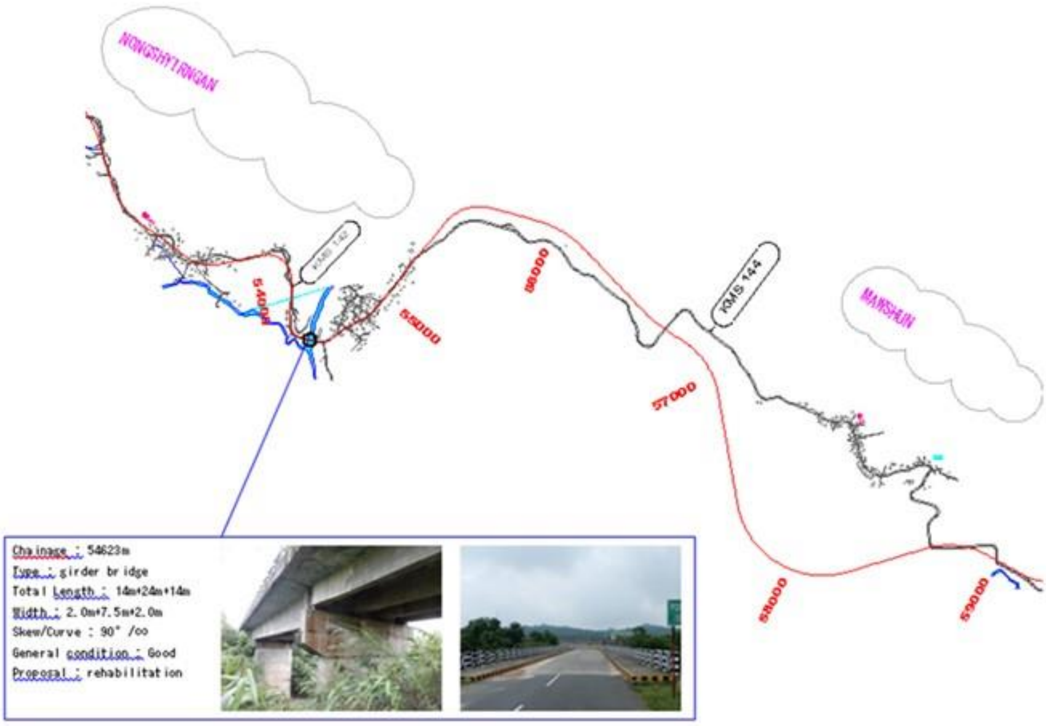


Source: JICA Study Team

Figure 3-14: KP39+000 - KP48+000

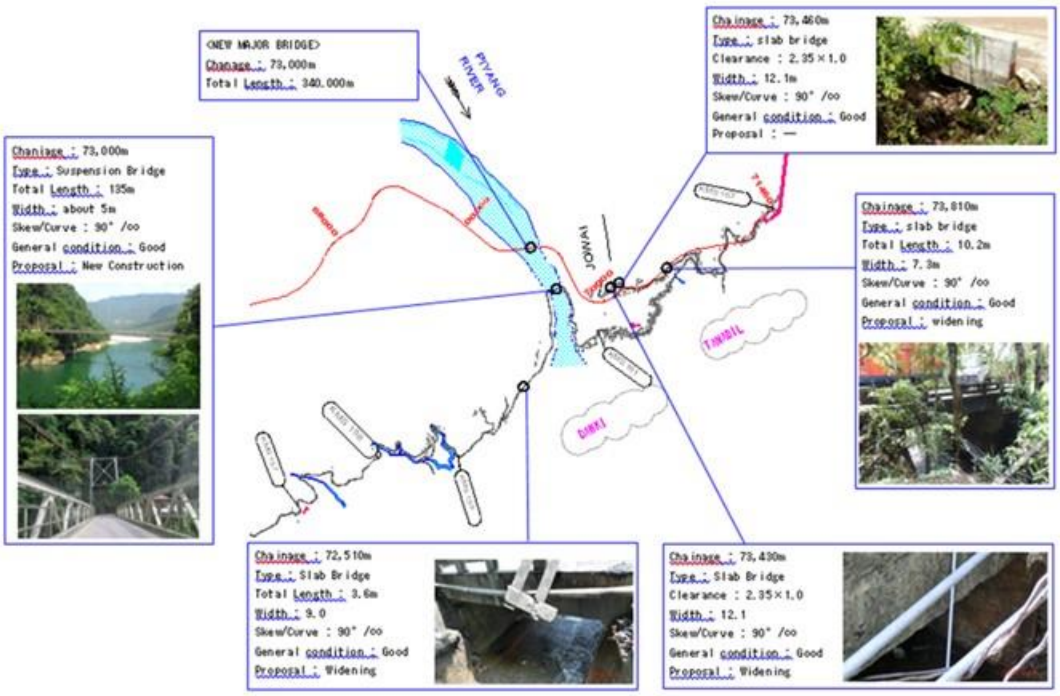
Source: JICA Study Team

Figure 3-15: KP48+000 - KP53+000



Source: JICA Study Team

Figure 3-16: KP53+000 - KP59+000



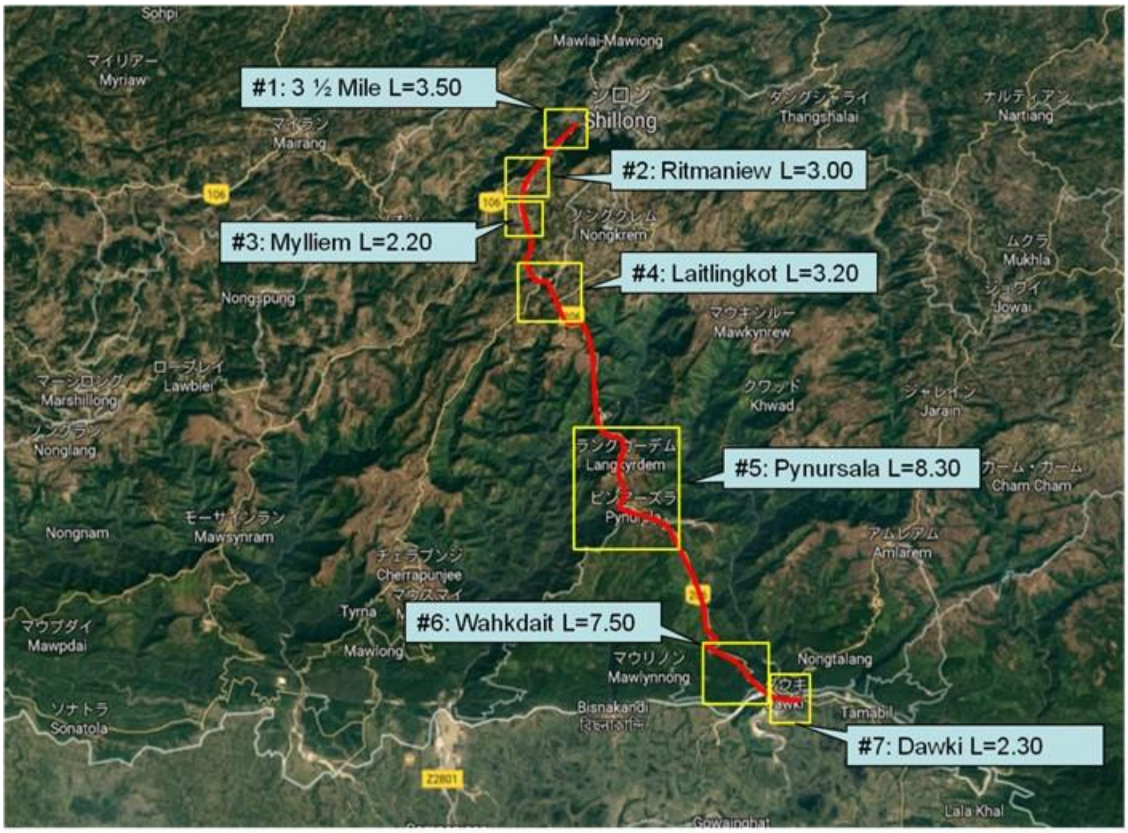
Source: JICA Study Team

Figure 3-17: KP68+000 - KP71+000

3.2.2 Seven Bypass Alignments

The DPR plans seven bypasses to detour built-up areas and geometrically problematic areas. Bypasses of #2 through #5 are to avoid the built-up areas and minimize the influence to the local communities, whereas bypasses #1, #6 and #7 are to select new road alignment and establish the road design as per the Indian Roads Congress (IRC) standards.

A review of those bypass alignments by JICA Study Team has revealed that bypass #1, #6 and #7 have some issues. The JICA Study Team have discussed those issues NHIDCL, Meghalaya State PWD, and DPR consultant and submitted recommendations described as follows.



Source: JICA Study Team

Figure 3-18: Location Map of Seven Bypasses

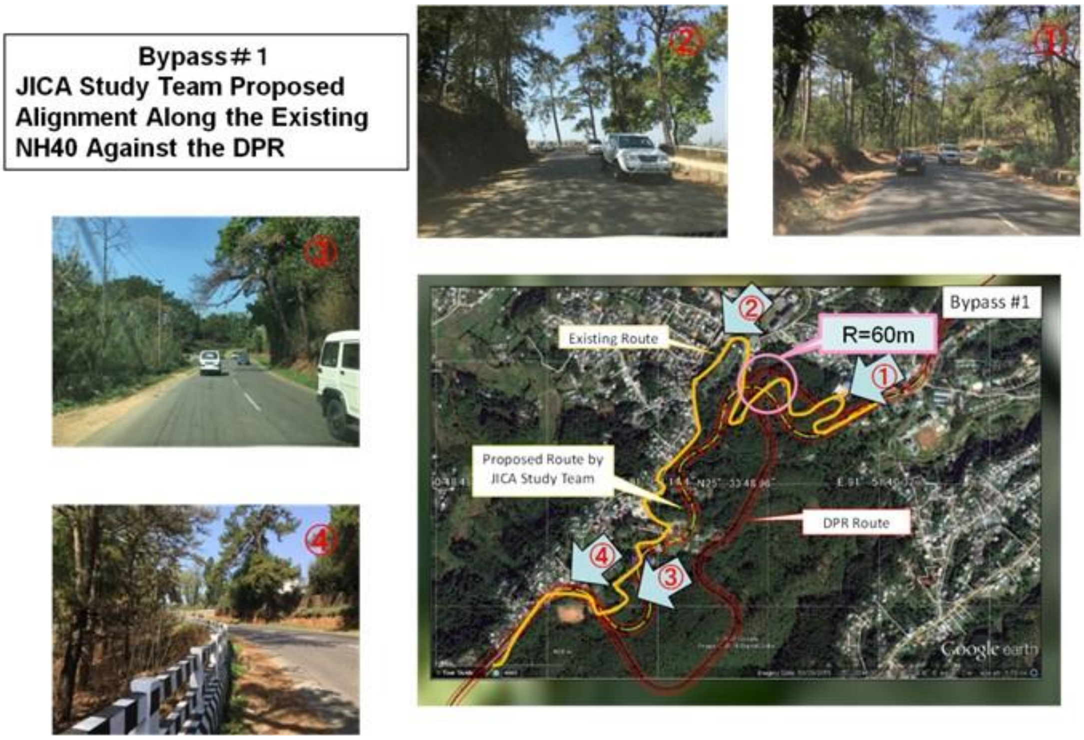
(1) Issue of Bypass #1 Alignment

The purpose of the Bypass #1 is to improve the poor alignment of the 3 1/2 Mile section of NH40, where it does zigzag with large rising slopes resulting in slower vehicle running speed and a lower traffic volume. However, the bypass alignment proposed by DPR contains the following problems.

1. Although the design standards (IRC:SP:73-2015) published by Indian Roads Congress (IRC) stipulates that the absolute minimum radius shall be 75 m, the radius of 60 m is used.
2. The alignment of the bypass passes through the central portion of the forest land, which, according to the Meghalaya State PWD, is presumably owned by the neighboring Ministry of Defense. Passing through the central portion of the land might hinder plans by the

Ministry of Defense to construct defense facilities or alike in this land in future consequently producing a concern of difficult negotiation of land acquisition.

The JICA Study Team proposed an alignment along the existing NH40 avoiding the central portion of the forest land. However, a detailed survey of land owners conducted by the JICA Study Team has revealed that the forest land is mostly owned by Ministry of Forest. In case of Ministry of Forest, the possibility of flattening the forest and developing the land is very small and hence almost no concern of land acquisition. The final alignment was proposed with an improved radius described in 1.



Source: JICA Study Team

Figure 3-19: Proposed Alignments of Bypass #1 by JICA and DPR

(2) Issue of Bypass #6 and #7 Alignment

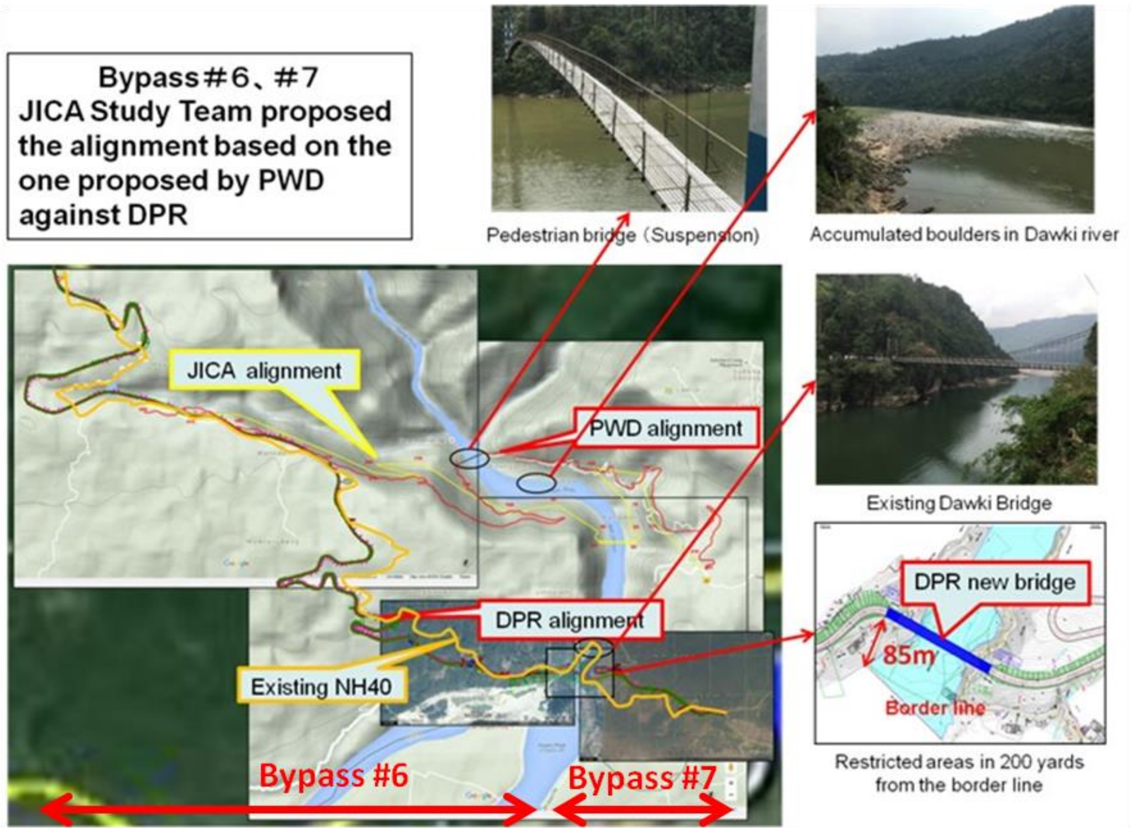
Bypass #6 and #7 are planned to improve the poor alignment of NH40 for the section that descends steep rugged slopes. Dawki River flows along the bottom of that rugged topography and there is a suspension bridge of a single track (bridge length 103 m) crossing the river, which is used as an one-way alternating traffic bridge. There is another suspension bridge for pedestrians behind the ridges of the mountain. This area is a popular tourist site using NH40 as crowded parking spaces as well for the tourists.

DPR originally planned the alignments of bypass #6 and #7 along the existing NH40. A new bridge crossing the Dawki River was planned with the bridge length of 230 m at the location of about 240 m downstream from the existing bridge.

During the consultation with the Meghalaya State PWD by the JICA Study Team, it was found out that the construction location of the new bridge proposed by DPR contained a problem. There is the border line between India and Bangladesh at the place where the river width of the

Dawki River widens, and the new bridge proposed by DPR is located 85 m away from the border line. Areas 180 meter from the border line are designated as "No Man's Land" and prohibit activities like a bridge construction.

It was also found out that the Meghalaya State PWD had studied a bypass alignment in the past and produced an alignment along the suspension bridge at the behind the mountain ridges avoiding the border line (Figure 3-17).



Source: JICA Study Team

Figure 3-20: Comparison of Alignments of Bypass #6 and #7

The alignments of bypass #6 and #7 were reexamined to cope with the above stated problem. The JICA Study Team decided to redesign the alignments along the route proposed by PWD and carried out topographic and geotechnical survey. The topography is very steep and rugged and there are many boulders accumulated on the bottom of the Dawki River. The traces of landslide were also observed. The design of the bridge required considering these topographic and geotechnical features.

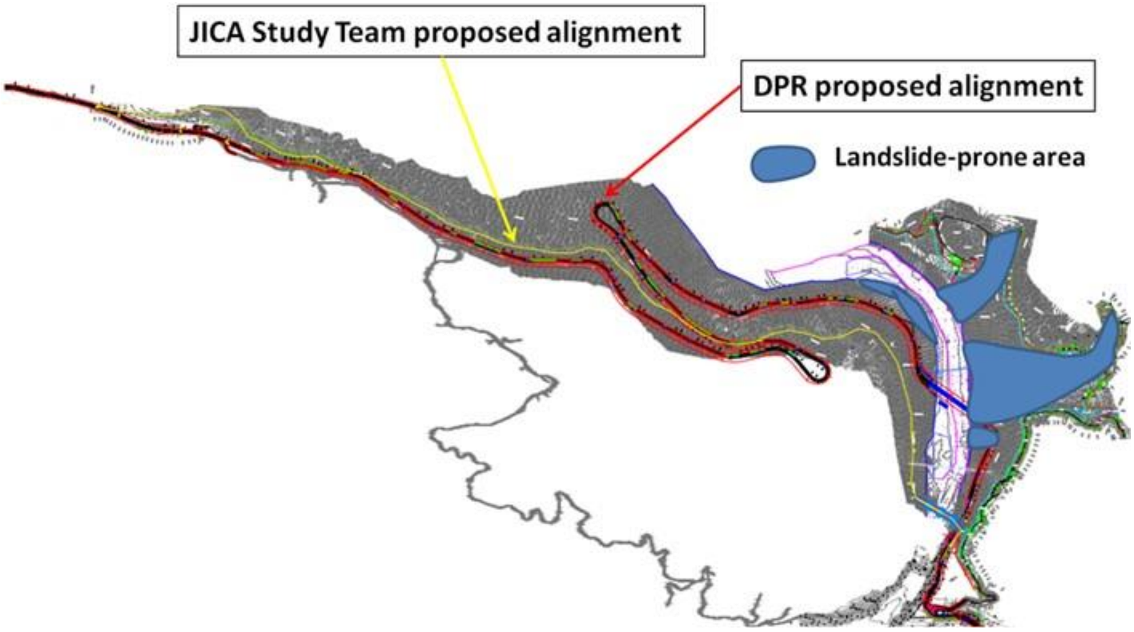
JICA Study Team designed the bypass alignment based on the results of the surveys. The DPR consultant also submitted their redesigned alignment and the both proposal were compared (Figure 3-18). The strong points and weak points of the proposals are described below.

Table 3-2: Comparison of Alignment Proposals between JICA and DPR

Strong Points of JICA Proposal	Weak Points of JICA Proposal
● Avoiding landslide-prone areas ● The bypass length is about one thirds (DPR 9,640m vs. JICA 6,160m) ● Removing two hairpins	● Piers are taller (DPR 30m vs. JICA 100m) ● The cost of the bridge is slightly higher

Source: JICA Study Team

After the consultation with NHIDCL, the Meghalaya State PWD, and the DPR consultant, the alignment proposed by the JICA Study Team as shown below has been selected as the final alignment.



Source: JICA Study Team

Figure 3-21: Proposed Alignments by JICA and DPR

3.2.3 Road Design and Typical Cross Sections

The IRC standards and specifications for Two Laning of highways with paved Shoulder (IRC:SP:73-2015[4]) prescribe the geometric design and general features for two laning of highways with paved shoulder and some important points applicable to NH40 are as follows.

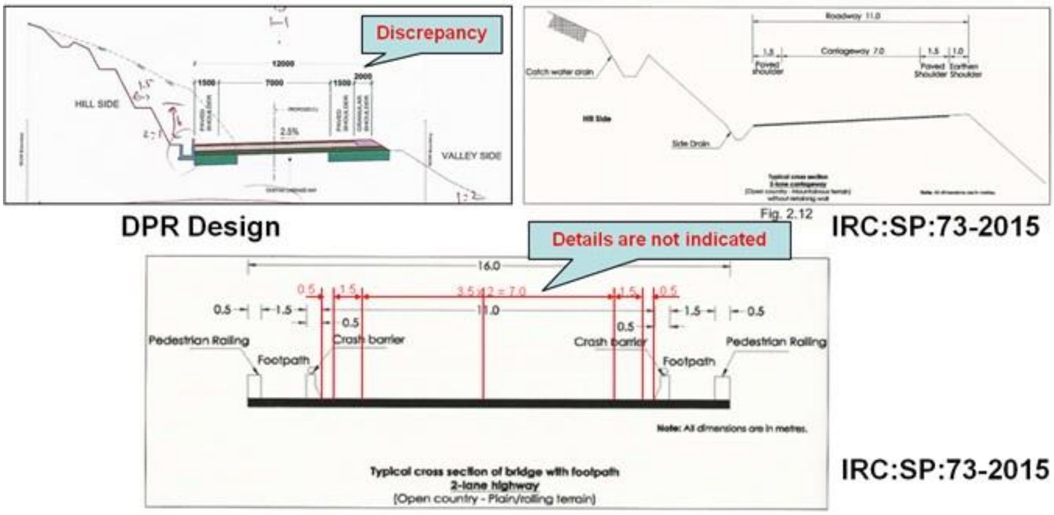
- Stretches passing through built-up areas shall normally be provided with 4-lane divided carriageway
- Where there are constraints of existing ROW width or difficulty in acquiring land along the existing alignment in built-up areas, the Authority may decided for construction of a bypass instead of 4-laning
- The geometric design of the Project Highway shall conform to the standards set out in this Section as a minimum

[4] IRC:SP:73-2015 Manual of Specifications & Standards for Two Laning of Highways with Paved Shoulder

The JICA Study Team pointed out discrepancies in cross sections between DPR and IRC:SP:73-2015 and discussed them with NHIDCL and the DPR consultant. The discrepancies are as follows.

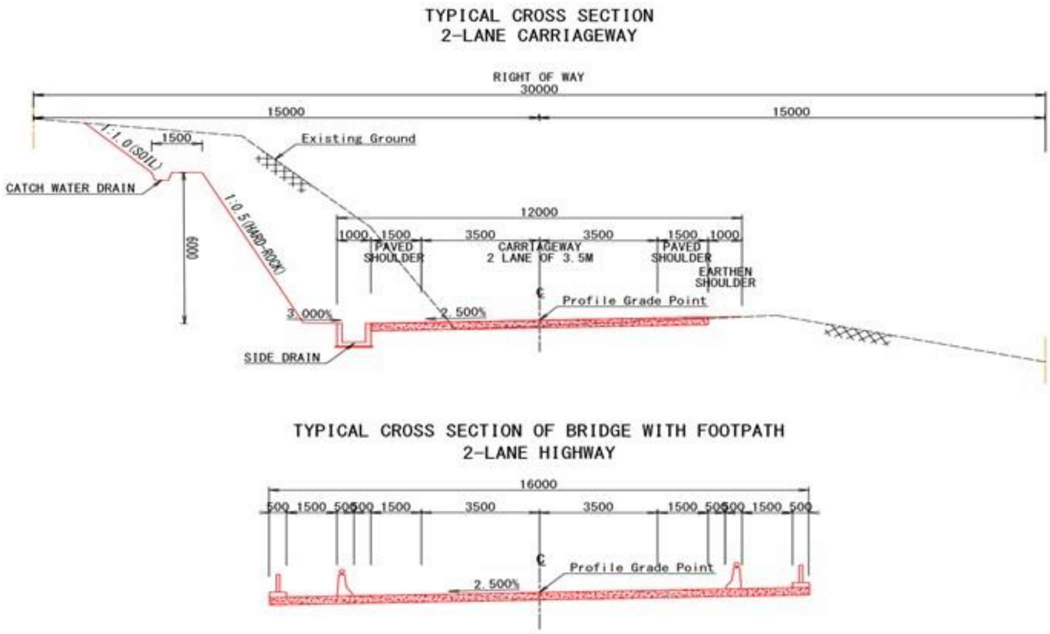
① The width of the earthen shoulder of IRC is 1.0 m whereas that of DPR is 2.0 m
② The details of width of bridge standard cross section are not indicated

As the result of the consultation with NHIDCL and the DPR consultant, the cross sections proposed by JICA Study Team as indicated below have been selected as the final.



Source: JICA Study Team

Figure 3-22: Discrepancies in Typical Cross Section between DPR and IRC



Source: JICA Study Team

Figure 3-23: Typical Cross Sections Proposed by JICA

3.2.4 Selection of Pavement Types

Regarding the selection of pavement types, the IRC standards and specifications (IRC:SP:73-2015) prescribe "The type of pavement to be provided shall be specified in Schedule 'B' of the contract. If nothing is specified the Concessionaire may adopt any type (flexible/rigid) of pavement structure for new construction and /or widening of existing carriageway."

Generally speaking, the executable limits for mechanical implementation of concrete pavement are smaller than 6% of longitudinal gradients and smaller than 100 m of horizontal curve radii, whereas those of NH40 are 7% and 75 m respectively.

In consideration of the current policy of GOI to give priority to concrete pavement, combination of cement-treated base and sub-base with bituminous surface layer as stipulated in IRC:37-2012 [5]is recommended by the JICA Study Team. This type of pavement has been successfully adopted for a road in Meghalaya by an Indian contractor[6].

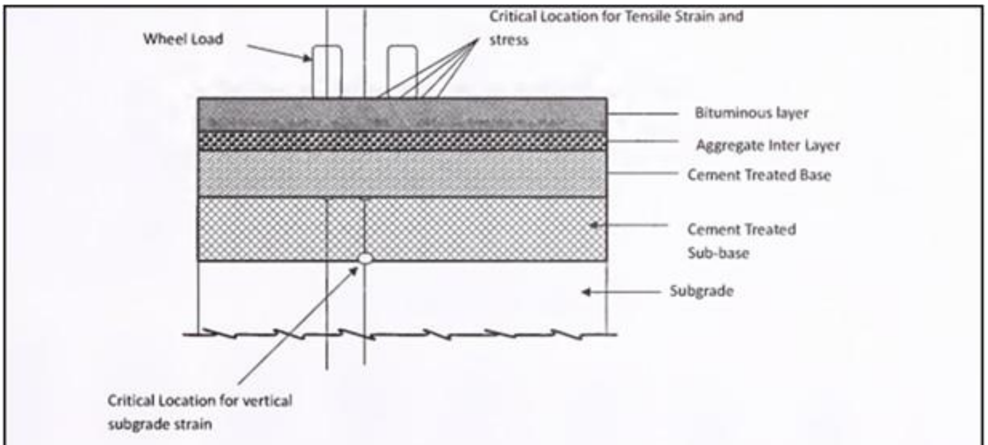


Fig. 10.2 Bituminous Surfacing, Cement Treated Base and Cement Treated Sub-Base with Aggregate Interlayer

Source: IRC:37:2012

Figure 3-24: Pavement Structure Proposed by JICA Study Team

3.2.5 Width of ROW

The IRC standards and specifications (IRC:SP:73-2015) stipulates "Two laning shall be accommodated within the existing ROW to the extent possible. However, additional land, if required for accommodating the two laning cross sections, improvement of geometrics, realignment, junctions, bypasses etc., shall be acquired by the Authority. For bypasses, ROW shall be 60 m."

NHIDCL has set out a policy about land acquisition as that ROW for two laning of NH40 including the bypass sections shall be 30 m in principle. When acquiring ROW encounters difficulties with social environmental impacts and other various reasons, the width shall be flexible and adopt the options of 24 m for hilly sections with sharp curves, 20 m for built-up sections, and as much width as required for high slope sections.

[5] IRC:37-2012 Tentative Guidelines for the Design of Flexible Pavements
[6] GR Infraprojects Ltd

Table 3-3: Width of ROW

Two-laning including bypasses	ROW (m)
General sections	30
Hilly sections with sharp curves	24
Built-up sections	20
High slope sections	As much as required

Source: JICA Study Team

3.2.6 Measures to Minimize Construction Period

The Project Road region falls in a long period monsoon zone of May through October and the Dawki area has an annual rainfall more than 10,000 mm. It is effective to carry out the construction works efficiently to adopt the precast method for road appurtenances like box-culverts. The precast method can also improve the quality control since the work is conducted indoors.

The precast method for road appurtenances is nothing new in Japan and commonly used for almost all road constructions. However, it is very seldom to find a company that produces road appurtenances with the precast method and sells them in the Indian market. Some road construction contractors have started to introduce the precast method by building their own fabrication yards near their road construction project sites. The pictures in Figure 3-22 show a sample of the precast method adopted for road construction site of NH40 in Meghalaya State.

The section between Shillong and Dawki of NH40 may encounter very limited working days because of the heavy rainfall especially during the monsoon season. The precast method enables the efficient construction work even during the monsoon season and completes the road earlier.

Source: JICA Study Team

Figure 3-25: Example of Adoption of Concrete Precast Method

3.2.7 Measures to Widen Cliff Road Sections

The IRC Guidelines for Geometric Design of Hill Roads (IRC:52-2001)[7] and Hill Road Manual (IRC:SP:48-1998)[8] set out the design principle as follows; "As a general rule, geometric features of highway except cross-sectional elements do not lend themselves suitable for stage construction. Particularly in the case of hill roads, improvement of features, like grade and curvature at a later date can be very expensive and may sometimes be impossible. It is, therefore,

[7] IRC: 52-2001 Recommendations about the Alignment Survey and Geometric Design of Hill Roads
[8] IRC:SP:48-1998 Hill Road Manual

necessary that ultimate geometric requirements of hill roads should be kept in view right in the beginning."

NH40 (Shillong-Dawki) passes through an areas which produce good quality aggregate for the construction industry. There are many quarries and aggregate factories along the route. It can be judged inductively from the situation of the existence of quarries that widening can be done easily by flattening the hillside. Structures for valley-side widening can be removed by selecting the road centerline on the hillside in designing road geometric alignment.

The general concept of the earthwork volume balancing is that an appropriate balancing of cut and fill earth volume makes the cost of earthwork minimum. However, regarding the Project Road NH40, even a larger cut earth volume than fill earth volume does not necessary lead to a higher construction cost. Because the cut materials are being used for aggregate for construction industry and the market exists nearby including the export to Bangladesh (1,000 truckloads everyday).

Considering the above-stated facts, the road centerline shall principally be selected on hillside to secure a space for road widening and remove structures for widening valley side.

Source: JICA Study Team

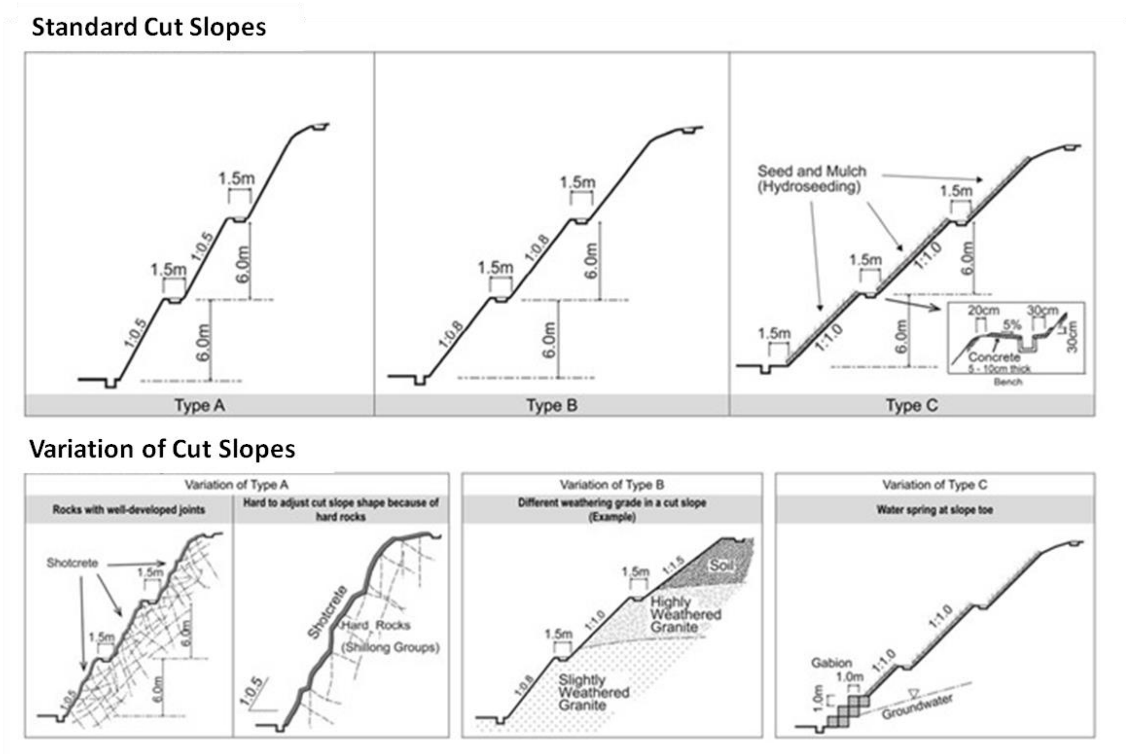
Figure 3-26: Road Widening of Cliff Sections

3.2.8 Measures to Protect Slopes

Regarding measures to protect slopes, the IRC manual for hill roads (IRC:SP:48-1998) states, "A hill road is formed either by full cutting into the hill or part cut and part fill. Stability of slopes, natural and man-made, is important for a hill road. Disturbance to slope can occur due to erosion caused by rain-fall and run-off and consequent slides. Effective erosion control measures protect slopes and prevent slides. The subject of slope stability and erosion control, therefore, becomes very vial for control and prevention of landslides/slips."

The JICA Study Team conducted geotechnical surveys with the objective of determining the nature and strength characteristics of the material comprising the slope. Then the Study Team classified the entire stretch of the project Road into three types and proposed proper slope gradients design respectively for hard rock (Type A), soft rock (Type B) and soil/weathered rock (Type C) by conducting rock/soil properties test for cut-slope protection.

As for the protection of the surface of slope, Hydro-seeding is proposed for the soil/weathered rock, whereas shotcrete is for rocks with well-developed joints and hard rock that is hard to cut slope shape. Gabion structure is also proposed for slopes with water spring at slope toes.



Source: JICA Study Team

Figure 3-27: Cut Slope Design Based on JICA Geotechnical Survey

3.2.9 Bridge Plan

After the discussions between JICA Study team and DPR Consultant during the site survey, the original bridge plan developed by the DPR Consultant has been revised. Although the detailed bridge design drawings have not yet been finalized, the following issues are recommended to improve the durability of bridges and to protect surrounding environment.

a) Improvement of skew angle

As new bridges on the new alignment are planned to cross the waterway to have angle made between road and waterway, DPR proposes many skewed bridges and some of which have very acute skew angles. In general, skewed bridges have disadvantage in the structure compared with straight bridges and need additional reinforcement against torsional force. Much attention is required during the placement of reinforcement bars especially at the corners of deck. It is recommended that skewed bridge should be changed to straight bridges or acute skew angles should be improved as much as possible to have nearly right angles. Although the straight bridge needs longer bridge length than skewed bridge but it has a great advantage to realize stable and durable structure and the increase of construction cost is within the acceptable level.

b) Structural type for short construction period

As the bridge near the starting point in Shillong at KP 0.260 crossing the deep river carries heavy traffic volume, planning of the new bridge to be constructed parallel to the existing bridge should take into account the difficult construction conditions at the site. DPR selects the steel truss which can avoid construction of piers in the deep river and can realize short construction period.

However, taking into account easy maintenance in the dense growing plants around the bridge, very limited land available for temporary work yard during construction, and minimum disturbance to the heavy traffic volume, it is recommended that steel box girder should be selected.

c) Minimum earthwork at construction site

The both sides of Dawki Bridge form steep slopes covered with dense forest and it is desirable to reduce the size of area to be excavated for the construction of piers and abutments situated along the slopes to secure the stability of the steep ground. By applying horizontally curved road alignment and by extending bridge sections, minimum excavation of the steep slopes can be achieved.

d) Prevention of muddy water flowing into waterway

The usage of well type foundation and usage of temporary steel sheet piles placed around the excavation site is effective to prevent muddy water from flowing into waterway.

Table 3-4: Bridge plan of DPR

No.	KP	Type	Length (m)	New Alignment	Measurements
1	0+000	Overpass	35	○	New Construction
2	0+260	Bridge	40		Widening (New Construction)
3	12+673	Overpass	35	○	New Construction
4	12+997	Bridge	34	○	New Construction
5	13+794	Overpass	30	○	New Construction
6	14+380	Bridge	25		Widening (New Construction)
7	18+185	Bridge	46		Widening (New Construction)
8	18+810	Bridge	25	○	New Construction
9	23+300	Bridge	26		Widening (New Construction)
10	40+750	Bridge	30	○	New Construction
11	43+690	Bridge	30	○	New Construction
12	50+798	Bridge	25		Rehabilitation
13	54+623	Bridge	52		Rehabilitation
14	73+000	Bridge	340	○	New Construction
15	73+810	Culvert	10		Widening

Source: JICA Study Team

CHAPTER 4 TRAFFIC SURVEY AND PROJECTIONS

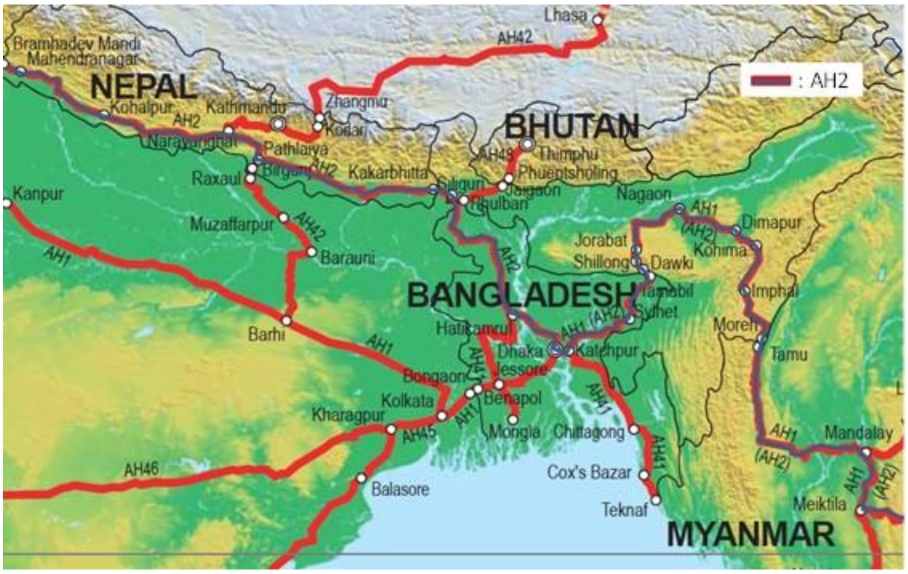
4.1 General

Prior to the traffic volume projection of NH40, previous traffic survey results and analyses from the Phase 1 Study were reviewed. Based on the results, additional traffic surveys were conducted in May and June, 2016.

The DPR consultant also conducted traffic surveys at several locations along NH40, and its results were also reviewed.

4.2 Study Road Network/Sections

The target road is NH40 from Shillong to Dawki in the Meghalaya State of India. This route is part of Asian Highway 2 (AH 2) which runs 13,177 km from Indonesia to Iran.



Source: JICA Study Team

Figure 4-1: Asian Highway 2 Network

Shillong is the capital of Meghalaya, and Dawki is one of the border crossing points with northern Bangladesh where rocks and gravel are exported by truck. The final report of “Data Collection Survey on Transport Infrastructure Development for Regional Connectivity in and around South Asia, March 2014” by JICA indicates that around 389,000 tons of bulk cargo was being transported in a year through this crossing point.

According to the information obtained at the Dawki border office in April, 2016, around 1,000 trucks are crossing the border daily carrying mainly lime stones to Bangladesh. The border is open from morning until evening daily, except for Sundays.

Source: JICA Study Team

Figure 4-2: Photos of Dawki/Tamabil Border Crossing Point

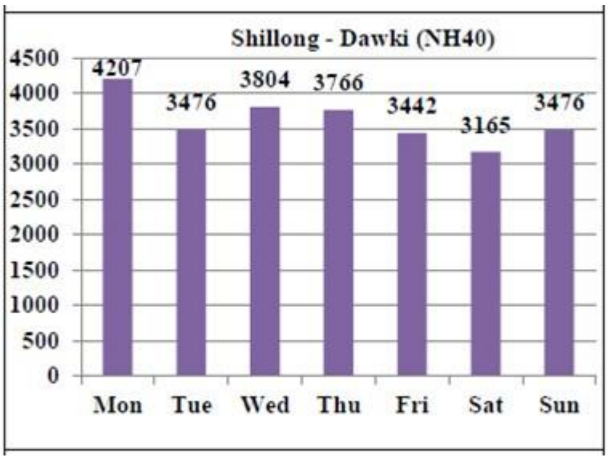
4.3 Existing Traffic Data and Analyses

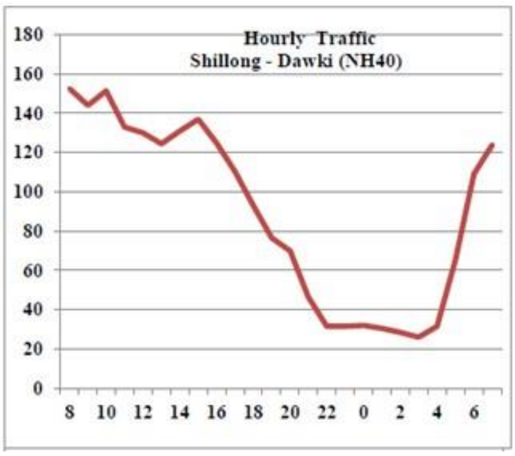
The Phase 1 study collected past traffic data on the Shillong – Dawki section from MORTH for 2005 and 2006. Additionally, they conducted a classified volume count survey as well as Origin-Destination (OD) survey.

Classified volume count surveys were carried out on 19-26 Feb, 2015 at two locations along NH40: Mylliem Nagar and Dawki. The survey data was analyzed to calculate the Average Daily Traffic (ADT), by simply taking the average for the 7 days of traffic data. The traffic volume is also presented by Passenger Car Unit (PCU) as per the factors in IRC 64-1990. Then the AADT was calculated after applying seasonal correction factors.

The OD survey was conducted at the same location on 23 and 24 February (Monday and Tuesday), 2015, respectively through Road Side Interview (RSI) method for 24 continuous hours on a random sample basis. A sample of well above 20% was targeted for RSIs. Vehicles were stopped with the help of local police and interviewed in accordance with the questionnaire.

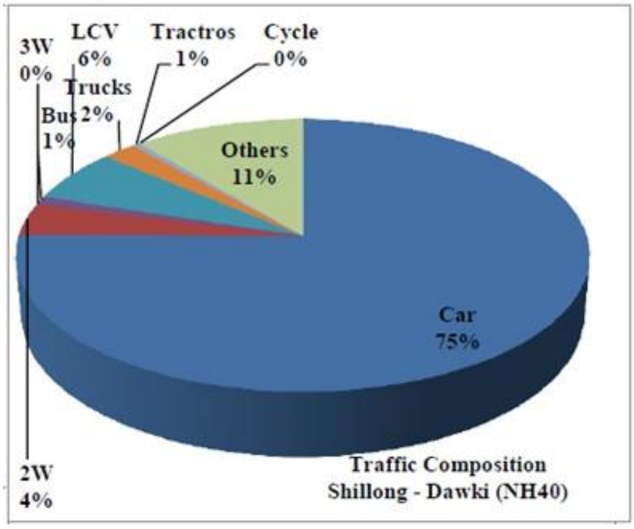
The results of traffic analyses in Phase 1 are shown below.





Source: JICA Study Team Phase 1

Figure 4-3: Traffic Volume and Hourly Variation on NH40



Source: JICA Study Team Phase 1

Figure 4-4: Traffic Volume Composition on NH40

Table 4-1: ADT of Shillong-Dawki in Phase 1 Study

Section	Unit	2W	3W	Car	Bus	Mini Bus	Truck (2-Axle)	Truck (3-Axle)	Truck (4 to 6-Axle)	Truck (7 & more Axle)	LCV	Bicycle	Animal vehicle	Agri. Tractors	Others	Total
Km 0 -Km 28	Veh.	180	0	3,829	30	36	608	0	0	0	737	0	0	0	16	5,436
	PCU	90	0	3,829	89	54	1,824	0	0	0	1,106	0	0	0	48	7,040
Km 28-Km 43	Veh.	78	0	1,213	0	0	146	0	0	0	423	0	0	0	2	1,862
	PCU	39	0	1,213	0	0	438	0	0	0	635	0	0	0	6	2,331
Km 43-Km75	Veh.	78	0	1,213	0	0	146	0	0	0	423	0	0	0	2	1,862
	PCU	39	0	1,213	0	0	438	0	0	0	635	0	0	0	6	2,331
Km 75 -Km 82	Veh.	78	0	1,213	0	0	146	0	0	0	423	0	0	0	2	1,862
	PCU	39	0	1,213	0	0	438	0	0	0	635	0	0	0	6	2,331
Km 82 -Km 84	Veh.	78	0	1,213	0	0	146	0	0	0	423	0	0	0	2	1,862
	PCU	39	0	1,213	0	0	438	0	0	0	635	0	0	0	6	2,331

Source: JICA Study Team Phase 1

Traffic growth was projected on the basis of historical trends using the elasticity approach. The total traffic that is likely to patronize the improved road facility will comprise; i) normal traffic, ii) generated or induced traffic, and iii) diverted traffic. Normal traffic is traffic currently using the study road and will continue to grow even without the proposed improvement. A minimum of 5% of normal traffic was considered as generated/induced traffic where sufficient road capacity for at least 5 years after the improvement of road is expected. Diverted traffic was not anticipated for the project road. The result of projection is shown below.

Table 4-2: Traffic Volume Projection of Shillong-Dawki in Phase 1 Study

Section	Unit	2020	2025	2030	2035
Km 0 –Km 28 , Mountainous/ Rolling	Veh.	9248	14286	21441	30671
	PCU	11616	17467	25443	35835
	No. of Lanes	>2	>2	>2	>2
Km 28 –Km 43 , Mountainous	Veh.	3195	4956	7477	10694
	PCU	3904	5901	8648	12208
	No. of Lanes	2	2	2	2
Km 43 –Km75, Mountainous/ Rolling	Veh.	3195	4956	7477	10694
	PCU	3904	5901	8648	12208
	No. of Lanes	2	2	2	>2 (mountainous part)
Km 75 –Km 82 , Mountainous	Veh.	3195	4956	7477	10694
	PCU	3904	5901	8648	12208
	No. of Lanes	2	2	2	2
Km 82 –Km 84 , Mountainous	Veh.	3195	4956	7477	10694
	PCU	3904	5901	8648	12208
	No. of Lanes	2	2	2	2

Source: JICA Study Team Phase 1

4.4 Traffic Survey

4.4.1 General

According to the results of traffic surveys from the Phase 1 study, only 2% of the total traffic on NH40 are trucks as seen in エラー! 参照元が見つかりません。. However, considering the information collected at the Dawki-Tamabil check-post that around 1,000 trucks are passing through daily with limestone loaded, 2% seemed too little. In order to cross check the traffic volume and vehicle composition, a traffic count survey and OD survey were conducted at Dawki. In addition, there could be a possibility that a part of cargo traffic from Kolkata port to Meghalaya through the chicken's neck could divert to the route from Chittagong port in Bangladesh through the Dawki border.

Considering the above, the traffic surveys were conducted at two points supplementing the survey results of Phase 1 study to assess the following assumptions.

- Assumption 1: The current low traffic volume (especially trucks) on NH40 is due to poor drivability and load restriction at Dawki Bridge.
- Assumption 2: There will be a shift of transport from the Kolkata port to the Chittagong port after the cross border agreement is concluded between India and Bangladesh.

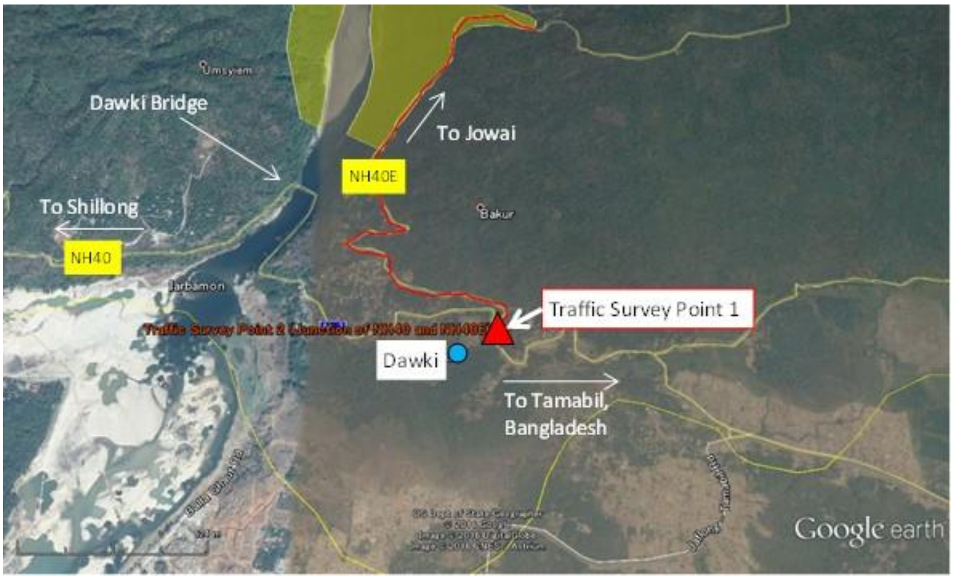
Table 4-3: Contents of Traffic Survey

Cross sectional traffic survey	
Survey point	2
Survey day and time	Continuous 7 days, 24 hours
Survey item	Passing number of vehicles by hour, by class, by direction, etc.
Roadside Origin/Destination (OD) survey	
Survey point	2
Survey duration and time	1 weekday, 16 hours (6:00～22:00)
Survey item	By class, OD, purpose, weight, trip time, conversion possibility, etc.
Requirement	Traffic police assistance

Source: JICA Study Team

4.4.2 Location of Survey

The location of the traffic count and OD survey are shown below.



Source: JICA Study Team

Figure 4-5: Location of Traffic Survey 1

Source: JICA Study Team

Figure 4-6: Location of Traffic Survey 2

4.4.3 Vehicle Categorization

The vehicle categorization for the traffic surveys used as per IRC 64-1990, is shown below.

Table 4-4: Traffic Type and PCU

Passenger Vehicles		Goods Vehicles	
Category	PCU	Category	PCU
Two wheeler	0.5	Truck (2-Axle)	3.0
Three wheeler/Auto Rickshaw	2.0	Truck (3-Axle)	4.5
Car	1.0	Truck (4 to 6-Axle)	4.5
Bus	3.0	Truck (7 & more Axle)	4.5
Mini Bus	1.5	Light Commercial Vehicle (LCV)	1.5
Bicycle	0.5	Tractor with Trailer	4.5
Rickshaw	2.0	Tractor without Trailer	1.5
		Animal drawn vehicle	6.0

Source: Phase 1 study report, IRC 64-1990

4.4.4 OD zone

The OD zoning was set as indicated below.

Table 4-5: OD Zone

No.	Place	District	State
1	Shillong	East Khasi Hills	Meghalaya
2	Dawki	Jayantia Hills	Meghalaya
3	Pynursla	East Khasi Hills	Meghalaya
4	Jowai	Jayantia Hills	Meghalaya
5	Nongtalang	Jayantia Hills	Meghalaya
6	Rest of East Khasi Hills	-	Meghalaya
7	Rest of Jayantia Hills	-	Meghalaya
8	Ri-ho District	-	Meghalaya
9	West Khasi Hills (Nongstoin), Garo Hills (Tura, William nagar, Baghmara, Ampati)	-	Meghalaya
10	Guwahati	Kamrup	Assam
11	Bongaigaon	Bongaigaon	Assam
12	Rest of Kamrup,Goalpara District	-	Assam
13	Nalbari, Barpeta, Kokrajhar, Rest of Bangaigaon, Dhubri, Chirang, Baksha, Udalgiri, Chirang	-	Assam
14	Karbi Along, Marigaon, Nogaon, Golaghat	-	Assam
15	Lakhimpur, Dhemaji, Sonitpur, Darang	-	Assam
16	Dibrugarh, Tinsukia, Sibsagar, Jorhat	-	Assam
17	Cachar hills, Cachar, Hailakandi, Karimganj	-	Assam
18	Tripura, Mizoram	-	-
19	Nagaland, Manipur	-	-
20	Arunachal Pradesh	-	-
21	Kolkata	-	-
22	Rest of West Bengal	-	-
23	Bangladesh	-	-
24	North zone of India(Jammu and Kashmir, Himachal Pradesh, Punjab, Uttarakhand, Uttar Pradesh and Haryana	-	-
25	East zone of India (Bihar, Orissa, Jharkhand)	-	-
26	West Zone of India (Rajasthan, Gujarat, Goa and Maharashtra)	-	-
27	South Zone of India(Andhra Pradesh, Karnataka, Kerala and Tamil Nadu)	-	-
28	Central Zone of India(Madhya Pradesh and Chhattisgarh)	-	-
29	Bhutan	-	-
30	Nepal	-	-

Source: JICA Study Team

4.4.5 Traffic Survey Result

The traffic counting and the OD survey were conducted during May and June, 2016. The period and time as well as ADT are shown in Table 4-6 and Table 4-7 respectively. ADT is presented in traffic volume and PCU. As for NH 40 (at Dawki), it was observed that 48% of the traffic in terms of number of vehicles and 74% in terms of PCU is freight traffic. Likewise for NH 31C in Assam, it was observed that 28% in terms of number of vehicles and 61% in terms of PCU is freight traffic.

Table 4-6: Period and Time of Traffic Survey

Type of Survey	Period and time	Duration
Classified Traffic Count on NH40	7 days x 24hrs	19-25 May, 2016
OD Survey on NH40	1 day x 16 hrs	23 May, 2016
Classified Traffic Count on NH31C	7 days x 24hrs	03-09 June, 2016
OD Survey on NH31C	1 day x 16 hrs	09 June, 2016

Source: JICA Study Team

Table 4-7: Traffic Counting Survey Result

	NH40		NH31C	
Vehicle Type	No	PCU	No	PCU
Two wheeler	103	51	2,882	1,441
Three Wheeler	0	0	817	817
Car	879	879	2,325	2,325
Mini bus	0	0	38	57
Bus	2	7	189	567
Total Passenger Traffic	984	937	6,251	5,207
LCV	1	2	728	1,092
2-Axle	888	2,665	809	2,427
3-Axle	22	66	536	1,609
Multi-Axle	0	0	970	4,363
Tractor	0	0	44	129
Total Freight Traffic	911	2,733	3,087	9,620
Slow Moving Vehicles	5	10	1,880	977
Total Traffic	1,900	3,680	11,218	15,804

Note: Slow moving vehicles includes cycles, rickshaws, animal/hand drawn vehicles
Source: JICA Study Team

For NH40, 7 am to 7 pm is the main operational period of traffic beyond which the traffic will be much less. The traffic volume rises from 7 am onwards, with trucks being at its peak during the evening time, from 5 pm to 6 pm. Passenger traffic had its peak at 3 pm to 4 pm.

Through the OD survey, it was observed that the movement of goods is confined to a limited influence area in Meghalaya state, the districts of East Khasi Hills and Jayantia Hills. The other end of the O-D is predominantly at Tamabil in Bangladesh and the remaining at Dawki. It is the quarry area of boulder and lime stone at Nongtalang which produces 80% of the total goods movement and the quarry area at Pynursla that accounts for 12%, while the remaining 8% to/from the different places of East Khasi Hills at one side of the O-D. The other end of O-D shows Tyamabil as a predominant destination.

Unlike goods vehicles, passenger trips have a wider influence area upto Guwahati or beyond, though about 90% of the passengers trips move within the state of Meghalaya. Nearly 60% of trips are distributed over the East Khasi Hills including the state capital of Shillong. Shillong is well connected by a network of roads to all important cities in the neighboring states and major cities in the country. Shillong at their either end of 20% of passenger traffic. Pynursla is a town in the middle of the Shillong-Dawki route and is also important for passenger traffic, as 25% of passenger traffic has Pynursla at either end. The remaining is within Jayantiya Hills (Jowai, a prominent destination) except for a very few to/from places of West Khasi Hills. Spatial pattern by vehicle type is summarized below.

Table 4-8: Spatial Pattern by Vehicle Type on NH40 (At Dawki)

Spatial Pattern	Freight traffic	Passenger traffic
Within State boundaries of Meghalaya	5%	92%
Meghalaya-Assam	0%	8%
India-Bangladesh	95%	0%
Total	100%	100%

Source: JICA Study Team

Observation on Assumptions

With regards to Assumption 1, it was found that the truck volume was more than what was counted in the Phase 1 study. When NH40 is improved with the new Dawki Bridge, the traffic volume is expected to increase as the economy and population grow. Also, large trucks will be used more instead of the two-axle trucks that are widely used at the moment.

As for Assumption 2, it was observed that majority of the cargo traffic is moving within Meghalaya state and/or between the Bangladesh border at Dawki-Tamabil. Therefore, it is unlikely that a part of the cargo traffic will divert to the route from Chittagong port through Dawki even after NH40 is improved.

4.5 Traffic Projections

4.5.1 Traffic Type

With respect to the traffic projection, types of traffic listed below will be assessed.

Table 4-9: Traffic Type

Type	Definition
Normal Traffic	Traffic which is currently using the target road and will continue to grow even without the proposed improvement
Induced Traffic	Traffic newly generated by the road improvement (short-term)
Diverted Traffic	Shifted traffic from parallel roads due to enhanced drivability by the road improvement

Source: JICA Study Team

4.5.2 Methodology of Traffic Projection

(1) Methodology

The DPR consultant conducted a more recent traffic survey in April, 2016, and the results were used in analysing the traffic volume and conducting the traffic projection. The projection of normal traffic is carried out in accordance with the method mentioned in IRC: 108, 1996, i.e. the elasticity approach in the same way as in the JICA Phase 1 study. The indicators used for the projection in the JICA Phase 1 study such as the number of registered vehicles, NSDP and per capita income as well as the elasticity values, etc, were followed. In addition, induced traffic and diverted traffic are also considered.

Table 4-10: Traffic Projection Methodology

Item	Formula	Parameters
Elasticity	Log e (P) = A0 + A1 Log e (EI)	• P = Traffic volume (of any vehicle type) • EI = Economic Indicator (GDP/NSDP/Population/PCI) • A0 = Regression constant • A1 = Regression co-efficient (Elasticity Index)
Passenger Vehicles	Grp = [(1+Rp) (1+ rpci x Em) – 1]	• Grp= Growth Rate Passenger Vehicle • Rp= Population Growth • Rpci= Per capita Income Growth • Em= Elasticity
Goods Vehicles	Grg = Em * R(nsdp)	• Grg= Growth Rate Goods Vehicle • Em= Elasticity Value • R(nsdp) = NSDP Growth Rate

Source: JICA Phase 1 Study, Derived from IRC: 108-1996

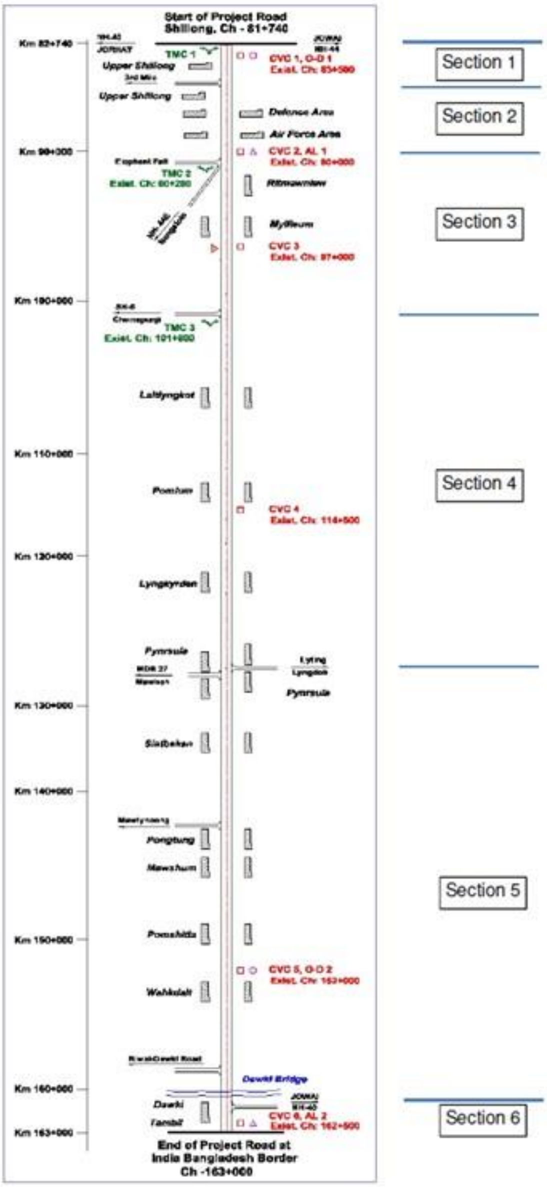
(2) Road Section

The target road was divided into six (6) sections considering their characteristics as shown below.

Table 4-11: Sections for Traffic Projection

No	Starting Point	Ending Point	Length (km)
1	Starting Point	3rd Mile	2.26
2	3rd Mile	Junction with NH44E	6.30
3	Junction with NH44E	Junction with SH5 (Cherrapunji Road)	11.43
4	Junction with SH5 (Cherrapunji Road)	Pynursala	29.27
5	Pynursala	Dawki	31.0
6	Dawki	Tamabil	1.0

Source: JICA Study Team based on the Draft Feasibility Report by the DPR Consultant



Source: Draft Feasibility Report by the DPR Consultant

Figure 4-7: Traffic Survey Location and Sections in the DPR

(3) Number of Registered vehicles

Vehicle registration data in Meghalaya state was used for determining the vehicle elasticity because no previous traffic count data was available.

Table 4-12: Vehicle Registration Data in Meghalaya

Year	Two Wheeler	Autos Rickshaw	Cars/Jeep Taxi	Bus	Truck	LCV
2005	27,237	3,001	36,856	3,285	15,819	1,907
2006	31,008	3,569	42,083	3,497	17,060	2,565
2007	36,112	4,081	47,076	3,639	17,937	3,222
2008	40,953	4,433	51,637	3,779	18,572	3,781
2009	45,747	4,842	57,999	3,905	19,747	4,425
2010	51,709	5,348	64,916	4,008	21,372	4,955
2011	56,790	6,000	73,419	4,117	23,064	6,058
2012	65,712	6,744	81,615	4,326	25,451	7,210
CAGR (%)	12.36%	10.91%	11.22%	3.65%	6.46%	17.92%

Source: JICA Phase 1 Study

(4) Economic Indicators

NDSP and per capita income in Meghalaya is summarized below. NSDP is used as an independent variable for estimating the elasticity of the goods vehicles such as trucks and LCVs, while per capita income data was used for passenger vehicles such as cars, buses, and two-wheelers.

Table 4-13: Economic Indicators

Year	NSCP (million INR)	Per Capita Income (INR)
2004-05	58,457	24,086
2005-06	63,028	25,642
2006-07	67,777	27,242
2007-08	69,909	27,764
2008-09	78,893	30,963
2009-10	83,964	32,569
2010-11	92,261	35,363
2011-12	102,988	34,217

Source: Ministry of Statistics & Programme Implementation, Government of India

(5) Elasticity

The projected elasticity value by vehicle types based on the JICA Phase 1 study is shown below.

Table 4-14: Elasticity Value by Vehicle Type

Year/ Period	2005-14	2014-17	2017-20	2020-25	2025-30	2030<
NSDP Growth Rate (%)	7.82%	7.82%	7.04%	6.69%	6.35%	6.03%
Population Growth Rate (%)	3.06%	2.60%	2.21%	1.88%	1.59%	1.36%
Per Capita Income Growth Rate (%)	4.76%	5.19%	4.82%	4.82%	4.78%	4.71%
Elasticity of Per Capita Income						
Two Wheeler: y=2.103x-10.98, R^2=0.948	2.10	1.79	1.70	1.61	1.53	1.45
Auto Rickshaw: y=1.860x-10.70, R^2=0.944	1.86	1.58	1.50	1.43	1.36	1.29
Cars/Jeep/Taxi: y=1.922x-8.862, R^2=0.961	1.92	1.63	1.55	1.47	1.40	1.33
Bus: y =0.619x + 1.871, R^2=0.93	0.62	0.68	0.75	0.83	0.78	0.74
Elasticity of NSDP						
Truck: y =0.817x+0.703, R^2=0.994	0.82	0.90	0.99	1.04	0.94	0.94
LCV: y =2.229x-16.78, R^2=0.963	2.23	1.56	1.25	1.19	1.13	1.07

Source: JICA Phase 1 Study

(6) Traffic Growth Rate

The following growth which is the same as JICA study Phase 1, was used for the traffic projection.

Table 4-15: Traffic Growth Rate Used for the Projection

Year/ Period	2005 - 14	2014 - 17	2017 -20	2020 - 25	2025-30	2030<
Two Wheeler	13.37%	14.70%	16.17%	16.98%	15.28%	8.29%
Autos Rickshaw	12.19%	11.02%	9.61%	8.88%	8.17%	7.50%
Cars / Jeep Taxi	12.48%	11.29%	9.85%	9.10%	8.38%	7.70%
Bus/Mini Bus	6.10%	6.23%	5.90%	5.92%	5.40%	4.91%
Truck (2-Axle)	6.41%	7.05%	6.98%	6.97%	5.96%	5.66%
Truck (3-Axle)	6.41%	7.05%	6.98%	6.97%	5.96%	5.66%
Truck (Multi-Axle)	6.41%	7.05%	6.98%	6.97%	5.96%	5.66%
LCV	17.44%	12.21%	8.79%	7.93%	7.16%	6.46%

Source: JICA Phase 1 Study

4.5.3 Result of the Traffic Survey and Projection in the DPR

The results of the traffic survey and projection are summarized in the tables below. AADT can be the base year (2016) traffic amount, however due to the non-availability of regular traffic counts, data for previous years is derived on the basis of monthly fuel sales for the year 2014-15. The fuel sales data have been collected from various stations in the project influence area to calculate the seasonal variation.

Table 4-16: ADT in Number of Vehicles in the DPR

Sl. No.	Veh. Type	ADT (In Nos.) Km 83+500	Km 90+000	Km 97+000	Km 114+500	Km 152+000	Km 162+500
1	Car	12569	10174	4098	2102	937	521
2	Mini-Bus	212	105	46	25	7	7
3	Pvt. Bus	101	48	23	13	1	1
4	Govt. Bus	47	37	27	5	13	6
5	LCV	811	581	506	284	556	437
6	2 Axle	339	322	147	88	14	557
7	3 Axle	18	33	2	0	0	2
8	4-6 Axle	0	2	0	0	0	0
9	>=7 Axle	0	0	0	0	0	0
10	2W	2822	989	773	253	46	45
11	3W	620	313	222	115	5	0
12	Tractor with Trailer	0	1	0	0	0	0
13	Tractor w/out Trailer	0	1	0	0	0	0
14	Cycle	8	7	2	0	0	0
Total		**17547**	**12613**	**5847**	**2886**	**1579**	**1575**

Source: Draft Feasibility Report by the DPR Consultant

Table 4-17: ADT in PCU in the DPR

Sl. No.	Veh. Type	ADT (In pcu) Km 83+500	Km 90+000	Km 97+000	Km 114+500	Km 152+000	Km 162+500
1	Car	12569	10174	4098	2102	937	521
2	Mini-Bus	318	157	69	38	10	10
3	Pvt. Bus	304	145	68	39	3	3
4	Govt. Bus	140	111	82	15	39	17
5	LCV	1216	871	758	426	834	656
6	2 Axle	1016	965	441	264	43	1670
7	3 Axle	55	100	7	1	0	6
8	4-6 Axle	1	10	1	0	0	0
9	>=7 Axle	0	0	0	0	0	0
10	2W	1411	494	387	126	23	23
11	3W	620	313	222	115	5	0
12	Tractor with Trailer	0	3	0	0	0	0
13	Tractor w/out Trailer	0	1	0	0	0	0
14	Cycle	4	3	1	0	0	0
Total		**17654**	**13349**	**6135**	**3127**	**1894**	**2904**

Source: Draft Feasibility Report by the DPR Consultant

Table 4-18: AADT in Number of Vehicles

Sl. No.	Veh. Type	AADT (In Nos.) Km 83+500	Km 90+000	Km 97+000	Km 114+500	Km 152+000	Km 162+500
1	Car	12183	9862	3973	2037	908	505
2	Mini-Bus	203	100	44	24	6	6
3	Pvt. Bus	97	46	22	12	1	1
4	Govt. Bus	45	35	26	5	13	5
5	LCV	777	557	484	272	532	419
6	2 Axle	324	308	141	84	14	533
7	3 Axle	18	32	2	0	0	2
8	4-6 Axle	0	2	0	0	0	0
9	>=7 Axle	0	0	0	0	0	0
10	2W	2736	958	750	245	44	44
11	3W	594	300	213	110	5	0
12	Tractor with Trailer	0	1	0	0	0	0
13	Tractor w/out Trailer	0	1	0	0	0	0
14	Cycle	8	7	2	0	0	0
Total		**16985**	**12210**	**5657**	**2791**	**1523**	**1515**

Source: Draft Feasibility Report by the DPR Consultant

Table 4-19: AADT in PCU

Sl. No.	Veh. Type	AADT (In pcu)					
		Km 83+500	Km 90+000	Km 97+000	Km 114+500	Km 152+000	Km 162+500
1	Car	12183	9862	3973	2037	908	505
2	Mini-Bus	305	150	66	36	10	10
3	Pvt. Bus	291	139	65	37	2	2
4	Govt. Bus	134	106	79	14	38	16
5	LCV	1165	835	727	409	799	628
6	2 Axle	973	925	422	253	41	1600
7	3 Axle	53	96	7	1	0	5
8	4-6 Axle	1	10	1	0	0	0
9	>=7 Axle	0	0	0	0	0	0
10	2W	1368	479	375	123	22	22
11	3W	594	300	213	110	5	0
12	Tractor with Trailer	0	3	0	0	0	0
13	Tractor w/out Trailer	0	1	0	0	0	0
14	Cycle	4	3	1	0	0	0
Total		17072	12909	5928	3021	1825	2788

Source: Draft Feasibility Report by the DPR Consultant

Table 4-20: Result of Traffic Projection (in PCU)

Section		Exisitng Chainage		Length (m)	Traffic (PCU)							
		From	To		2016	2020	2025	2030	2035	2040	2045	2050
1	Railbong Point to 3rd Mile	81+740	84+000	2260	17072	23107	32780	45249	60959	80190	105513	138863
2	3rd Mile to Junction with NH44E	84+000	90+300	6300	12909	17594	25113	34814	47029	61957	81639	107593
3	Junction with NH44 to Junction with SH5 (Cherrapunji Road)	90+300	101+730	11430	5928	7992	11285	15516	20849	27388	35988	47300
4	Junction with SH5 (Cherrapunji Road) to Pynursala	101+730	131+000	29270	3021	4077	5761	7924	10650	13992	18387	24169
5	Pynursla to Dawki	131+000	162+000	31000	1825	2431	3375	4562	6062	7915	10337	13506
6	Dawki to Tambil	162+000	163+000	1000	2788	3517	4648	6073	7884	10162	13101	16894

Source: Draft Feasibility Report by the DPR Consultant

4.5.4 Traffic Projection Result

(1) Diverted Traffic

Based on the OD survey results, Road Side Interviews (RSI) and further analysis of relevant study reports, the potential amount of diverted traffic on NH40 wasexamined.

<u>Traffic using NH40E</u>
Jowai, an important business and educational hub in the district of Jayantia Hills attractspassenger trips from/to the Dawki side. Keeping in mind two alternative alignments, project road (NH 40) and NH 40E, drivers/occupants were interviewed on their route preference for their destination of Jowai. It was found that they preferred to use NH 40 and make their trips via Shillong even with the detour of around 90 km, the reason being security problems and risk of landslides, etc, on the NH 40E route. According to the OD matrix below, passenger traffic between Dawki-Jowai dominated 14% of the total. Therefore, the JICA study team conservatively considered 5% of the passenger traffic to be diverted to NH 40.

Table 4-21: OD Matrix for Passenger Traffic at Dawki

		Destination										
		1	2	3	4	5	6	7	9	10	15	Total
Origin	1	0%	11%	0%	0%	0%	0%	0%	0%	0%	0%	11%
	2 (Dawki)	8%	6%	13%	**5%**	1%	10%	**3%**	1%	2%	3%	52%
	3	0%	13%	0%	0%	0%	0%	0%	0%	0%	0%	13%
	4 (Jowai)	0%	**3%**	0%	0%	0%	0%	0%	0%	0%	0%	3%
	5	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	1%
	6	0%	15%	0%	0%	0%	0%	0%	0%	0%	0%	15%
	7 (Rest of Jayantia Hills)	0%	**3%**	0%	0%	0%	0%	0%	0%	0%	0%	3%
	9	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	10	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	1%
	15	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	1%
	Total	8%	54%	13%	5%	1%	10%	3%	1%	2%	3%	100%

Source: JICA Study Team

<u>Traffic coming from India via inland waterway through Bangladesh</u>

Transportation of goods through the inland waterway of the Bangladesh-India protocol routes has finally begun in June, 2016. There is a possibility that a part of those goods which had been transported by land through the chicken's neck could potentially use this route as an alternative.

However as mentioned previously, based on the findings from the OD survey, the majority of cargo traffic on NH40 is moving within Meghalaya State and/or between Bangladesh border at Dawki-Tamabil. Also at this stage, it is uncertain that this route will be used to transport cargoes between India and Bangladesh through NH40 even after trade through the protocol route becomes active. Taking these factors into consideration, this traffic was not considered in the projection.

Source: Website of Bangladesh Inland Water Transport Authority (BIWTA)

Figure 4-8: Bangladesh – India Protocol Route

(2) Induced Traffic

The state of Meghalaya has a large reserve of coal. According to the website of the Department of Mining and Geology of the Government of Meghalaya, around 133 million tons are already proved and current yearly production is about 5 million tons. An additional443 million tons are estimated to be available.

Source: Website of Department of Mining and Geology, Government of Meghalaya

Figure 4-9: Mineral Map of Meghalaya

According to the guideline for transportation of coal in 2014 published by the Government of Meghalaya, each 2-axle truck is permitted to transport only 9 tons.

The JICA study team has contacted the Director of Mineral Resources and obtained the following statistics. Other stones and granite which are categorized as minor minerals are administered by the state forest department and the statistics of these minerals could not be obtained.

Table 4-22: Statistics of Coal and Limestone Exports

	Export from Dawki to Bangladesh (ton)		No. of Trucks		Average load (ton) per truck	
Year	Coal	Limestone	Coal	Limestone	Coal	Limestone
2011-2012	151,514	290,259	30,327	13,967	5	21
2012-2013	48,771	481,312	8,728	23,085	6	21
2013-2014	210,897	835,846	24,055	45,812	9	18
2014-2015	19,170	427,498	2,188	23,415	9	18
2015-2016	42,723	294,968	7,317	12,569	6	23

Source: Directorate of Mineral Resources, Shillong Meghalaya

From the above record, the export volume of coal is not stable and shows large fluctuations. It is uncertain whether the export of coal will further increase through the border, therefore it was not considered in the projection.

(3) Traffic Projection Results

The traffic projection results by section are summarized below.

Table 4-23: Results of Traffic Projection

Sec.	Km	Year	2016	2020	2025	2030	2035
1	0-2.26km	Veh. no	17,822	23,341	32,383	43,131	46,800
		PCU	17,916	23,464	32,554	43,359	57,099
		Lane	-	4	4	4	4
2	2.26-8.56km	Veh. no	12,807	16,733	23,271	30,955	40,817
		PCU	13,540	17,733	24,602	32,769	43,153
		Lane	-	4	4	4	4
3	8.56-19.99km	Veh. no	5,935	7,773	10,784	14,363	18,915
		PCU	6,219	8,145	11,300	15,051	19,820
		Lane	-	2	2	2	2
4	19.99-49.26km	Veh. no	2,925	3,831	5,315	7,079	9,322
		PCU	3,163	4,143	5,747	7,655	10,081
		Lane	-	2	2	2	2
5	49.26-80.26km	Veh. no	1,596	2,090	2,900	3,863	5,087
		PCU	1,915	2,508	3,480	4,635	6,103
		Lane	-	2	2	2	2
6	80.26-81.26km	Veh. no	1,588	2,080	2,885	3,843	5,061
		PCU	2,923	3,823	5,311	7,074	9,316
		Lane	-	2	2	2	2

Source: The JICA study team

The capacity of 2-lane and 4-lane roads above were set as per the recently revised guidelines; IRC SP 84-2014 and IRC SP 73-2015 as well as IRC 64-1900, which are summarized below. It is recommended that LOS B should be adopted for major arterial routes, but LOS C could also be adopted under certain circumstances. In this case, the traffic might experience congestion and inconvenience during some of the peak hours. For LOS C, design service volume can be taken as 40% higher than that for LOS B.

As for Section 6 between Dawki and Tambil (Bangladesh border), all vehicles stop at the check post for clearances which are causing the congestion with long queues of vehicles parked alongside the road. Therefore, it is recommended to make it a 4-lane to secure a parking lane.

Table 4-24: Design Service Volume for Highways in PCU/Day

No. of Lanes	Terrain	Level of Service B	Level of Service C
2-lane with paved shoulders	Rolling	13,000	18,200
	Mountainous and steep	9,000	12,600
4-lane	Plain and rolling	40,000	60,000
	Mountainous and steep	20,000	30,000

Source: IRC

CHAPTER 5 PRELIMINARY DESIGN OF NH40 (Shillong - Dawki)

5.1 Natural Condition Surveys

5.1.1 Meteorological and Hydrological Surveys

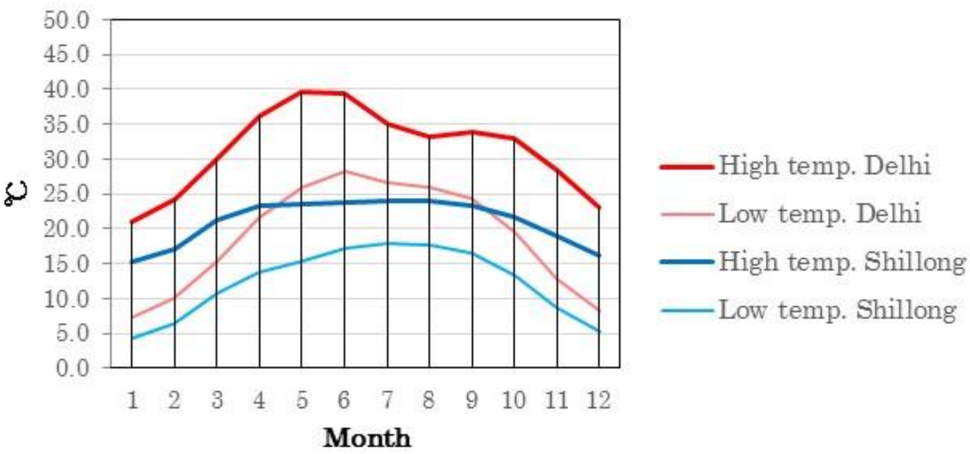
(1) General

The project road stretches about KP81.26 km long, connecting Shillong, located at an altitude of 1,500 m to Dawki at an altitude of 50 m near the border with Bangladesh. The altitude goes up from 1,500 m to 1,800 m traveling from the starting point to the KP25.00 km point, then comes down to 1,500 m again at KP30.00 km and KP35.00 km. It continues to go down toward the ending point of the project road.

At such a high altitude, the mean annual temperature is comparatively low at 21°C, but the annual rainfall is over 2,000 mm. Drainage measures are especially important in road planning for such a precipitous area with high rainfalls, and sufficient attention should be given to the planning of road cross drainage as well as roadside drains. Drain facilities that smoothly lead rainwater from the mountain side of the road to the downstream side will not only ensure road safety but also protect the life of the local residents.

(2) Meteorological Condition

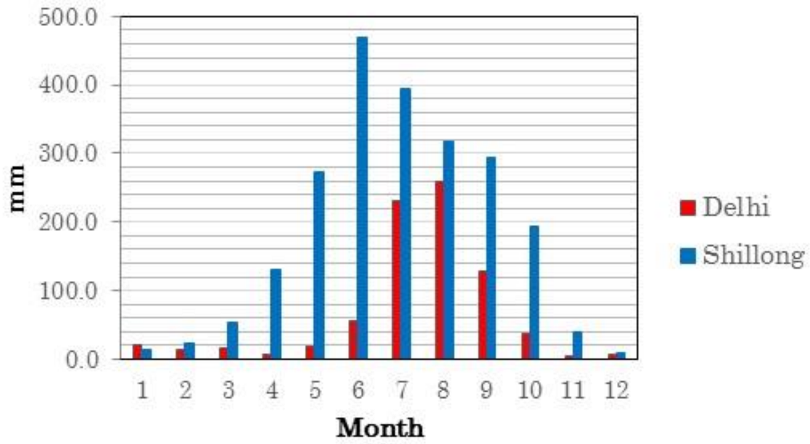
Figure 5-1 and 5-2 show annual temperature and rainfall. Shillong has a mild climate with the highest temperature ranging from 15°C to 24°C and the lowest from 4°C to 18°C. The temperature difference between Shillong and Delhi is very distinctive.



Source: JICA Study Team

Figure 5-1: High & Low Temperatures (Delhi, Shillong)

The annual rainfall is over 2,000 mm and there is a remarkable difference from Delhi. Rainfall in the six months from May to October accounts for nearly 90% of the annual rainfall, which speaks to the intensity of the rainfall in the period.



Source: JICA Study Team

Figure 5-2: Rainfall (Delhi, Shillong)

(3) Hydrological Study

For drainage design, the rainfall and catchment area are set according to the local characteristics and drainage discharge is calculated. Drainage structures shall be designed in accordance with the calculated values. For drainage design, the calculation method specified in IRC shall be used. IRC:SP:42-2014 Guidelines of Road Drainage and IRC:SP:13-2004 Guidelines for the Design of Small Bridges and Culverts, were used as technical standards.

a) Calculation Method

Drainage discharge is calculated with a rational formula, using the critical intensity rainfall at the peak hour.

$$Q = 0.028 \times C \times I \times A$$

where Q: Drainage Discharge (m^3/s)
C: Runoff Coefficient
I: Critical Intensity Rainfall (cm/hr) adjusted by reaching time
A: Catchment Area (ha)

Critical intensity rainfall is shown in the following formula.

$$I_c = F/T \times ((T+1)/(t_c+1)), \quad t_c = (0.87 \times L^3/H)^{0.385}$$

where F: Rainfall Intensity (mm/h)
T: Duration of Storm (h)
t_c: Time of Concentration (h)
L: Distance from the Critical Point to the Drainage Structure (km)
H: Fall in level from the Critical Point to the Drainage Structure (m)

b) Return Period

Return period is determined according to the type of structure and its length. If insufficient drainage is likely to cause a serious impact on road traffic and surrounding areas, the return period is set longer. If insufficient drainage is not likely to cause a serious impact or restoration is considered relatively easy, the return period is set shorter.

For cross drainage pipes that are 2 to 6 meters long, the return period should be 50 years. Some of the planned cross drainage pipes are more than 6 m long. However, considering the consistency with the observation data, their return period should also be set as 50 years.

c) Critical Intensity Rainfall

Critical intensity rainfall was determined according to the ATLAS of Statewise Generalised ISOPLUVIAL (Return Period) Maps of Eastern India (Par-II), issued by the GOI. Checking the project location in the critical intensity rainfall map and considering the contours of the rainfall map, critical intensity rainfall was determined for each section.

The following table shows rainfall intensity of each section.

Table 5-1: Rainfall Intensity along Project Road

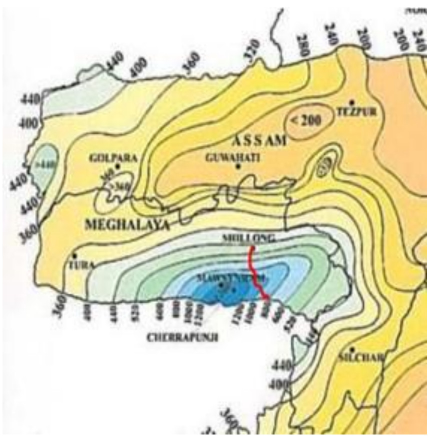
From (KP)	To (KP)	50-Years Return Rainfall intensity
Shillong 0 +000	Sadew 10+000	320 mm/hr
Sadew 10+000	Pomkaniew 20+000	600 mm/hr
Pomkaniew 20+000	Mawkajem 30+000	800 mm/hr
Mawakajem 30+000	Langkyrdem 35+000	1,000 mm/hr
Langkyrdem 35+000	Pongtung 55+000	1,200 mm/hr
Pongtung 55+000	Dawki 75+000	1,000 mm/hr

Source JICA Study Team

Table 5-2: Number of Rainy Days

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Des	Year
Delhi	1.7	1.3	1.2	0.9	1.4	3.6	10	11.3	5.4	1.6	0.1	0.6	39.1
Shillong	2.9	3.3	6.9	13.1	21.4	24.2	24.5	23.5	22.1	12.5	4.4	2.1	160.9

Source JICA Study Team



Source: ATLAS of Statewise Generalised ISOPLUVAL (Return Period) Maps of Eastern India (Part-II)

Figure 5-3: ISOPLUVAL Map with Project Location

d) Runoff Coefficient

The project site is categorized as "Rock, steep but wooded 0.8" in IRC SP13. The area is a steep mountainous area with rocky soil.

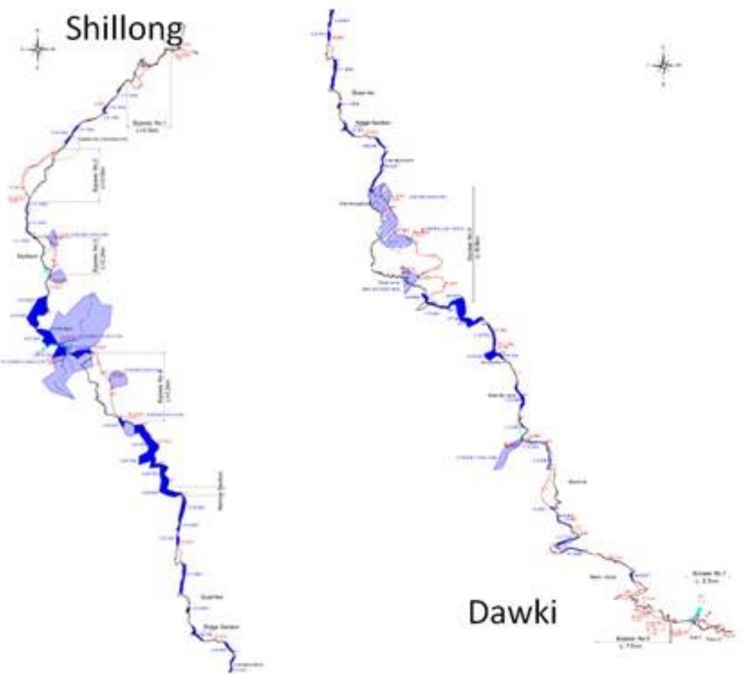
Table 5-3: Runoff Coefficient

Steep, bare rock and also city pavements	0.90
Rock, steep but wooded	0.80
Plateaus, lightly covered	0.70
Clayey soils, stiff and bare	0.60
-do- lightly covered	0.50
Loam, lightly cultivated or covered	0.40
-do- largely cultivated	0.30
Sandy soil, light growth	0.20
-do- covered, heavy brush	0.10

Source: IRC:SP:13-2004

e) Catchment Areas

Based on a survey map and a topographic map, catchment areas where cross pipes and bridges are located will be studied. Figure 5-4 shows a catchment area map.



Source: JICA Study Team

Figure 5-4: Catchment Areas

f) Results of Drainage Discharge Calculation

Table 5-4 lists the values of drainage discharge of each cross pipe and bridge calculated from critical rainfall intensity, catchment area, etc.

For the calculation of drainage discharge, it is one catchment to each existing cross-drainage nearby. In the 1.0m pipe where the capacity of stream flow is from 1.0m3/s to 3m3/s, there are some cross-drainages that exceed capacity. It is advisable to install more cross drainages for bigger sections.

Table 5-4: Discharge Summary

N0.	Chainage (Project Alignment)	Existing Drainage Form	Existing Drainage Section W×H, φ (m)	Catchment area (m2)	Length of Tributary (m)	Difference of elevation (m)	Q50 (m3/s)	Remark
	260	Bridge	L=40.0m				-	
1	370	1-slab	0.7×0.7	4,300	70	20.0	1.13	
2	470	1-slab	0.7×1.0	4,300	70	20.0	1.13	
3	750	1-pipe	0.6	7,400	70	10.0	1.94	
4	1,560	1-pipe	0.6	9,000	180	20.0	2.30	
5	1,670	1-pipe	0.9	9,000	180	20.0	2.30	
6	1,700	1-slab	0.8×(0.5)	9,000	180	20.0	2.30	
7	1,940	1-pipe	1	5,800	85	10.0	1.51	
8	1,930	1-slab	0.7×0.5	5,800	85	10.0	1.51	
9	3,870	1-pipe	0.6					
10	3,880	1-pipe	0.9					
11	4,000	1-slab	0.7×0.9	11,600	359	29.0	2.87	
12	4,800	1-pipe	0.9	14,900	365	19.0	3.63	
13	5,660	1-pipe	0.9	6,700	171	15.0	1.71	
14	6,260	1-pipe	0.9	-	-	-	-	
15	6,450	1-pipe	0.9	12,600	232	20.0	3.18	
16	6,680	1-pipe	0.9	12,600	232	20.0	3.18	
17	6,890	1-pipe	0.9	9,600	78	5.0	2.49	
18	7,180	1-pipe	0.6	9,600	78	5.0	2.49	
18	7,280	1-slab	3.1×1.0	9,600	78	5.0	2.49	
19	7,680	Box?		114,500	582	20.0	26.32	
20	10,620	1-pipe	0.9	4,300	121	8.0	1.11	
21	10,720	1-pipe	0.9	4,300	121	8.0	1.11	
22	10,910	1-pipe	0.9	4,300	121	8.0	1.11	
23	11,120	1-pipe	0.9	4,800	141	5.0	1.22	
24	11,200	1-pipe	0.9	4,800	141	5.0	1.22	
25	11,340	2-slab	2-1.0×1.0	4,800	141	5.0	1.22	
26	11,400	1-slab	1.0×1.0	4,800	141	5.0	1.22	
27	11,550	1-pipe	0.9	4,800	141	5.0	1.22	
28	11,630	1-slab	1.0×0.8	4,800	141	5.0	1.22	
29	12,080	1-slab	1.0×1.5	4,800	141	5.0	1.22	
30	12,220	1-pipe	0.9	7,900	151	5.0	1.99	
	14,526	Bridge	L=7.0m		480	50.0		
	14,975	Bridge			480	50.0		
31	15,300	1-pipe	0.9	43,400	480	50.0	10.62	
32	15,360	1-pipe	0.9	43,400	480	50.0	10.62	

N0.	Chainage (Project Alignment)	Existing Drainage		Catchment area (m2)	Length of Tributary (m)	Difference of elevation (m)	Q50 (m3/s)	Remark
		Form	Section W×H, ϕ (m)					
33	15,530	2-pipe	0.9	43,400	480	50.0	10.62	
34	15,660	1-pipe	0.9	43,400	480	50.0	10.62	
35	15,990	1-pipe	0.9	43,400	480	50.0	10.62	
36	16,280	1-pipe	0.9	52,600	560	40.0	12.55	
37	16,360	1-slab	0.5×0.2	52,600	560	40.0	12.55	
38	16,400	2-pipe	0.9	52,600	560	40.0	12.55	
39	16,540	1-pipe	0.9	52,600	560	40.0	12.55	
40	16,730	1-pipe	0.9	52,600	560	40.0	12.55	
41	16,870	1-pipe	0.9	52,600	560	40.0	12.55	
42	17,110	1-pipe	0.9	25,200	402	35.0	6.20	
43	17,250	1-pipe	0.9	25,200	402	35.0	6.20	
44	17,340	1-pipe	0.9	25,200	402	35.0	6.20	
45	17,380	1-pipe	0.9	25,200	402	35.0	6.20	
46	17,420	1-pipe	0.9	25,200	402	35.0	6.20	
47	17,590	1-pipe	0.9	25,200	402	35.0	6.20	
48	17,680	1-pipe	0.9	25,200	402	35.0	6.20	
49	17,870	1-pipe	0.9	25,200	402	35.0	6.20	
50	17,950	1-pipe	0.9	25,200	402	35.0	6.20	
51	18,020	1-pipe	0.9	25,200	402	35.0	6.20	
52	18,080	1-pipe	0.9	25,200	402	35.0	6.20	
	18,185	Bridge	L=44.5m	5,641,200	3,510	116.0	912.69	
53	18,440	1-pipe	0.9	51,600	621	70.0	12.44	
54	18,610	1-pipe	0.9	51,600	621	70.0	12.44	
55	18,760	1-slab	0.5×0.5	51,600	621	70.0	12.44	
	18,810	Bridge	L=26.0m	1,309,600	2,390	101.0	242.75	
56	18,880	1-pipe	0.9	12,700	210	116.0	3.30	
57	19,020	1-pipe	0.9	12,700	210	40.0	3.26	
58	19,210	1-pipe	0.9	12,700	210	40.0	3.26	
59	19,240	1-pipe	0.9	12,700	210	40.0	3.26	
60	19,460	1-pipe	0.9	12,700	210	40.0	3.26	
61	19,520	1-pipe	0.9	12,700	210	40.0	3.26	
62	19,630	1-pipe	0.9	12,700	210	40.0	3.26	
63	19,730	1-pipe	0.9	12,700	210	40.0	3.26	
64	19,810	1-pipe	0.9	12,700	210	40.0	3.26	
65	19,990	1-pipe	0.9	12,700	210	40.0	3.26	
66	23,350	1-pipe	0.9	32,300	248	20.0	10.84	

N0.	Chainage (Project Alignment)	Existing Drainage Form	Existing Drainage Section W×H, ϕ (m)	Catchment area (m2)	Length of Tributary (m)	Difference of elevation (m)	Q50 (m3/s)	Remark
67	23,450	1-pipe	0.9	32,300	248	20.0	10.84	
68	23,580	1-pipe	0.9	32,300	248	20.0	10.84	
69	24,200	1-pipe	0.9	32,300	248	20.0	10.84	
70	24,280	1-pipe	0.9	32,300	248	20.0	10.84	
71	24,460	1-pipe	0.9	32,300	248	20.0	10.84	
72	24,620	1-pipe	0.9	32,300	248	20.0	10.84	
73	24,700	1-pipe	0.9	32,300	248	20.0	10.84	
74	24,900	1-pipe	0.9	32,300	248	20.0	10.84	
75	25,040	1-pipe	0.9	35,400	248	20.0	11.88	
76	25,240	1-pipe	0.9	35,400	248	20.0	11.88	
77	25,380	1-pipe	0.9	35,400	248	20.0	11.88	
78	25,430	1-slab	1.0×5.1	139,400	634	40.0	43.66	
79	25,640	1-pipe	1	28,500	226	40.0	9.73	
80	25,840	1-slab	3.1×5.0	28,500	226	40.0	9.73	
81	26,060	1-pipe	0.9	28,500	226	40.0	9.73	
82	26,190	1-pipe	0.9	28,500	226	40.0	9.73	
83	26,390	1-pipe	0.9	28,500	226	40.0	9.73	
84	26,440	1-pipe	0.9	28,500	226	40.0	9.73	
85	26,600	1-pipe	0.9	28,500	226	40.0	9.73	
86	26,760	1-slab	1.0×2.0	28,500	226	40.0	9.73	
87	26,900	1-pipe	0.9	28,500	226	40.0	9.73	
88	27,050	1-pipe	0.9	25,700	310	40.0	8.63	
89	27,140	1-pipe	0.9	25,700	310	40.0	8.63	
90	27,200	1-slab	1.0×1.0	25,700	310	40.0	8.63	
91	27,240	1-pipe	0.9	25,700	310	40.0	8.63	
92	27,280	1-slab	2.8×3.0	25,700	310	40.0	8.63	
93	27,350	1-slab	0.7×1.0	25,700	310	40.0	8.63	
94	27,400	1-slab	4.0×5.0	25,700	310	40.0	8.63	
95	27,480	1-pipe	0.9	25,700	310	40.0	8.63	
96	27,710	1-slab	1.0×	25,700	310	40.0	8.63	
97	27,980	1-pipe	1.0	25,700	310	40.0	8.63	
98	28,310	1-pipe	0.9	20,900	148	30.0	7.23	
99	28,440	1-pipe	0.9	20,900	148	30.0	7.23	
100	28,570	1-pipe	0.9	20,900	148	30.0	7.23	
101	28,740	1-pipe	0.9	20,900	148	30.0	7.23	
102	28,880	1-pipe	1.0	20,900	148	30.0	7.23	

N0.	Chainage (Project Alignment)	Existing Drainage		Catchment area	Length of Tributary	Difference of elevation	Q50	Remark
		Form	Section W×H, ϕ (m)	(m2)	(m)	(m)	(m3/s)	
103	28,930	1-pipe	1.0	20,900	148	30.0	7.23	
104	29,140	1-pipe	1.0	5,800	72	30.0	2.04	
105	29,250	1-pipe	0.9	5,800	72	20.0	2.03	
106	29,320	1-pipe	1.0	5,800	72	20.0	2.03	
107	29,480	1-pipe	1.0	5,800	72	20.0	2.03	
108	29,530	1-pipe	0.9	5,800	72	20.0	2.03	
109	29,670	1-pipe	0.9	5,800	72	20.0	2.03	
110	29,700	1-pipe	0.9	6,000	70	15.0	2.10	
111	29,810	1-pipe	1.0	6,000	70	15.0	2.10	
112	29,900	1-pipe	1.0	6,000	70	15.0	2.10	
113	30,000	1-pipe	1.0	6,000	70	15.0	2.10	
114	30,060	1-pipe	1.0	6,000	70	15.0	2.10	
115	30,120	1-pipe	1.0	6,000	70	15.0	2.10	
116	30,920	1-pipe	1.0	6,200	92	20.0	2.70	
117	30,980	1-pipe	1.0	6,200	92	20.0	2.70	
118	31,090	1-pipe	1.0	6,200	92	20.0	2.70	
119	31,140	1-pipe	1.0	6,200	92	20.0	2.70	
120	31,210	1-slab	1.0×	6,200	92	20.0	2.70	
121	31,290	1-pipe	1.0	6,200	92	20.0	2.70	
122	31,340	1-pipe	1.0	6,200	92	20.0	2.70	
123	31,420	1-pipe	1.0	6,200	92	20.0	2.70	
124	31,600	1-pipe	1.0	6,200	92	20.0	2.70	
125	31,640	1-pipe	1.0	6,200	92	20.0	2.70	
126	31,720	1-slab	1.0×	6,200	92	20.0	2.70	
127	31,780	1-slab	1.0×	6,200	92	20.0	2.70	
128	31,840	1-pipe	1.0	6,200	92	20.0	2.70	
129	31,900	1-slab	1.0×	6,200	92	20.0	2.70	
130	31,960	1-slab	1.0×	6,200	92	20.0	2.70	
131	32,020	1-pipe	1.0	6,200	92	20.0	2.70	
132	32,080	1-pipe	1.0	6,200	92	20.0	2.70	
133	32,230	1-pipe	1.0	6,200	92	20.0	2.70	
134	32,930	1-slab	1.0×	6,900	100	20.0	3.00	
135	33,030	1-pipe	1.0	6,900	100	20.0	3.00	
136	33,760	1-pipe	1.0	4,000	75	20.0	1.75	
137	33,880	1-pipe	1.0	4,000	75	20.0	1.75	
138	33,920	1-pipe	1.0	4,000	75	20.0	1.75	

N0.	Chainage (Project Alignment)	Existing Drainage		Catchment area (m2)	Length of Tributary (m)	Difference of elevation (m)	Q50 (m3/s)	Remark
		Form	Section W×H, ϕ (m)					
139	33,970	1-pipe	1.0	4,000	75	20.0	1.75	
140	34,070	1-pipe	1.0	4,000	75	20.0	1.75	
141	34,140	1-slab	1.0×	4,000	75	20.0	1.75	
142	34,170	1-pipe	1.0	4,000	75	20.0	1.75	
143	34,220	1-pipe	1.0	4,000	75	20.0	1.75	
144	34,300	1-pipe	1.0	4,000	75	20.0	1.75	
145	34,430	1-pipe	1.0	4,000	75	20.0	1.75	
146	34,510	1-pipe	1.0	4,000	75	20.0	1.75	
147	34,520	1-pipe	1.0	4,000	75	20.0	1.75	
148	34,580	1-slab	1.0		-	-	-	No Catchment
149	35,080	1-pipe	1.0		-	-	-	No Catchment
150	35,330	1-slab	1.0	7,300	75	5.0	3.80	
151	35,430	1-pipe	1.0	7,300	75	5.0	3.80	
152	35,540	1-slab	0.5×	7,300	75	5.0	3.80	
153	35,580	1-slab	0.5×	7,300	75	5.0	3.80	
154	36,180	1-slab	0.7×	7,300	75	5.0	3.80	
155	36,290	1-pipe	1.0	4,400	65	5.0	2.30	
156	36,390	1-pipe	1.0	4,400	65	5.0	2.30	
157	36,440	1-pipe	1.0	4,400	65	5.0	2.30	
158	36,460	1-pipe	1.0	4,400	65	5.0	2.30	
159	36,520	1-pipe	1.0	4,400	65	5.0	2.30	
160	36,610	1-pipe	1.0	4,400	65	5.0	2.30	
161	36,660	1-pipe	1.0	4,400	65	5.0	2.30	
162	36,800	1-pipe	1.0	4,400	65	5.0	2.30	
163	36,840	1-pipe	1.0	4,400	65	5.0	2.30	
164	36,960	1-pipe	1.0	4,400	65	5.0	2.30	
165	37,000	2-pipe	1.0	4,400	65	5.0	2.30	
166	37,040	1-pipe	1.0	4,800	65	5.0	2.51	
167	37,080	1-pipe	1.0	4,800	65	5.0	2.51	
168	37,070	1-pipe	1.0	4,800	65	5.0	2.51	
169	37,250	1-slab	1.0×	4,800	65	5.0	2.51	
170	37,320	1-pipe	1.0	4,800	65	5.0	2.51	
171	37,360	1-pipe	1.0	4,800	65	5.0	2.51	
172	37,400	1-pipe	1.0	4,800	65	5.0	2.51	
173	37,490	1-pipe	1.0	4,800	65	5.0	2.51	
174	37,640	1-pipe	1.0	4,800	65	5.0	2.51	

N0.	Chainage (Project Alignment)	Existing Drainage Form	Existing Drainage Section W×H, ϕ (m)	Catchment area (m2)	Length of Tributary (m)	Difference of elevation (m)	Q50 (m3/s)	Remark
175	37,710	1-pipe	1.0	4,800	65	5.0	2.51	
176	45,970	2-pipe	1.0	36,800	347	25.0	18.16	
177	46,260	1-pipe	1.0	11,100	60	30.0	5.86	
178	46,320	1-pipe	1.0	11,100	60	30.0	5.86	
179	46,410	1-pipe	1.0	11,100	60	30.0	5.86	
180	46,540	1-pipe	1.0	11,100	60	30.0	5.86	
181	46,710	1-pipe	1.0	11,100	60	30.0	5.86	
182	46,990	1-pipe	1.0	11,100	60	30.0	5.86	
183	47,100	1-pipe	1.0	25,000	230	40.0	12.80	
184	47,490	1-pipe	1.0	25,000	230	40.0	12.80	
185	47,660	1-pipe	1.0	25,000	230	40.0	12.80	
186	47,750	1-pipe	1.0	21,300	347	40.0	10.64	
187	47,840	1-pipe	1.0	21,300	347	40.0	10.64	
188	47,940	1-pipe	1.0	21,300	347	40.0	10.64	
189	48,010	1-pipe	1.0	21,300	347	40.0	10.64	
190	48,080	1-pipe	1.0	21,300	347	40.0	10.64	
191	48,200	1-pipe	1.0	21,300	347	40.0	10.64	
192	48,340	1-pipe	1.0	21,300	347	40.0	10.64	
193	48,400	1-pipe	1.0	21,300	347	40.0	10.64	
194	48,460	1-pipe	1.0	18,300	165	30.0	9.46	
195	48,540	1-pipe	1.0	18,300	165	30.0	9.46	
196	48,650	1-pipe	1.0	18,300	165	30.0	9.46	
197	48,740	1-pipe	1.0	18,300	165	30.0	9.46	
198	48,880	1-pipe	1.0	24,200	313	60.0	12.28	
199	49,000	1-pipe	1.0	24,200	313	60.0	12.28	
200	49,070	1-pipe	1.0	24,200	313	60.0	12.28	
201	49,240	1-pipe	1.0	24,200	313	60.0	12.28	
202	49,380	1-pipe	1.0	24,200	313	60.0	12.28	
203	49,800	1-pipe	1.0	12,200	67	20.0	6.42	
204	49,900	1-pipe	1.0	12,200	67	20.0	6.42	
205	50,220	4-pipe	1.0	12,200	67	20.0	6.42	
206	50,370	1-pipe	1.0	12,200	67	20.0	6.42	
207	50,440	1-pipe	1.0	12,200	67	20.0	6.42	
208	50,500	1-pipe	1.0	12,200	67	20.0	6.42	
	50,798	Bridge	L=24.8m	115,500	478	100.0	57.64	Bridge
209	50,970	1-pipe	1.0	11,800	98	20.0	6.17	

N0.	Chainage (Project Alignment)	Existing Drainage Form	Existing Drainage Section W×H, ϕ (m)	Catchment area (m2)	Length of Tributary (m)	Difference of elevation (m)	Q50 (m3/s)	Remark
210	51,060	1-pipe	1.0	11,800	98	20.0	6.17	
211	51,210	1-pipe	1.0	11,800	98	20.0	6.17	
212	52,300	1-pipe	1.0	11,600	75	20.0	6.10	
213	52,390	1-pipe	1.0	11,600	75	20.0	6.10	
214	52,520	1-pipe	1.0	11,600	75	20.0	6.10	
215	52,690	1-pipe	1.0	11,600	75	20.0	6.10	
216	53,440	2-pipe	1.0	11,600	75	20.0	6.10	
217	53,550	1-pipe	1.0	11,600	75	20.0	6.10	
218	53,620	1-pipe	1.0	11,600	75	20.0	6.10	
219	53,730	1-pipe	1.0	11,600	75	20.0	6.10	
220	54,330	1-pipe	1.0	3,000	41	10.0	1.58	
221	54,650	1-pipe	1.0	3,000	41	10.0	1.58	
	55,006	Bridge	L=52.0m	5,512,800	2,741	224.0	1,777.85	
222	55,250	1-slab	1.0×1.0	2,200	40	5.0	0.97	
223	55,410	1-slab	1.0×2.0	2,200	40	5.0	0.97	
224	55,660	1-pipe	1.0	2,200	40	5.0	0.97	
225	55,810	1-pipe	1.0	2,200	40	5.0	0.97	
226	55,850	1-pipe	1.0	2,200	40	5.0	0.97	
227	55,660	1-pipe	1.0	2,200	40	5.0	0.97	
228	55,810	1-pipe	1.0	19,000	20	5.0	8.40	
229	55,860	1-pipe	1.0	19,000	20	5.0	8.40	
230	56,160	1-pipe	1.0	19,000	20	5.0	8.40	
231	56,230	1-pipe	1.0	19,000	20	5.0	8.40	
232	56,760	1-pipe	1.0	19,000	20	5.0	8.40	
233	56,940	1-pipe	1.0	19,000	20	5.0	8.40	
234	57,100	1-pipe	1.0	19,000	20	5.0	8.40	
235	58,970	1-pipe	1.0	5,800	155	10.0	2.47	
236	59,200	1-pipe	1.0	5,900	20	5.0	2.61	
237	59,500	1-pipe	1.0	5,900	20	5.0	2.61	
238	60,080	1-pipe	1.0	5,900	20	5.0	2.61	
239	60,150	1-pipe	1.0	5,900	20	5.0	2.61	
240	61,220	2-pipe	1.0	7,000	20	10.0	3.10	
241	61,440	1-pipe	1.0	7,000	20	10.0	3.10	
242	61,720	1-pipe	1.0	7,000	20	10.0	3.10	
243	61,850	1-pipe	1.0	7,000	20	10.0	3.10	
244	61,960	1-pipe	1.0	7,000	20	10.0	3.10	

N0.	Chainage (Project Alignment)	Existing Drainage		Catchment area (m2)	Length of Tributary (m)	Difference of elevation (m)	Q50 (m3/s)	Remark
		Form	Section W×H, ϕ (m)					
245	62,110	1-pipe	1.0	7,000	20	10.0	3.10	
246	63,090	1-pipe	1.0	1,800	20	10.0	0.80	
247	63,290	1-pipe	1.0	1,800	20	10.0	0.80	
248	63,390	1-pipe	1.0	1,800	20	10.0	0.80	
249	63,490	1-pipe	1.0	5,600	20	5.0	2.48	
250	63,890	1-pipe	1.0	5,600	20	5.0	2.48	
251	65,930	1-pipe	1.0	5,600	20	5.0	2.48	
252	66,130	1-slab	0.5×	5,100	20	5.0	2.25	
253	66,300	1-slab	0.5×	5,100	20	5.0	2.25	
254	66,400	1-slab	0.5×	5,100	20	5.0	2.25	
255	66,490	2-slab	1.0×	5,100	20	5.0	2.25	

Source: JICA Study Team

5.1.2 Topographical Survey

(1) General

Meghalaya State is also known as Meghalaya plateaus, and its topography comprises of mountain and plateau regions. The altitude of these plateaus ranges from 150 m to nearly 2,000 m. The highest is in the plateaus of the central region such as Khasi Hills while the lowest is that of the Garo Hills. The highest peak in Meghalaya State is Shillong Peak which is 1,961 m. The longitudinal profile of the target section is shown below.

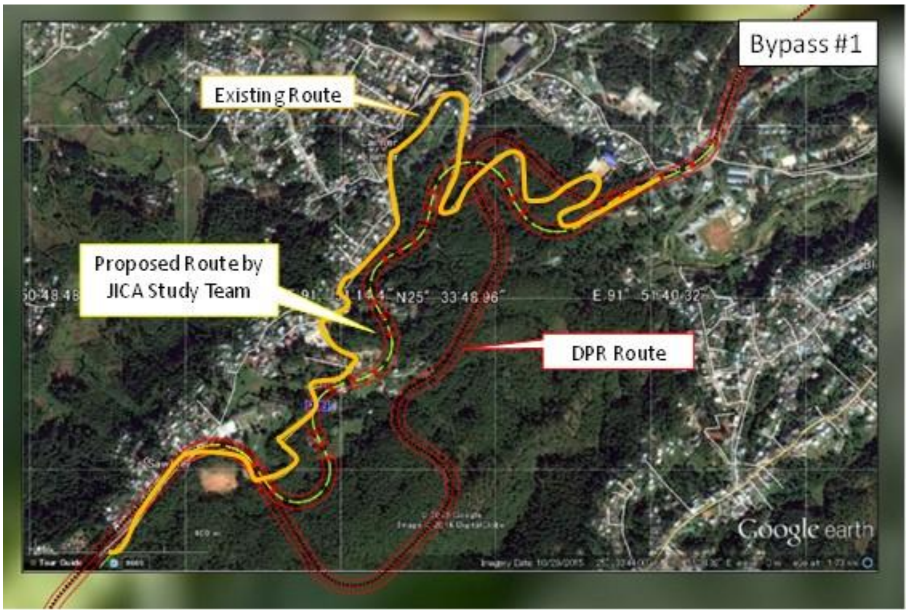
Source: Phase 1 Study

Figure 5-5: Existing Longitudinal Profile of Target Road

For road design including determining the optimal horizontal and longitudinal alignment, a topographic survey was planned. As the DPR consultant had already conducted the detailed topographic survey along NH40 and proposed seven bypasses including land usage and cross sectional survey with intervals of less than 40 m, the additional topographic survey was only conducted at sections where a different route alignment was proposed by the JICA Study Team.

(2) Location of Topographic Survey

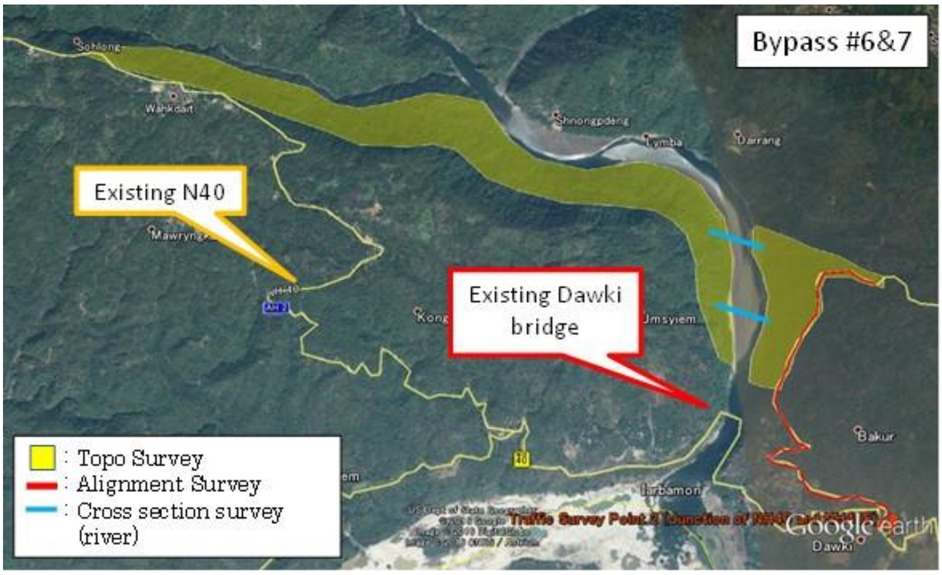
After reviewing the route alignment proposed by the DPR consultant, the JICA Study Team has identified possible alternative alignments at two bypass locations and conducted additional topographic surveys. The areas of such surveys are shown below. At bypass No. 1, a 50 m strip along the route proposed by the JICA Study Team (25 m from the center line to both sides) was surveyed.



Source: JICA Study Team

Figure 5-6: Topographic Survey Area at Bypass No. 1

At bypass No. 6 and No. 7, the wide area on the northern side of the hill behind the existing NH40 was surveyed in order to identify a suitable route alignment. In addition, a river cross section survey was conducted at two sections in Dawki River for the bridge design.



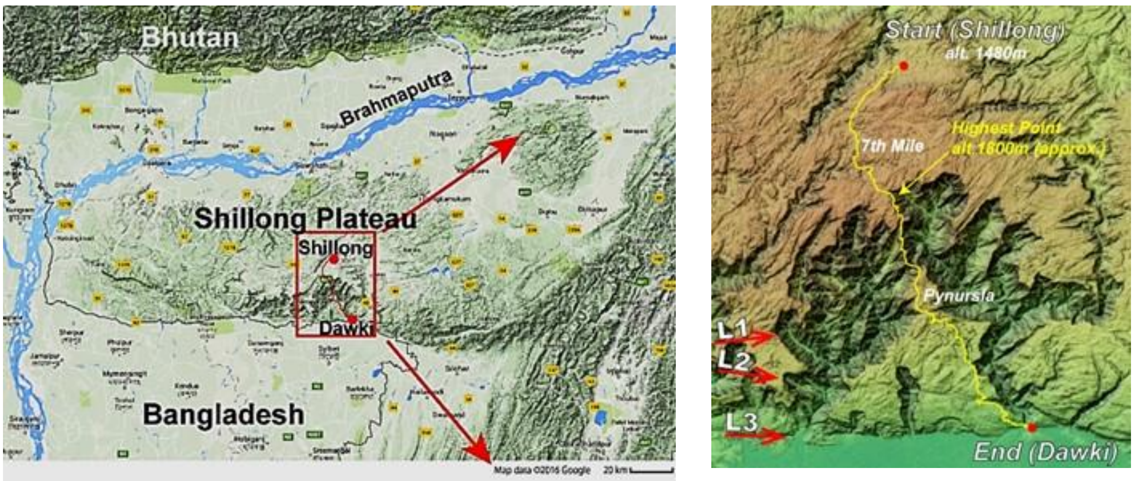
Source: JICA Study Team

Figure 5-7: Topographic Survey Area at Bypass No. 6 and No. 7

5.1.3 Geographical Survey

(1) Geographical Feature

NH40 extends approximately 80 km from the center of the west part of Shillong Plateau to the south rim of Shillong Plateau. The Shillong Plateau is a plateau in eastern Meghalaya state, northeastern India. The plateau's southern, northern and western ridges form the Garo, Khasi and Jaintia Hills respectively. The elevation at the highest point of NH40 is about 1800 m above sea level at KP23+000 from Shillong city (1470 m above sea level). NH40 gradually goes down from the highest point towards Dawki (50 m above sea level). Itpasses through a steep hilly area between KP2+000 to KP35+500, especially from KP29+500 to KP35+500, then goes on a narrow ridge (Figure 5-8).



Source: JICA Study Team based on Google Maps and NASA SRTM3 Version 3

Figure 5-8: Topographical Map along NH40


Source: JICA Study Team

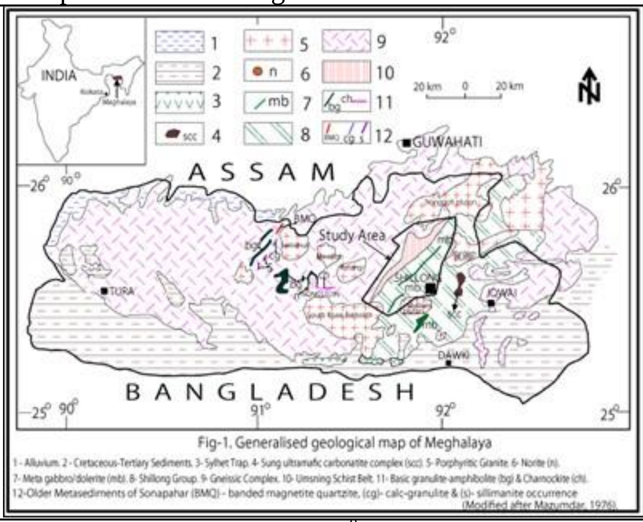
Figure 5-9: NH40 Passing Through Steep Hilly Area

Shillong Plateau shows numerous fracture lineaments in satellite images or topographic maps and has been subjected to extensive compressive forces in the N-S and E-W directions. Three clear lineaments extending east and west can be identified on the topographical map as shown with arrows, L1, L2 and L3 in Figure 5-8. These lineaments may be expressions of underlying geological structures such as faults. L1 and L2 shown in Figure 5-9 may be Dauki Fault and derived fault.

(2) Geology

There are several papers about the geology of Shillong Plateau or the NER of India. Figure 5-10 shows a geological map of Shillong Plateau presented by M.A.Khonglah et. Al. (2008). According to Figure 5-10, four kinds of geology specified in Table 5-5 are shown between Shillong and Dawki.

Although meta basics could not been found along NH40 by the JICA Study Team, other three geological groups, Cretaceous-Tertiary Sediments, Mylliem Pluton (Granite) and Shillong Group were found along NH40.



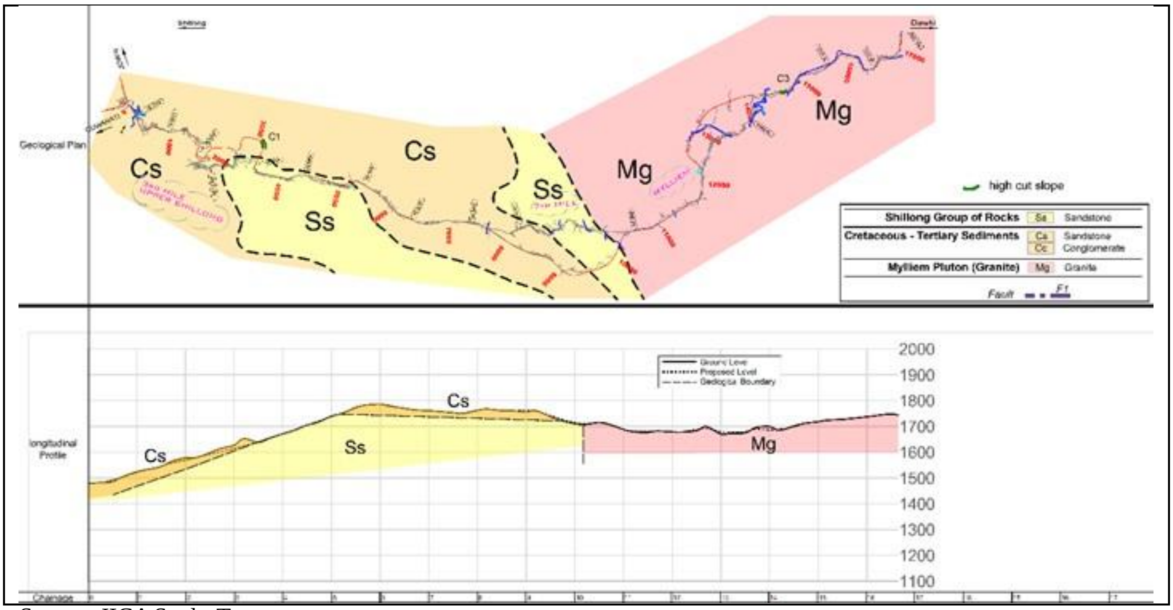
Geological Formation (Geological age)	Lithology
Cretaceous-Tertiary Sediments (Cretaceous-Tertiary)	sandstone shale conglomerate limestone, etc.
Meta Basics (Middle – late Cretaceous)	
Mylliem Pluton (Middle – late Proterozoic)	granite
Shillong Group (Lower Proterozoic)	phyllite slate quartzite conglomerate etc.

Source: M.A.Khonglah et. Al.(2008)[9]

Figure 5-10: Geological Map of Meghalaya

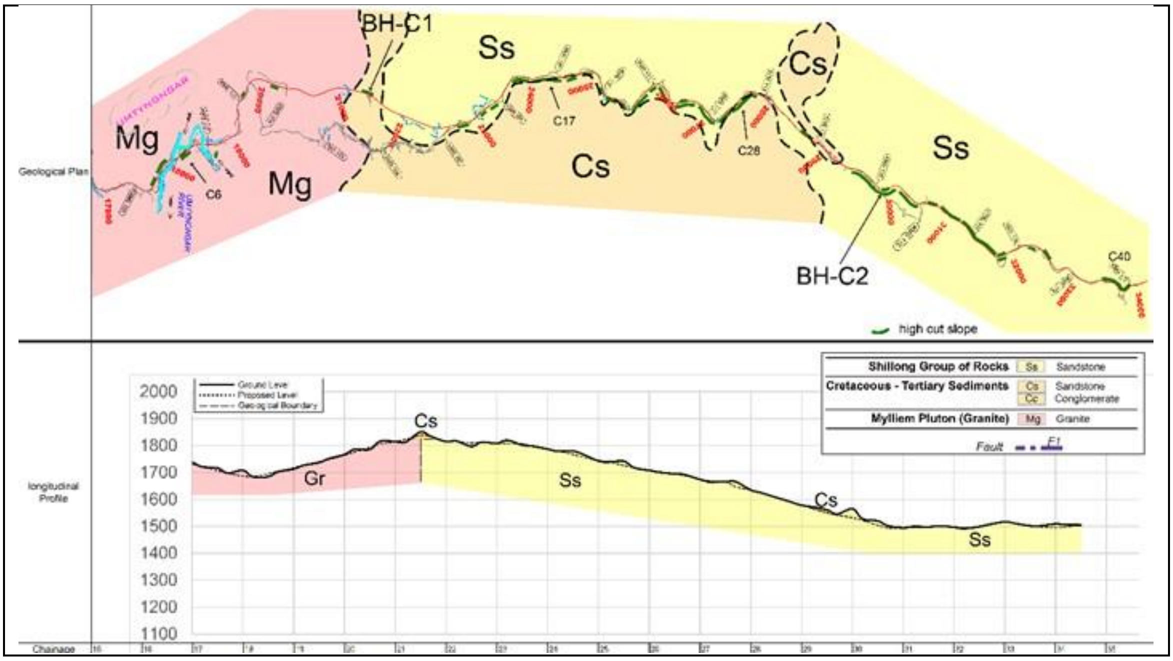
[9] 1) M.A.Khonglah et. al.(2008); Geology and structure of the areas in and around Shillong, Meghalaya, North East India, Revisited, Nagaland University Reserach Journal Special Publication 2008

Figure 5-11 to 5-14 shows the distribution of geological material along NH40 between Shillong and Dawki confirmed by the JICA Study Team, and Table 5-5 shows the geological classification.



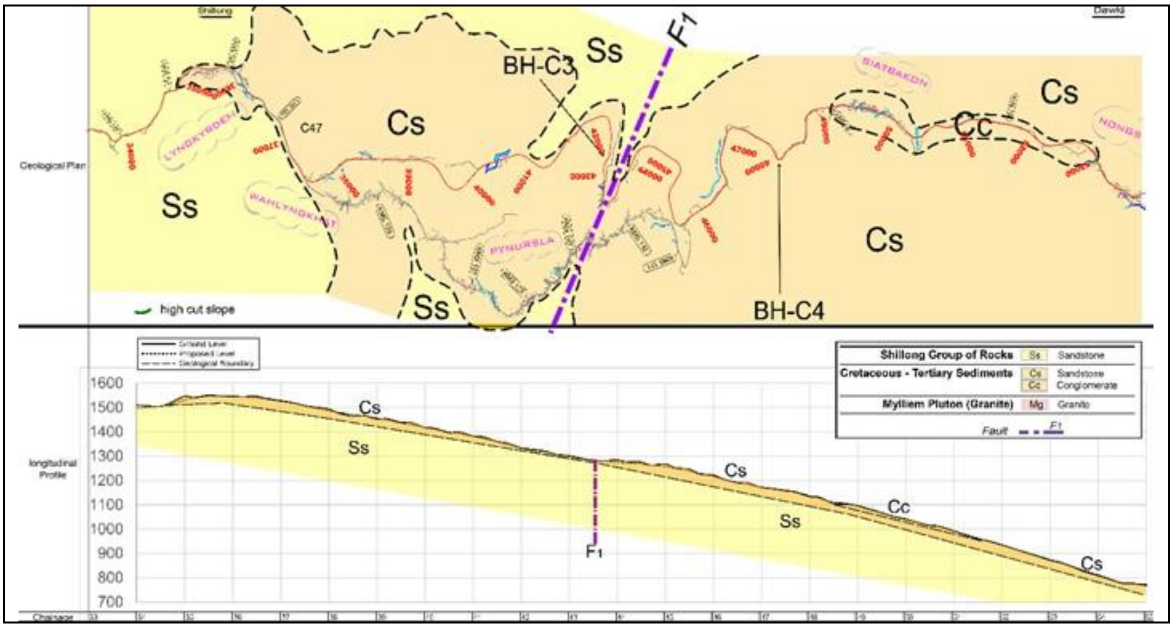
Source: JICA Study Team

Figure 5-11: Geological Map and Longitudinal Section along NH40 (0-17km)



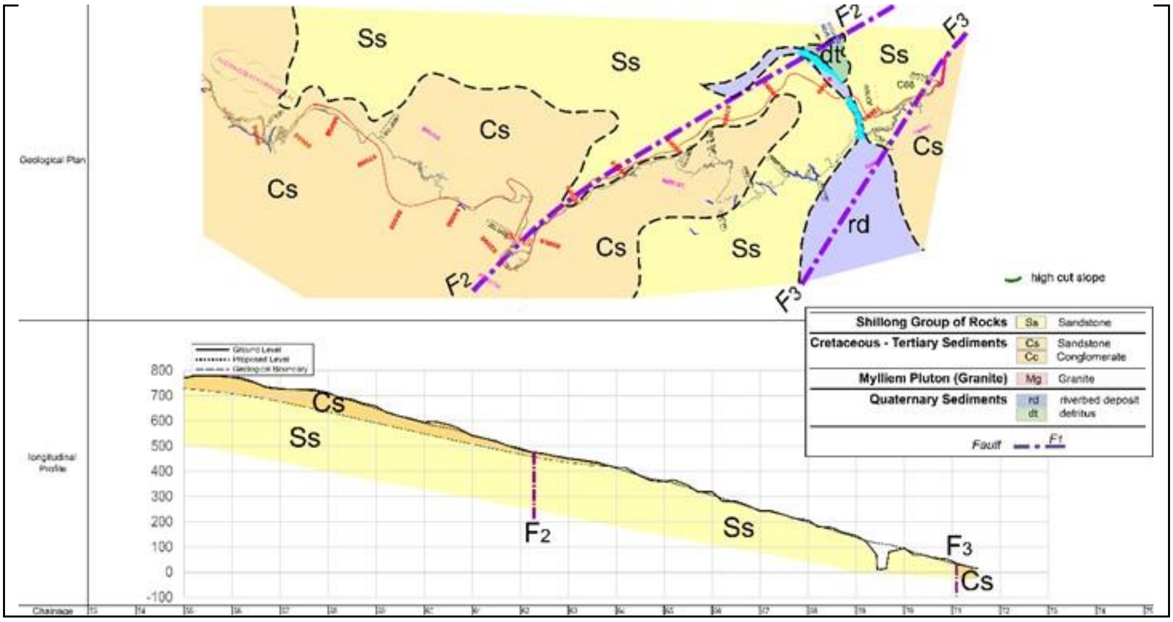
Source: JICA Study Team

Figure 5-12: Geological Map and Longitudinal Section along NH40 (17-34km)



Source: JICA Study Team

Figure 5-13: Geological Map and Longitudinal Section along NH40 (34-55km)



Source: JICA Study Team

Figure 5-14: Geological Map and Longitudinal Section along NH40 (55km-end)

Table 5-5: Geology along NH40 between Shillong and Dawki

Geological Formation	Material (Rocks)		location (KP)	length
Shillong Group of Rocks	Sandstone	(Ss)	03+300 – 05+200	1,900m
			09+500 – 11+200	1,700m
			22+000 – 29+000	700m
			29+400 – 35+000	5,600m
			63+800 – 71+200	7,400m
Cretaceous-Tertiary Sediments	Sandstone/ Tuffaceous Sandstone/ Conglomerate	(Cs)	00+000 – 03+300	3,300m
			05+200 – 09+500	4,300m
			21+300 – 22+000	700m
			29+000 – 29+400	400m
			35+000 – 63+800	28,800m
			71+200 -	
Mylliem Pluton (Granite)	Granite	(Mg)	11+200 – 21+300	10,100m

Source: JICA Study Team

(3) Description of Geological Formations

a) Shillong Group of Rocks

Shillong Group of Rocks along NH40 consist of mainly sandstone, and mudstone, chert, conglomerate can also be seen. According to the papers, the age of Shillong Group is Proterozoic and is a very old formation, but it does not look so old along NH40. Most of the rocks belonging to Shillong Group are very hard, but contains many cracks and joints.

KP85+000 KP33+400 KP24+670

Source: JICA Study Team

Figure 5-15: Pictures of Shillong Group

b) Createaceous-Tertiary Sediments

Cretaceous-Tertiary Sediments along NH40 covers the Shillong Group of Rocks, and forms the flat plane in hilly areas such as the Pynursla town area. They consist of tuffaceous sandstone and mudstone layers. Breccia and conglomerate also can be seen along NH40. The rocks which compose Cretaceous-Tertiary Sediments are mostly soft rocks and they become softer with weathering, making them vulnerable to erosion.

KP46+880 | KP58+800 km | In Pynursla

Source: JICA Study Team

Figure 5-16: Pictures of Createaceous-Tertiary Sediments

c) Mylliem Pluton (Granite)

Mylliem Pluton is a granite mass with about 10 km in diameter and intrudes into the Shillong Group of Rocks. Granite seen along NH40 contains hard boulders which is 50 cm to 3 m in diameter in a relatively soft granite matrix.

KP15+800 | After KP20+000 | Close-up image of fresh granite

Source: JICA Study Team

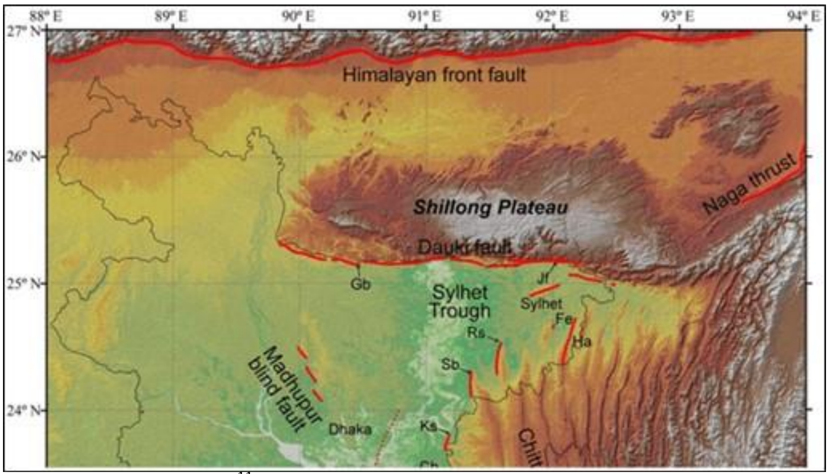
Figure 5-17: Pictures of Mylliem Pluton (Granite)

(4) Dauki Fault[10]

The Dauki fault is a major active fault along the southern boundary of the Shillong Plateau that may be a source of destructive seismic hazards for the adjoining areas, including northeastern Bangladesh. The Dauki fault separates the plateau from a -17 km thick tertiary section of recent sediments in the Bengal basin to the south as shown in Figure 5-18. The fault may be a potential zone for future earthquakes in NE India and Bangladesh. The 1897 Ms 8.0 Great Assam earthquake which caused severe damage to the Assam region in India and Sylhet district in Bangladesh was generated by the Dauki Fault.

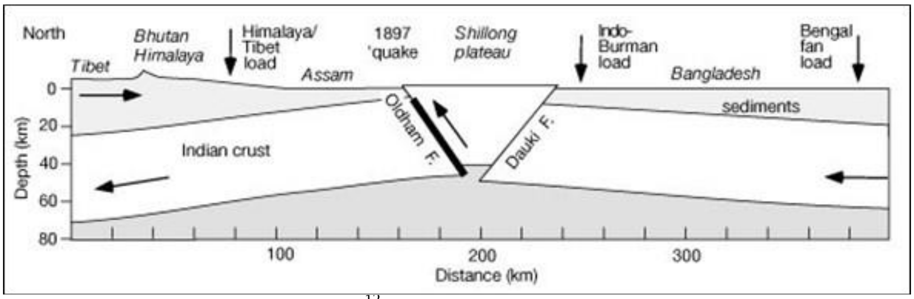
L3 in Figure 5-8 and F3 in Figure 5-14 are the Dauki Fault, and L2 in Figure 5-8 and F2 in エラー! 参照元が見つかりません。4 are derived faults from Dauki Fault.

[10] The name of the fault, Dauki Fault may be derived from the town Dawki.



Source: Mohammad Atikul Islam (2014)[11]

Figure 5-18: Dauki Fault and Shillong Plateau



Source: Roger Bilham and Philip England (2001)[12]

Figure 5-19: Origin of Shillong Plateau and Dauki Fault

(5) Soil Investigation at Cut Slopes

Four numbers of investigation borings, namely BH-C1, BH-C2, BH-C3 and BH-C4 were done in order to investigate the geological / geotechnical condition at proposed cut slopes. The boring works were done by BPC from 24 May 2016 to 9 June 2016. Borehole locations are shown in Table 5-6.

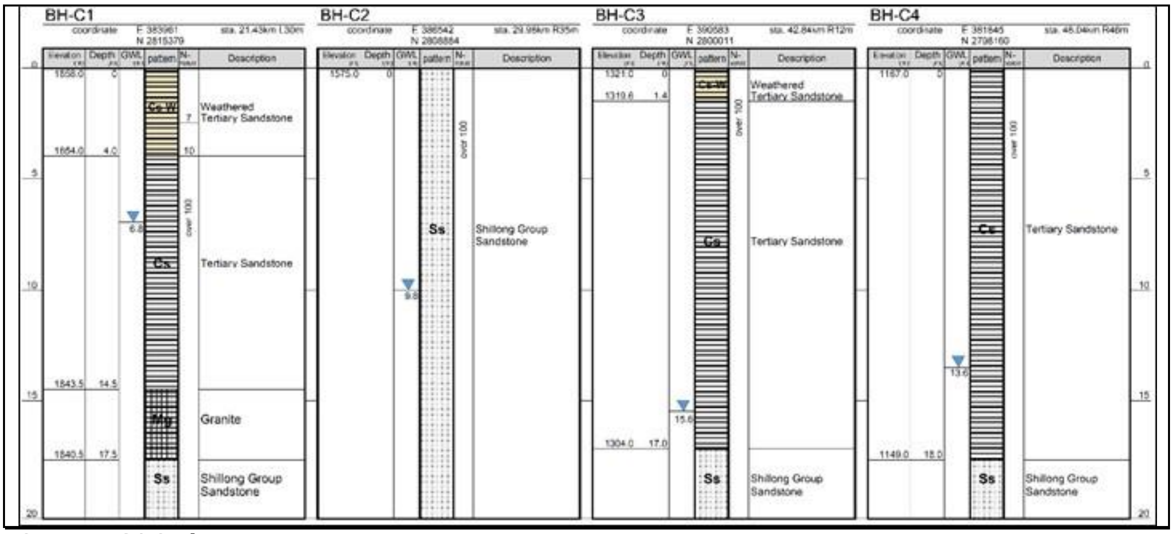
Table 5-6: Location of Investigation Boring at Cutting

Borehole No.	Coordinate	KP		Total Depth
BH-C1	E 383961 N 2815379	21+430	L 30m	20m
BH-C2	E 386542 N 2808884	29+980	R 35m	20m
BH-C3	E 390583 N 2800011	42+840	R 12m	20m
BH-C4	E 381845 N 2798160	48+040	R 46m	20m

Source: JICA Study Team

[11] Mohammad Atikul Islam (2014); Indian-Burma Plate Boundary Fault, (http://plannerview.blogspot.jp/2014/03/indian-burman-plate-boundary-fault.html)
[12] Roger Bilham and Philip England (2001); plateau 'pop-up' in the great 1897 Assam earthquake, Nature 410, 2001

The final report of soil investigation works were submitted by BPC and attached to this report. Figure 5-20 shows the results of investigation borings interpreted by the JICA Study Team based on the final report submitted by BPC. The JICA Study Team also prepared the geological cross sections as shown Figure 5-21 – 5-24.

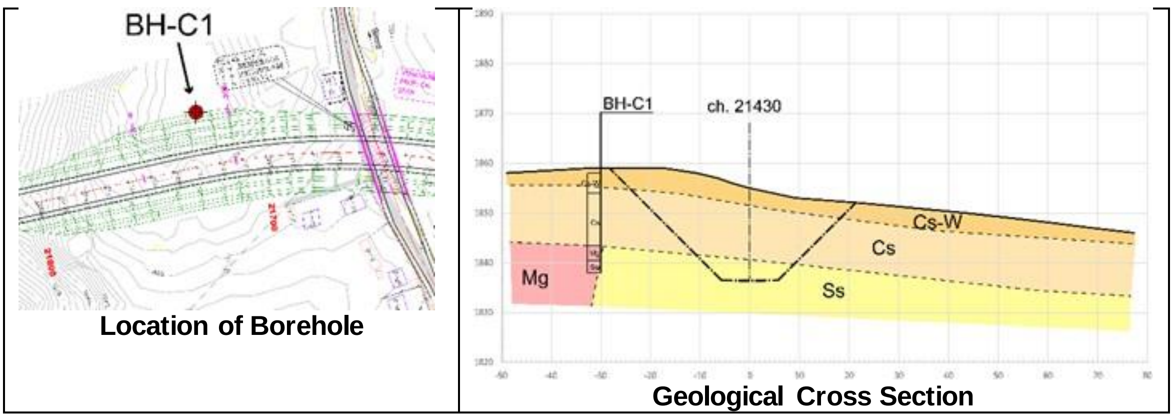


Source: JICA Study Team

Figure 5-20: Results of Investigation Boring at Cut Slopes

<u>KP 21430 (BH-C1)</u>

Cuttings are proposed at both sides of the proposed road at this location. The left side of the cut slope is about 30 m high. According to the boring result, reddish brown weathered sandstone of which N-values are 7 and 10 are found 3 to 4m deep from the ground surface (about 1859 m above sea level). Below the weathered sandstone, Cretaceous-Tertiary Sandstone (Cs) is found until about 1840 m a.s.l. Cs is a soft rock and relatively hard when fresh. However, Cs is capable of being slaked when exposed in the weather long time. Below 1840 m is Shillong Group of Rocks (Ss) which is hard and tolerant to weathering but rich in cracks. Although granite was found in the borehole, it is expected that it will not appear on cut slopes at this location.

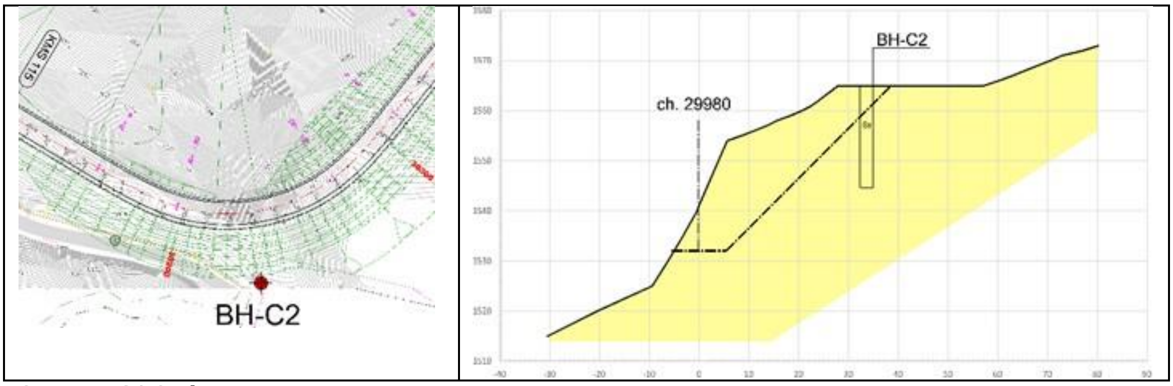


Source: JICA Study Team

Figure 5-21: Geological Cross Section at KP 21430

<u>KP 29980 (BH-C2)</u>

A high cut of about 30 m high is proposed on the right side of the road at this site. According to the boring result, Ss were found at all the depth of the borehole. The rocks of Ss around this place used as aggregate / gravel are very hard and tolerant to weathering, but many cracks were found at around 20 – 50cm intervals. The cut slope requires special attention as there is danger of rock falls due to the prevalence of cracks.

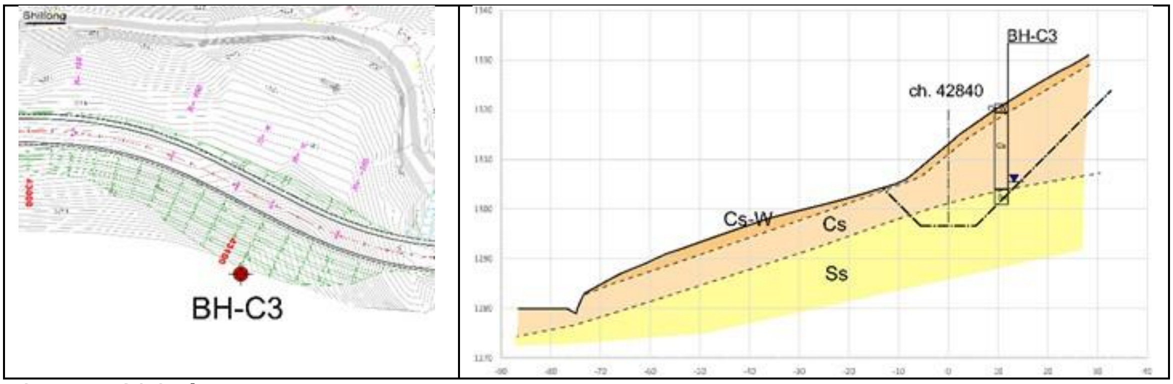


Source: JICA Study Team

Figure 5-22: Geological Cross Section at KP 29980

<u>KP 42840 (BH-C3)</u>

Cuttings are proposed on both sides of the proposed road at this location. The right side of the cut slope is about 30 m high and left side about 10m high. According to the boring result, reddish brown weathered sandstone is found 1 to 2 m deep from the ground surface. Below the weathered sandstone, Cretaceous-Tertiary Sandstone (Cs) is found until about 1300 m a.s.l. Cs is soft rock and relatively hard when fresh. However, Cs is capable of being slaked when exposed in the weather long time. Below 1300 m is Shillong Group of Rocks (Ss) which is hard and tolerant to weathering but rich in cracks.



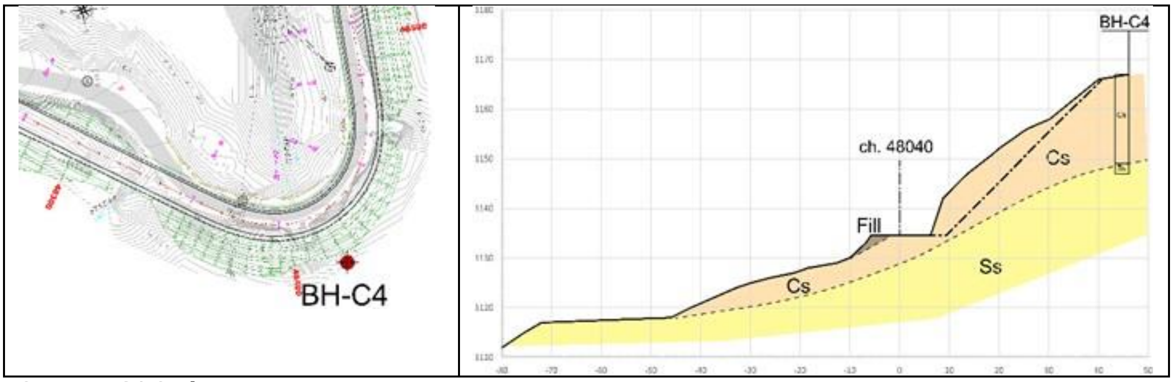
Source: JICA Study Team

Figure 5-23: Geological Cross Section at KP 42840

<u>KP 48040 (BH-C4)</u>

Cuttings are proposed on both sides of the proposed road at this site. The left side of the cut slope is about 30 m high. According to the boring result, surface soil or highly weathered rocks were not found.

Only Cretaceous-Tertiary Sandstone (Cs) would appear on cut slopes at this point, even though Shillong Group of Rocks (Ss) were obtained in the borehole. Cs is soft rock and relatively hard when fresh. However, Cs is capable of being slaked when exposed in the weather for a long time.



Source: JICA Study Team

Figure 5-24: Geological Cross Section at KP48+040

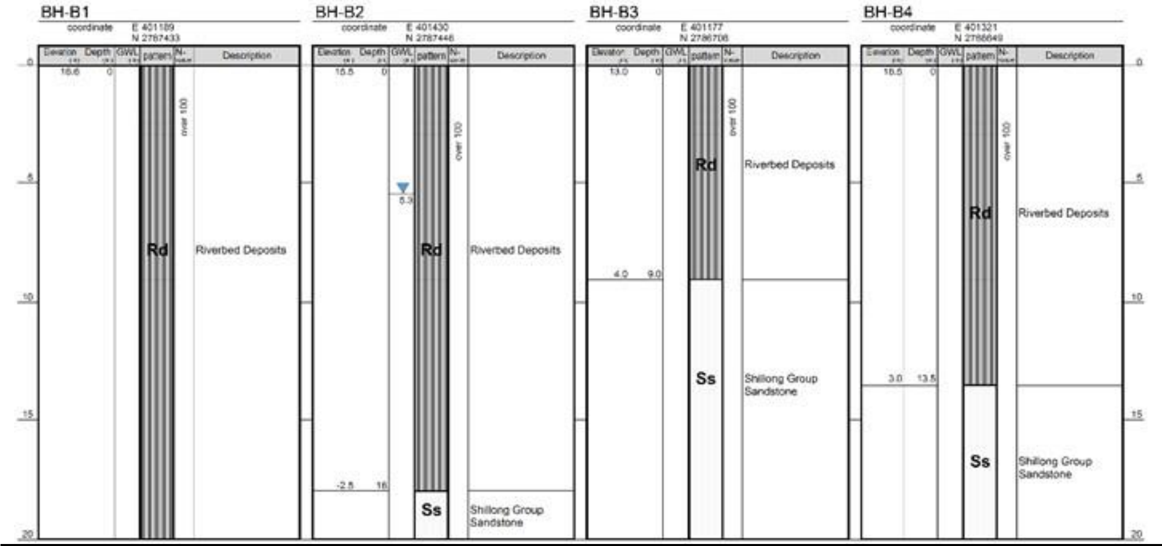
(6) Soil Investigation at Dawki Bridge

Four investigation borings were done in order to investigate the geological / geotechnical condition at the proposed Dawki Bridge. The boring works were done by BPC from 09 July 2016 to 15 August 2016. Borehole locations are shown in Table 5-7.

Table 5-7: Location of Investigation Boring at Dawki Bridge

Borehole No.	Coordinate	Total Depth
BH-B1	E 401189 N 2787433	20m
BH-B2	E 401430 N 2787446	20m
BH-B3	E 401177 N 2786706	20m
BH-B4	E 401321 N 2786649	20m

The final report of soil investigation works were submitted by BPC and attached to this report. Figure 5-25 shows the results of investigation borings interpreted by the JICA Study Team based on the final report submitted by BPC. The JICA Study Team also prepared the geological cross sections as shown Figure 5-26.



Source: JICA Study Team

Figure 5-25: Results of Investigation Boring at Dawki Bridge

KP 68720 (BH-B1, BH-B2)

Two numbers of boring, namely BH-B1 and BH-B2 were done on an alignment of the Dawki Bridge that was initially proposed. The alignment is now along a cross line at KP 68720 in the final plan. The two borings were on the riverbed of Dauki River.

At BH-B1, Riverbed deposit (Rd) was found from the ground surface to the borehole bottom (20 m deep), base rocks were not found. At BH-B2, Riverbed deposit (Rd) was found from the ground surface to 18 m deep, and Shillong Group of Rocks (Ss) as base rocks was found below 18 m. Rd is the aggregate of various stones which are very hard. Ss is yellowish brown colored, slightly weathered rock.

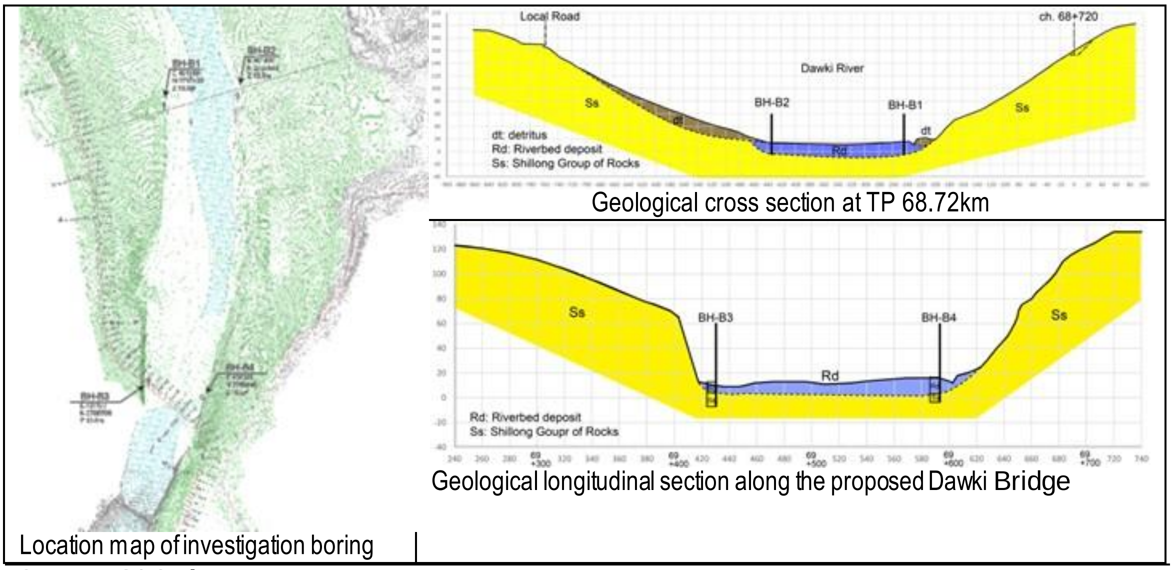
According to the study result by the JICA Study Team, traces of a landslide can be seen on the left bank of the Dawki River along this alignment as shown in Figure 5-24. The landslide may be surface failure of the slope and relatively shallow and debris are piled on the lower part of the slope. Therefore the left bank slope could be unstable and it is not suitable for bridge foundations.

Proposed Dawki Bridge (BH-B3, BH-B4)

Two numbers of boring, namely BH-B3 and BH-B4 along a proposed alignment of Dawki Bridge were done on the riverbed of the Dauki River.

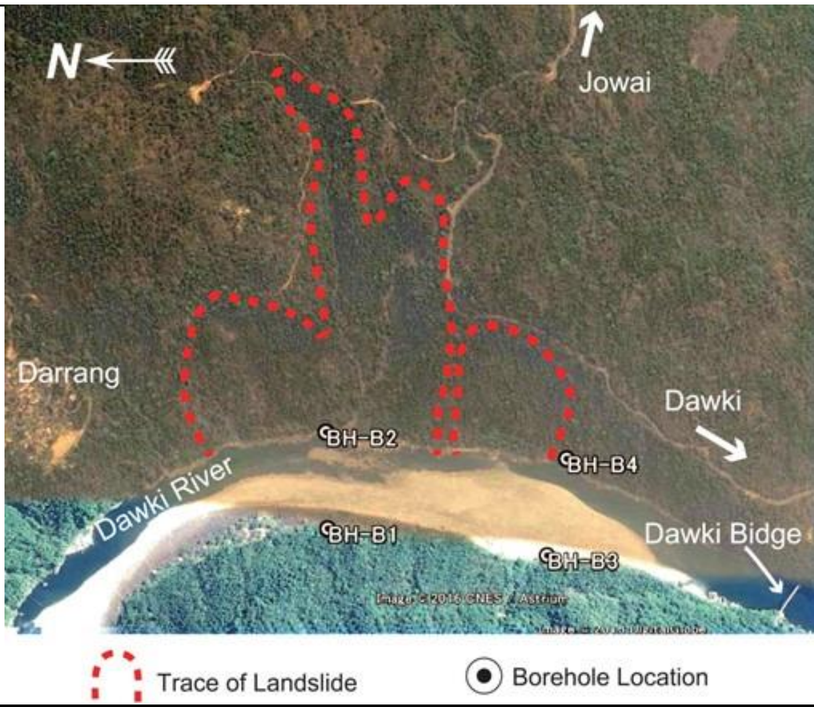
Riverbed deposit (Rd) was found at 9.0m deep at BH-3 and at 13.5m at BH-B4. Rd is the aggregate of various stones which are very hard. Shillong Group of Rocks (Ss) as base rocks was below Rd at both of the boreholes. Ss was purplish brown to dark grey, slightly weathered rock.

Hard rocks are found on both sides of the river bank at the proposed Dawki Bridge, therefore the slopes seem stable and are suitable for foundations of the bridge.



Source: JICA Study Team

Figure 5-26: Geological Cross Section at TP68.72km and proposed Dawki Bridge



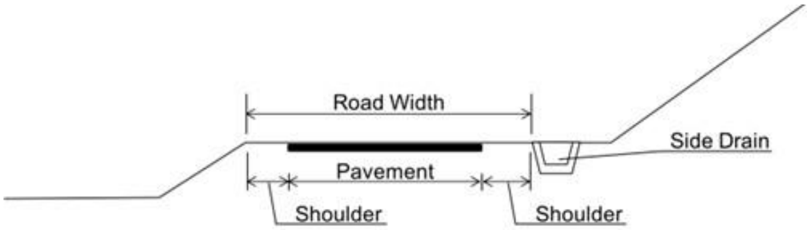
Source: JICA Study Team

Figure 5-27: Trace of Landslide on Left Bank of Dawki River

5.1.4 Road Inventory Survey

(1) Road Width

IRC SP73-2015 stipulates lane width of 3.5m and shoulder width according to the road conditions applied to two lane rural roads. As shown in the figure below, within the road width there is a carriageway composed of two lanes for NH40. The shoulder would be either paved or unpaved. The paved shoulder width is 1.5 m for both hillside and valley sides. Additional earthen shoulder of 1.0 m is added to the valley side according to the standard.



Source: JICA Study Team Phase 1

Figure 5-28: Definition of Road Width

However, the present roadway width of the existing NH40 varies according to the JICA study Phase 1 as shown in the table below. Some sections even have only one lane with the width of 3.75 m plus 0.5 m shoulders. Another section in the mountain area has 1.5 lanes of 5 m width plus 0.5 m shoulders.

Table 5-8: Present Conditions of NH40

No.	Items	Unit	NH40 from Shillong to Dawki *[1]				
			0-18	28-43	43-75	75-82	82-84
			80-108	108-123	123-155	155-162	162-164
1	Number of lanes		2	1.5	2	1	2
2	Carriageway width	m	7	5	7	3.75	7
3	Shoulder width	Section average	0.5	0.5	0.4	0.5	0.5
4	Shoulder type	Paved or unpaved	unpaved	unpaved	unpaved	unpaved	unpaved
5	Average altitude	m	1710	1552	813	47	30
6	Average roughness	IRI	3.6	5.5	5	7	5.5
7	Total area of cracks	%	3.5	20	16	40	30
8	Raveled area	%	2	30	10	10	30
9	No. of pot holes	Per km	2	10	22	50	50
10	Edge break area	m^2/km	45	50	80	150	150
11	Ave. travel speed	km/h	43	40	43	18	15
12	Road capacity	PCU:IRC73-1980	10,000	5,000	10,000	1,000	10,000

Source: JICA Study Team Phase 1

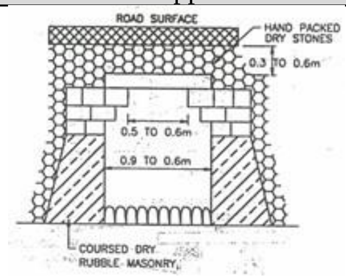
IRI: International Roughness Index, Note 1: (Upper: distance, lower: kilo-post)

(2) Drainage

a) Cross Drainage

Currently, various types of cross drainage structures are installed according to the runoff volume. The most common drain structure is a cross pipe and the second most common structure is a small section box culvert. This is likely due to the fact that culvert pipes are precast products and have high workability.

The scupper type drain is made by piling blocks to provide necessary cross-section area. There are scuppers installed in some locations on the Dawki side, but their number is scarce. The structure is shown in the figure below.

<table>
<tr><th>1-Pipe</th><th>2-Pipe</th><th>1-Box</th></tr>
<tr><td>
D900, D1000</td><td>
D900, D1000</td><td>
500x500,</td></tr>
<tr><th>1-Box (Bigger)</th><th>Scupper</th><th>Scupper</th></tr>
<tr><td>
2.0m x 2.0 m</td><td>
(71.5 km)</td><td>

IRC:SP:48-1998</td></tr>
</table>

Source: JICA Study Team

Figure 5-29: Cross Drainage

Some culvert pipes are filled with deposited sediment. Such deposition occurs where cross pipes are surrounded with earth sediment and blockage is especially severe on the inlet side.

Half buried pipe	Stagnated mud water
	

Source: JICA Study Team

Figure 5-30: Blocked Cross Drainage

In planning of new construction and replacement of culvert pipes, measures to remove sediment or to ensure its smooth flow to the downstream side should be included.

b) Catch Pit

Figure below (left) shows the standard structure of a cross pipe on the inlet side. The structure is designed to handle rainwater flowing from the mountain and roadside drains. Currently, several measures are taken to prevent blockage of the road's culvert pipes caused by sediment deposition.

To make maintenance easier, steps leading to the bottom of gullies have been installed to monitor the condition of the pipes and structure as well as sediment deposition. For the prevention of sediment inflow, walls are installed to prevent the inflow of sediment except drainage water from roadside drains.

Standard Structure	With steps	With sidewall
		
KP31+000	KP11+500	KP23+500

Source: JICA study Team

Figure 5-31: Catch Pit

As the road passes through a high rainfall area, it is assumed that a large amount of sediment flows in as rainfall increases during the rainy season. Therefore, installation of a catch pit as shown above is considered effective in preventing sediment from flowing into culvert pipes.

Creating a space to catch mud by deepening a gully can also be an effective measure to allow for more efficient maintenance work.

Source: JICA Study Team

Figure 5-32: Falling Works (17+700)

In case the outlet side of a culvert pipe is located high above the ground, falling works are installed as shown in the figure to the right. This is a preferable structure to prevent scouring of the existing ground and it is advisable to use it for the improvement and new construction of cross pipes.

c) Roadside Drain

Although roadside drains are observed in most of the urban areas, there are some sections without drains especially in the places where no houses exist nearby. Most roadside drains are concrete drains or earth ditches. In cut earth sections of the road, these drains are installed as an integral part of retaining walls or slope protection works. In rare cases, slopes are excavated to be used as roadside drains in areas with rocky soil.

Earth Ditch	Concrete Drain
 KP4+000	 KP16+000
With Slope Protection	Effective use of natural ground slopes
 KP24+500	 KP72+300

Source: JICA Study Team

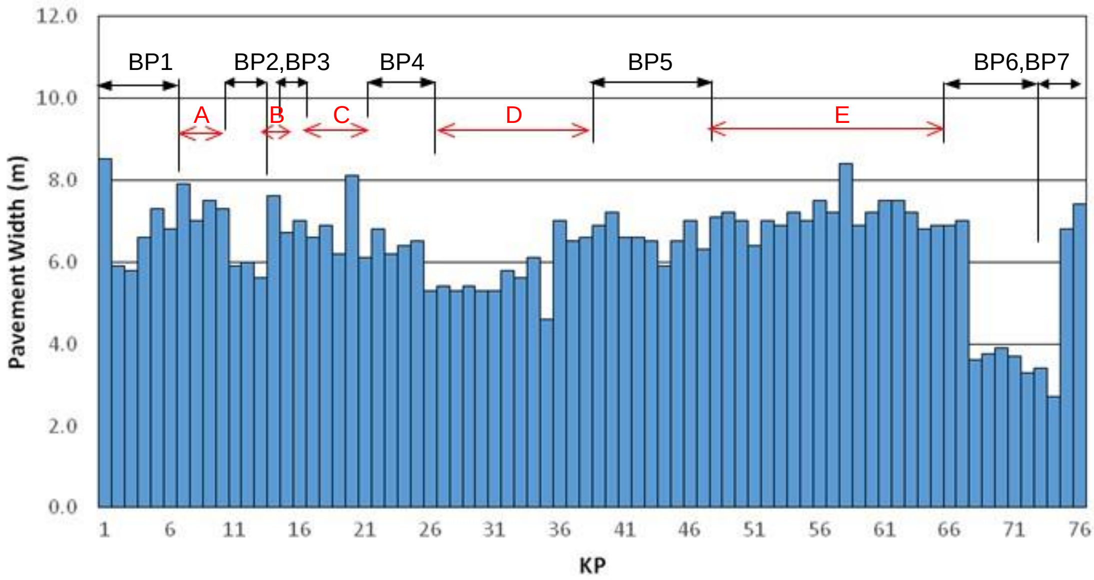
Figure 5-33: Roadside Drain

Some of the sections with roadside concrete drains have sediment deposition. For easy maintenance, it is advisable to install mud storage facilities at regular intervals.

(3) Pavement

The condition of the existing pavement has been checked. The following figure shows the pavement width for the existing road width. The pavement width is about 5 m wide along the entire route, except for the last section of about 10 km before the end point where it is less than 4 m. The pavement width is smaller than that of the planned road (10 m, 1.5＋3.5+3.5+1.5) along the entire route.

The total length of bypasses is about 29 km, and the total length of the sections of the existing road that need widening, shown as A-E in the following chart, is about 46 km. A survey of the existing pavement condition has been conducted for Sections A-E.



Source: JICA Study Team

Figure 5-34: Existing Pavement Width

Below is the summary of the pavement condition survey results for the sections of the existing road that need widening. As damage has spread widely, repair and replacement are deemed necessary. In the sections of the existing road that need widening, the alignment of the existing road is not always the same as that of the planned road, and the number of locations where widening works will suffice is limited. Considering the state of deterioration, it is advisable to remove the existing pavement and lay a new one instead.

<u>Sections A, B and C</u>

With alligator cracks widely spread, the overall bearing capacity of the base course and subgrade is likely to have degraded. As the traffic volume is comparatively high near the starting point, it is assumed that traffic load also has an impact.

Overall alligator cracks	Alligator cracks on shoulders
	
KP6+000	KP7+700

Source: JICA Study Team

Figure 5-35: Pavement Condition of Section A (Bypass #1 – Bypass #2)

Alligator cracks over entire surface	
	
KP11+700	KP12+200

Source: JICA Study Team

Figure 5-36: Pavement Condition of Section B (Bypass #2 - Bypass #3)

Alligator cracks over entire surface	Alligator cracks on shoulders
	
KP16+500	KP18+300

Source: JICA Study Team

Figure 5-37: Pavement Condition of Section C (Bypass #3 - Bypass #4)

<u>Section D and E</u>

Potholes caused by surface delamination are widespread. Probable causes include insufficient compaction when asphalt was laid.

Filled potholes	Alligator cracks and potholes
	
KP32+700	KP36+500

Source: JICA Study Team

Figure 5-38: Pavement Condition of Section D (Bypass #4 - Bypass #5)

Filled potholes	Potholes and alligator cracks
	
KP53.40 km	KP57.3 km

Source: JICA study Team

Figure 5-39: Pavement Condition of Section E (Bypass #5 - Bypass #6)

(4) Traffic Safety Apparatus

As there are many steep slopes, guardrails are installed on the valley side. Figure 5-40 shows the types of guardrails used. Concrete blocks appear to be used often in scenic spots as they do not hinder the view. Concrete walls are used in residential areas on the side of Shillong. In some heavy fog-prone sections safety posts are used instead of or together with guardrails.

In planning guardrails, types of works should be selected according to the local characteristics such as necessity of sidewalks, scenic spots and heavy fog-prone sections.

Concrete	Painted Concrete	Concrete Blocks
		
KP23+900	KP34+700	KP46+100
Concrete Wall	Cable	Delineator
		
KP2+100	KP2+700	KP33+800

Source: JICA Study Team

Figure 5-40: Different Types of Guardrails along NH40

(5) Traffic Signs

Figure 5-41 shows typical signs installed along the existing road. There are signs showing road conditions (series of turns, sharp curves, intersections, etc.) in mountainous areas and regulatory signs for pedestrian crossing, speed restriction, no passing zones, etc. in residential areas.

Series of right/left turns	Sharp curb	Intersection
		
KP61.50 km	KP46.10 km	KP46.00 km
Pedestrian crossing	**Speed limit**	**No passing**
		
KP7.50 km	KP2.70 km	KP0.50 km

Source JICA Study Team

Figure 5-41: Different Types of Traffic Signs along NH40

(6) Visibility in Fog

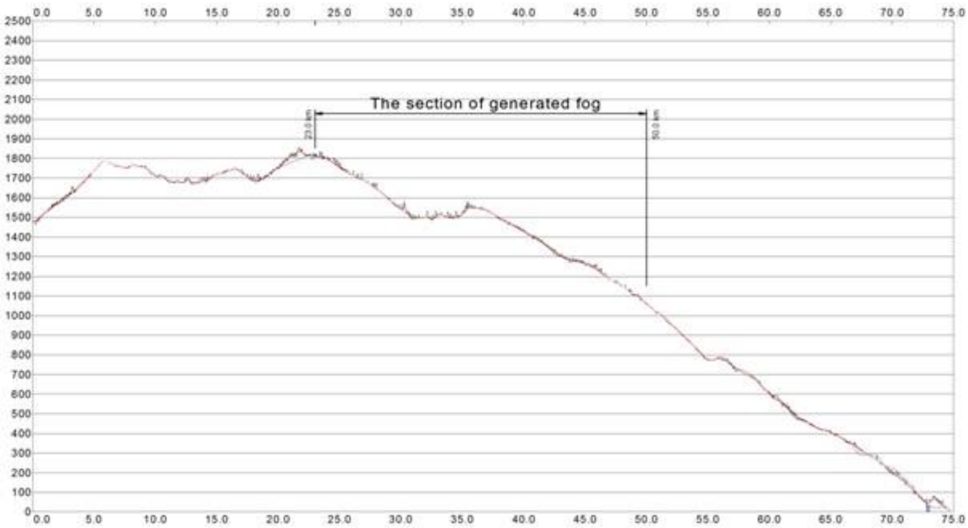
The existing road has sections that become very foggy in the morning. Study results indicate that the fog is generated on the Dawki (south) side at an altitude of 1,800-1,000 m. Figure 5-42 shows the visibility with and without fog.

Visibility without fog	Visibility with fog
	

Source: JICA Study Team

Figure 5-42: Poor Visibility due to Fog (KP34+700)

With dense fog, forward visibility is very poor. Cars pass at reduced speed with the headlights on or hazard lamps flashing. It is advisable to install more safety posts and install signs that encourage drivers to turn headlights on.



Source JICA Study Team

Figure 5-43: Section of Frequent Fog

5.1.5 Slope Inventory Survey

(1) Present Condition of Cut Slopes

The JICA Study Team investigated the present condition of cut slopes, natural slopes and streams. As a result, the Study Team did not find any slow mass movement which moves slowly in a huge area. However, some small rock falls, small collapses and erosion are found. The table below shows the result of the site investigations.

Table 5-9: Conditions of Existing Cut Slopes

Geology	Present Cut Slopes Configurations	Present Cut Slopes Conditions
Shillong Group of Rocks	1:0.5 without benches, without surface protection	Stable
Cretaceous-Tertiary Sediments	1:0.5 without benches, without surface protection	Surface erosion, rock falls, surface slide can be seen
Mylliem Pluton (Granite)	1:0.5 without benches, without surface protection	Stable, Hard boulders can be seen

Source: JICA Study Team

The followings are the explanation based on geological sections.

Table 5-10: Present Condition of Cut Slopes along NH40

	Location & geology	Description of Present Cut Slopes	Pictures of Present Condition of Cut Slopes
1	KP0.0 – 3.3 (3.3 km) C-T Sediments Sandstone (Cs)	Rocks are relatively hard and slopes are stable in this section.	 KP0+300
2	KP3.3 – 5.2 (1.9 km) Shillong Group Sandstone (Ss)	This section of Ss contains Schist. Slope condition is not clear because there are no high slopes in this section. Rocks are hard and strong.	 KP3+500
3	KP5.2 – 9.5 (3.3 km) C-T Sediments Sandstone (Cs)	Rocks are relatively hard and slopes are stable in this section.	 KP9+300
4	KP9.5 – 11.2 (1.7 km) Shillong Group Sandstone (Ss)	Rocks are hard, and slopes are stable. Near the start point, rocks are weathered and relatively soft.	 KP9+000
5	KP11.2 – 21.3 (10.1 km) Mylliem Pluton Granite (Mg)	Granite is hard and stable. Round hard boulders of granite in relatively soft granite matrix are often seen.	 KP18+800

	Location & geology	Description of Present Cut Slopes	Pictures of Present Condition of Cut Slopes
6	KP21.3 – 22.0 (0.7 km) C-T Sediments Sandstone (Cs)	Slopes of Cs are stable, but are easily eroded. Rocks are soft and can be dug using a small hammer.	 KP21+500
7	KP22.0 – 29.0 (7.0 km) Shillong Group Sandstone (Ss)	Sandstone rocks are hard, and slopes are stable.	 KP24+850
8	KP29.0 – 29.4 (0.4 km) C-T Sediments Breccia (Cs)	This place of Cs contains many breccia. Slopes are stable, but are easily eroded. Rocks are soft and can be dug using a small hammer.	 KP28+500
9	KP29.4 – 35.0 (5.6 km) Shillong Group Sandstone (Ss)	Rocks contain siliceous sandstone or chert, so rocks are very hard. Although the cut slopes are mostly stable, dense cracks are seen in every cut slope.	 KP33+850
10	KP35.0 – 45.7 (10.7 km) C-T Sediments Sandstone (Cs)	This place of Cs is sandstone mainly and contains conglomerate and mudstone layers. Rocks are soft and can be dug using a small hammer. Erosion and small collapse are seen on most of slopes.	 KP40+100
11	KP45.7 – 49.0 (3.3 km) C-T Sediments Tuffaceous Sandstone (Cts)	Tuffaceous Sandstone contains a lot of tuff (volcanic ash), and is easy to soften by slaking. 1:1.5 of gradient of present cut slopes without surface protection seems stable, but gully erosion, small rock fall are seen at several cut slopes.	

	Location & geology	Description of Present Cut Slopes	Pictures of Present Condition of Cut Slopes
			KP47+000  KP49+000
12	KP49.0 – 53.0 (4.0 km) C-T Sediments Conglomerate (Cc)	Rocks contain 5-20 cm diameter of gravel. Relatively soft and easily eroded.	 KP53+500
13	KP53.0 – 63.8 (10.8 km) C-T Sediments Sandstone (Cs)	Rocks seem hard and slopes seem stable, small gully can be seen on the slopes.	 KP63+800
14	KP63.8 – 71.2 (7.4 km) Shillong Group Sandstone (Ss)	Rocks are hard and the cut slopes are stable. Neither serious erosion nor rock fall can be seen along the road.	 KP69+300
15	KP71.2 - end C-T Sediments Sandstone (Cs)	Details are not clear due to small number of cut slopes. It may be same condition of Cts.	 KP71+500

Source: JICA Study Team

(2) Proposed High Cut Slopes

The design by Transys Consulting Pvt. Ltd proposes many high cut slopes as seen in Table 5-11 below. The configurations of all cut slopes are the same and with the following design.

Gradient of cut slope: 1:1.5
Height of bench: 6 m
Width of bench: 1.5 m

Table 5-11: List of Proposed Cut Slopes Designed by DPR Consultant

(KP00 – 63+000)

	from	to	right / left	total length	max. height*	Geology*
1	2810	3080	r	270	16	Cs
2	3110	3320	r	210	30	Cs
3	3110	3320	l	210	32	Cs
4	13930	14030	l	100	20	Mg
5	13930	14020	r	90	15	Mg
6	14080	14150	l	70	15	Mg
7	14220	14310	r	90	16	Mg
8	14230	14300	l	70	24	Mg
9	17490	17560	l	70	17	Mg
10	17490	17570	r	80	17	Mg
11	17700	17830	r	130	16	Mg
12	17710	17830	l	120	26	Mg
13	17880	18130	l	250	21	Mg
14	17940	18080	r	140	19	Mg
15	18250	18420	r	170	40	Mg
16	18270	18410	l	140	40	Mg
17	19620	19760	l	140	16	Mg
18	20340	20460	r	120	17	Mg
19	20340	20460	l	120	17	Mg
20	21330	21580	l	250	20	Cs
21	21330	21580	r	250	18	Cs
22	21610	21700	r	90	15	Cs
23	22780	22930	r	150	15	Ss
24	23090	23220	r	130	30	Ss
25	23130	23200	l	70	25	Ss
26	23260	23400	r	140	22	Ss
27	23280	23380	l	100	17	Ss
28	24240	24430	r	190	25	Ss
29	24250	24410	l	160	23	Ss
30	24480	24620	r	140	29	Ss
31	24490	24590	l	100	23	Ss
32	24680	24890	r	210	25	Ss
33	24680	24850	l	170	24	Ss
34	25420	25570	r	150	19	Ss
35	25630	25820	r	190	20	Ss
36	25820	25930	r	110	32	Ss
37	25850	25920	l	70	20	Ss
38	26110	26210	r	100	26	Ss
39	26140	26190	l	50	22	Ss
40	26210	26380	r	170	33	Ss
41	26250	26330	l	80	19	Ss
42	26500	26770	r	270	36	Ss
43	27020	27140	r	120	23	Ss
44	27170	27310	r	140	17	Ss
45	27330	27640	r	310	30	Ss
46	27640	27850	r	210	31	Ss
47	29480	29880	r	400	21	Ss
48	29880	30220	r	340	54	Ss
49	29980	30210	l	230	48	Ss
50	30220	30580	r	360	23	Ss
51	30670	30830	l	160	23	Ss
52	30860	31160	l	300	24	Ss

53	31190	31280	l	90	25	Ss
54	31280	31350	l	70	16	Ss
55	31350	31550	l	200	15	Ss
56	31550	31850	l	300	18	Ss
57	31850	32030	l	180	32	Ss
58	32300	32780	r	480	23	Ss
59	32510	32670	l	160	36	Ss
60	32550	32650	r	100	29	Ss
61	33480	33630	l	150	35	Ss
62	33740	33960	l	220	24	Ss
63	33760	33840	r	80	23	Ss
64	33970	34190	l	220	20	Ss
65	34190	34390	l	200	36	Ss
66	34200	34310	r	110	30	Ss
67	34700	34930	r	230	17	Ss
68	34880	34930	l	50	19	Ss
69	34970	35070	r	100	32	Ss
70	35100	35190	r	90	41	Cs
71	35100	35190	l	90	37	Cs
72	35190	35330	r	140	34	Cs
73	35210	35350	l	140	31	Cs
74	36460	36550	l	90	18	Cs
75	36820	36990	l	170	16	Cs
76	42150	42370	r	220	18	Cs
77	42200	42350	l	150	15	Cs
78	42420	42900	r	480	22	Cs
79	42910	43120	r	210	16	Cs
80	43600	43700	r	100	15	Cs
81	43850	44450	r	600	17	Cs
82	45330	45680	r	350	26	Cs
83	45340	45450	l	110	15	Cs
84	45520	45670	l	150	24	Cs
85	45840	46080	r	240	21	Cts
86	45920	46050	l	130	20	Cts
87	46250	46440	r	190	24	Cts
88	46650	46760	r	110	21	Cts
89	47040	47140	r	100	16	Cts
90	47200	47320	r	120	20	Cts
91	47220	47310	l	90	22	Cts
92	47870	47990	r	120	21	Cts
93	48120	48250	r	130	15	Cts
94	48320	48450	r	130	17	Cts
95	58880	59010	r	130	15	Cs
96	60100	60380	l	280	25	Cs
97	60120	60370	r	250	19	Cs
98	60460	60600	l	140	18	Cs
99	60600	60780	l	180	19	Cs
100	61740	61880	r	140	15	Cs

Source: JICA Study Team

Max.height: Maximum height at 7 m right / left side from the proposed center line

Geology: Ss: Shilling Group of Rocks, Mg: Granite of Mylliem Pluton, Cs: Sandstone of Cretaceous-Tertiary Sediments, Cts: Tuffaceous Sandstone of Cretaceous-Tertiary Sediments

5.2 Preliminary Design

5.2.1 General

Since the project road traverses mountains with sharp curves, changing points in the terrain and landslide-prone slopes are carefully examined to grasp the topographic changes as accurately as possible for adequate designing.

Full field reconnaissance is conducted by videotaping with GPS data to check the natural conditions for the preliminary designing. Since the DPR of the project road is still under preparation, the JICA Study Team is in contact with the DPR consultant to coordinate the work after the initial field reconnaissance.

The cost estimating will take into consideration the challenges of working in severe climate conditions and remoteness of the project location such as construction being suspended due to heavy rain during the rainy season, the availability of construction materials, and limited availability of labor in the project region.

The JICA Study Team considers recent road development policies formulated by GOI as shown in the table below. Recognizing India's technical experience in road development in mountainous regions, the JICA Study Team will integrate the best design components of both Indian and Japanese expertise in road designing in areas of rugged topography, landslide disaster countermeasures, road safety, and aesthetics.

Table 5-12: Recent Road Development Policies of India

Policies	Outline
Cement Concrete Pavement	In light of maintenance easiness, cement concrete (CC) pavement is preferred for all NH projects, and when the cost difference with asphalt concrete (AC) pavement is less than 20%, CC pavement shall be adopted.
Green Highways (Plantation & Maintenance) Policy-2015	To develop eco-friendly NH with participation of the community, farmers, NGOs, private sector, institutions, movement agencies and the Forest Department. The main objectives of planting along the highways are to enhance aesthetics of the project corridors and places of importance by planting selective ornamental trees, landscaping and turfing with grass and ornamental shrubs.
Extensive Guidelines Development	IRC published 24 new guidelines in 2015 that include Road Bridge Standard Specifications, Maintenance of Concrete and Bituminous Roads, Traffic forecast on Highways, Road Markings and Safety Barriers, Recycling of Bituminous Pavements, and Environment Management Plan.

Source: JICA Study Team

5.2.2 Road Geometric Design

(1) General

Geometric design of roads is strongly related to the positioning of the physical elements of the roadway according to design standards and constraints. The basic objectives in geometric design are to optimize efficiency and safety of traffic while minimizing cost and environmental damage. Geometric design of roads also affects design requirements for achieving broader community goals, which are providing access to employment, schools, businesses and residences, and accommodating a range of travel needs. Once the geometry of the road is improved, transport patterns of goods and passengers in the target region will change. Geometric design can be broken into three main parts: horizontal and vertical (profile) alignment and cross-section. Combined, they provide a three-dimensional layout for a roadway.

Topography and land-use have a significant impact on highway location, geometrics, and in determining the type of highway and its design speed. The existing NH40 runs through hilly and mountainous areas, which affect the type of road to be designed to improve geometries and strengthen the road structures to meet future demand.

The design of a highway should be based on traffic data for that highway. In selecting a road design, design hourly volume is generally used to represent the traffic volume for the future. The future traffic volume is based on the present traffic plus all traffic increases (traffic growth, generated traffic and development traffic). On minor, low volume roads, average daily traffic (ADT) is often sufficient. Current traffic volume of NH40 at Mylliem Nagar between Shillong and Dawki is 3,200 to 4,200 vehicles/day based on the traffic count survey in 2015.[13]

The vehicle that should be used in the process of road design for normal operation is the largest one that represents a significant percentage of the traffic on the road for the design year. For most highways in the world, the design semitrailer combinations are used for the design process. The application of this theory should be examined carefully to consider present conditions of the area where the target road runs through.

(2) Design Speed

Design speed is a selected speed used to determine the various geometric design features of the roadway. It is important to design facilities with all elements in balance, consistent with an appropriate design speed. Design elements such as sight distance, vertical and horizontal alignment, lane and shoulder widths, roadside clearances, super-elevation, etc., are influenced by design speed.

The selection of design speed for a given functionally-classified roadway is influenced primarily by the character of terrain, economic considerations, extent of roadside development (i.e., urban or rural), and highway type. The assumed design speed should be a logical one with respect to the character of terrain and the type of roadway. Some geometric features of highway design, such as super elevation rate, critical length of grade, horizontal curves, etc., need to consider average running speed on the roadway. It is preferable for the design speed to be uniform along a given highway, but variations in terrain may make changes in speed unavoidable. Where this is so, the design speed should not be changed abruptly, but in a gradual manner by introducing successive sections of increasing/decreasing design speed so that the road users easily adapt to the conditions of the road.

According to the standard by “IRCSP73-2015: Manual of Specifications & Standards for Two Laning of Highways with Paved Shoulder”, ruling design speed for plain and rolling (up to 25% cross slope of the ground) is 100 km/h and mountainous and steep (more than 25%) is 60 km/h. Applicable minimum design speed of both terrains are 80 km/h and 40 km/h, respectively. For designing NH40, which is considered as a rural two-lane road passing through mountainous and steep terrain, appropriate design speed would be between 60 km/h and 40 km/h.

[13] Preparatory Study for Road Network Improvement in North-East States of India, 2016, JICA

(3) Design Standards

Roads are designed based on design guidelines and standards, which are adopted by state and national authorities. Design guidelines take into account speed, vehicle type, slope, view obstructions, and sight distance. With proper application of guidelines, along with good engineering judgment, an engineer can design a roadway that is comfortable, safe, and appealing to drivers.

Each country has its own standards based on the policy and topographic conditions of the country. Table 5-14 gives a comparison of the standards between Japan and IRC. Previously, IRC:SP:73 "Manual of Standard & Specifications for Two Laning of State Highways on BOT Basis" was first published in August 2007. The Project Preparation, Contract Management & Quality Assurance Committee (G1) felt the necessity to revise this document and consulted a sub-group which consisted of a group of experts to finalize a draft document to put before the General Specifications & Standards Committee (GSS). After examination and approval of several committees and the Council, the draft revision of IRC: SP:73 "Manual of Specifications and Standards for Two Laning of Highways with Paved Shoulder" was approved in 2015. The list of IRC design standards is shown in Table 5-13.

Table 5-13: IRC Design Standards for Roads

Code No.	Title
IRC:37-2012	Tentative Guidelines for the Design of Flexible Pavements
IRC:52-2001	Recommendations about the Alignment Survey and Geometric Design of Hill Roads
IRC:58-2011	Guidelines for Design of Plain Jointed Rigid Pavements for Highways
IRC:67-2012	Code of Practice for Road Signs
IRC:73-1980	Geometric Design Standards for Rural (nonurban) Highways
IRC:86-1983	Geometric Design Standards for Urban Roads in Plains
IRC:101-1988	Guidelines for Design of Continuously Reinforced Concrete Pavement with Elastic Joints
IRC:SP:42-2014	Guidelines of Road Drainage
IRC:SP:48-1998	Hill Road Manual
IRC:SP:50-2013	Guidelines on Urban Drainage
IRC:SP:73-2015	Manual of Specifications & Standards for Two Laning of Highways with Paved Shoulder
IRC:SP:84-2014	Manual of Specifications & Standards for Four Laning of Highways Through Public Private Partnership
IRC:SP:88-2010	Manual on Road Safety Audit
IRC:SP:106-2015	Engineering Guidelines on Landslide Mitigation Measures for Indian Roads

Source: JICA Study Team

Table 5-14: Comparison of Geometric Standards between Japan and India

Design Speed (km/h)		Horizontal Curves (m)				Min. length of transition curves (m)		Gradient (%)				Min. radii of vertical curves (m)			Min. length of vertical curves	
Japan	IRC	Japan		IRC		Japan	IRC	Japan		IRC		Japan		IRC	Japan	IRC
		Min.	Abs.	Min.	Abs.			Min.	Abs.	Min.	Abs.	Convex	Concave		(m)	
120		710	570			100		2	5			11,000	4,000		100	
100	100	460	380	400	250	85		3	6	2.5	3.3	6,500	3,000		85	
80	80	280	230			70		4	7			3,000	2,000		70	
60	60	150	120	150	75	50		5	8	5	6	1.400	1,000		50	
50		100	80			40		6	9			800	700		40	
40	40	60	50			35		7	10	6	7	450	450		35	
30		30				25		8	11			250	250		25	
20		15				20		9	12			100	100		20	

Source: JICA Study Team
Note: Min.= Minimum, Abs. = Absolute minimum
Japan= Japan Road Association (Geometric design guide stipulated by by-law)
IRC = Indian Road Congress (IRC:SP:73-2015: Manual of Specifications and Standards for Two Laning of Highways with Paved Shoulder)

a) Lane width

Generally, a lane width is selected according to the class of road. The IRC: SP73-2015 specifies that the lane width of a rural two-lane road such as the NH40 is 3.5 m.

b) Shoulders

Wide, surfaced shoulders provide a suitable, all-weather area for stopped vehicles to be clear of the travel lanes. Shoulders are of considerable value on high-speed facilities such as rural highways. In addition to serving as emergency parking areas, shoulders lend lateral support to the travel lane pavement structure, provide a maneuvering area, increase sight distance of horizontal curves, and give drivers a sense of a safe, open roadway.

The IRC: SP73-2015 specifies shoulders for rural two-lane road with pavement in mountainous and steep terrain. Width for the hillside is 1.5 m and for the valley side is a combination of 1.5 m paved and 1.0 m earthen.

c) Super elevation

As a vehicle passes through a horizontal curve, centrifugal force is counter-balanced by the vehicle weight due to roadway super-elevation and by the side friction between tires and surfacing as shown in the following equation in metric:

$$e + f = V^2/127\ R$$

Where:
e = super elevation rate, %
f = side friction factor
V = vehicle speed, km/h
R = curve radius, m

There are practical limits to the rate of super-elevation. High rates create steering problems for drivers traveling at lower speeds, particularly during icy or snowy conditions. On urban facilities, lower maximum super-elevation rates may be employed since adjacent buildings, lower design speeds, and frequent intersections are limiting factors.

Although maximum super-elevation is not commonly used on urban streets, if possible, maximum super-elevation rates of 4 percent should be used. For urban freeways and all types of rural highways, maximum rates of 6 to 8 percent are generally used.

The maximum super elevation allowed for the project road would be 7%, which is specified by IRC: SP73-2015.

d) Horizontal curvature

There are a number of important considerations in achieving safe, smooth traffic flow, and comfortable driving facilities. These principles are outlined below and are particularly applicable to high-speed trunk facilities.

- Flatter than minimum curvature for a certain design speed would be desirable where possible, keeping the minimum guidelines for the most critical conditions.
- Compound curves should be used with caution. Where compound curves are used, the radius of the flatter curve should not be more than 50 percent greater than the radius of the sharper curve for rural highway conditions.
- Alignment consistency should be sought. Sharp curves should not follow tangents or a series of flat curves. Sharp curves should be avoided on high, long fill areas.
- Reverse curves on high-speed facilities should include an intervening tangent section of sufficient length to provide adequate super-elevation transition between the curves.

- Broken-back curves (two curves in the same direction connected with a short tangent) should normally not be used. This type of curve is unexpected by drivers and is not aesthetically pleasing.
- Horizontal alignment and its associated design speed should be consistent with other design features and topography.

The minimum radii of curves are important control values in designing for safe operation. Table 5-15 compares the newly updated standards (IRCSP73-2015) and previous ones (IRC52-2001) only for the horizontal curvatures. The standard values in the previous one resemble the Japanese standards.

Table 5-15: Minimum Horizontal Curves (m)

Class	Topographic Features	Ruling	Minimum
Mountainous	25% - 60%	150（80）	75（50）
Steep	More than 60%	150（50）	75（30）

Source: JICA Study Team
Note[14]

For designing NH40, which is considered as a rural two-lane road passing through mountainous and steep terrain, the appropriate design speed would be between 60 km/h and 40 km/h. Standards for the minimum horizontal curvature for 60km/h of both countries are the same, which is 150 m. However, IRC specifies this minimum radius should apply to 40 km/h design speed whereas the Japanese standard allows a much smaller radius (60 m) for the design speed of 40 km/h. Even the absolute minimum of 75 m by IRC exceeds the Japanese minimum of 60 m. The application of minimum radius, and even absolute minimum radius, may be difficult due to topographic conditions along NH40.

Transition curves would be used for connecting straight, curves or combination of these. The minimum length of transition curves would be determined from the two considerations as follows;

(i) The rate of changes of centrifugal acceleration should not cause discomfort to drivers, which can then cause danger to traffic. Based on this consideration, the length of transition curves is calculated by[15]:

$$Ls = 0.0215\,V^3/CR$$

Where, Ls = Length of transition curves in meters
V = Speed in km/h
R = Radius of circular curve in meters
C = 80/(75+V) (subject to a maximum of 0.8 and minimum of 0.5)

(ii) The rate of change of super elevation should not cause discomfort to travelers. The rate of change should not be steeper than 1 in 60 in mountainous/steep terrain. The formula for the minimum length of transition curves on this basis is calculated by:

$$Ls = 2.7V^2/R$$

e) Sight distance

[14] IRC:SP:73-2015: Manual of Specifications & Standards for Two Laning of Highways with Paved Shoulder. The numbers in the parenthesis are taken from IRC52-2001: Recommendations about the Alignment Survey and Geometric Design of Hill Roads.

[15] Source: IRC:SP:73-2015: Manual of Specifications & Standards for Two Laning of Highways with Paved Shoulder

Visibility is one of the important requirements for safety and comfort on the road. This is interpreted as sight distance, one of the several principal elements of design that are common to all types of highways and streets. Of utmost importance in highway design is the arrangement of geometric elements so that there is adequate sight distance for safe and efficient traffic movement.

(i) Stopping Sight Distance
Sight distance is the length of roadway ahead that is visible to the driver. The available sight distance on a roadway should be sufficiently long to enable a vehicle traveling at or around the design speed to stop before reaching a stationary object in its path.

Stopping sight distance is the sum of two distances: (a) the distance traversed by the vehicle from the instant the driver recognizes an object necessitating a stop to the instant the brakes are applied; and (b) the distance needed to stop the vehicle from when the instant brake application begins. These are referred to as brake reaction distance and braking distance, respectively.

(ii) Decision Sight Distance
Decision sight distance is the distance required for a driver to detect an unexpected or otherwise difficult-to-perceive information source, recognize the source, select an appropriate speed and path, and initiate and complete the required maneuver safely and efficiently. Because decision sight distance gives drivers additional margin for error and affords them sufficient length to maneuver their vehicles at the same or reduced speed rather than to just stop, its values are substantially greater than stopping sight distance.

(iii) Passing Sight Distance
Passing sight distance is applicable only in the design of two-lane roadways.

(iv) Intersection Sight Distance
A driver approaching an intersection should have an unobstructed view of the entire intersection and an adequate view of the intersecting highway to be able to control the vehicle to avoid a collision. When designing an intersection, the following factors should be taken into consideration:

- Adequate sight distance should be provided along both highway approaches and across corners.
- Gradients of intersecting highways should be as flat as what is practical on sections that are to be used for storage of stopped vehicles.
- Combination of vertical and horizontal curvature should allow adequate sight distance of the intersection.
- Traffic lanes should be clearly visible at all times.
- Lane markings and signs should be clearly visible and understandable from a desired distance.

Sight distance criteria are provided for the following types of intersection controls:

- Intersections with no control
- Intersections with stop control on a minor road
- Intersections with yield control on a minor road
- Intersections with traffic signal control

IRC: SP73-2015 indicates that intermediate sight distance should be maintained throughout the road sections for two-lane roads. Intermediate sight distance in IRC terms can be similarly interpreted as decision sight distance mentioned above. However, IRC also recommends providing passing sight distance as much as possible. For stretches where even intermediate sight distance is not available, safe stopping sight distance should be provided as a minimum requirement. In sections that do not provide passing sight distance, “no-overtaking” signs should be posted.

Table 5-16: Sight Distance Guidelines

Speed	Stopping	Intermediate	Overtaking

	Sight Distance	Sight Distance	Sight Distance
60 (km/h)	90 m	180 m	340 m
40 (km/h)	45 m	90 m	165 m

Source: IRCSP73-2015: Manual of Specifications & Standards for Two Laning of Highways with Paved Shoulder

f) Profile (vertical alignment)

The two basic elements of vertical alignment are grade and vertical curves. The effects of rate and length of grade are more clearly seen on the operating characteristics of trucks than on passenger cars and thus may introduce undesirable speed differentials between the vehicle types. The term "critical length of grade" is used to indicate the maximum length of a specified ascending gradient upon which a loaded truck can operate without an unreasonable reduction in speed. Where critical length of grade is exceeded for two-lane highways, climbing lanes should be considered.

Vertical curves provide gradual changes between tangents of different grades. The simple parabola is used in the highway profile design of vertical curves. The IRC specifies the maximum gradients applied to the roadway design.

Table 5-17: Limiting Gradient

Nature of Terrain	Ruling Gradient	Limiting Gradient
Plain and rolling	2.5 %	3.3 %
Mountainous	5.0 %	6.0 %
Steep	6.0 %	7.0 %

Source: IRC:SP:73-2015: Manual of Specifications & Standards for Two Laning of Highways with Paved Shoulder

Generally, a sag vertical curve should be long enough that the light beam distance is nearly the same as the stopping sight distance. Accordingly, it is appropriate to use stopping sight distances for different design speeds to establish sag vertical curve lengths wherever practical. For sag vertical curves, drainage criteria and minimum curve lengths are established similarly to crest vertical curves.

g) Broken-back Curve

The "broken-back" or "flat-back" arrangement of curves (with a short tangent between two curves in the same direction) should be avoided except where very unusual topographical or right-of-way conditions make other alternatives impractical. Except on circumferential highways, most drivers do not expect successive curves to be in the same direction; the preponderance of successive curves in opposite directions may develop a subconscious expectation among drivers that successive curves in the same direction are unexpected. Broken-back alignments are also not pleasing in appearance. Use of spiral transitions or compound curve alignments, in which there is some degree of continuous super-elevation, is preferable for such situations. The term "broken-back" usually is not applied when the connecting tangent is of considerable length. Even in this case, the alignment may be unpleasant in appearance when both curves are clearly visible for some distance ahead.[16]

[16] AASHTO. 2011. *A policy on Geometric Design of Highways and Streets*. 6th Edition. Washington DC

Source: JICA Study Team

Figure 5-44: Broken-back Curves of NH40 (Guwahati-Shillong)

(4) Typical Cross Section

The IRC standards and specifications for two laning of highways with paved shoulder (IRC:SP:73-2015[17]) prescribe the geometric design and general features for two laning of highways with paved shoulder. Some important points applicable to NH40 are as follows.

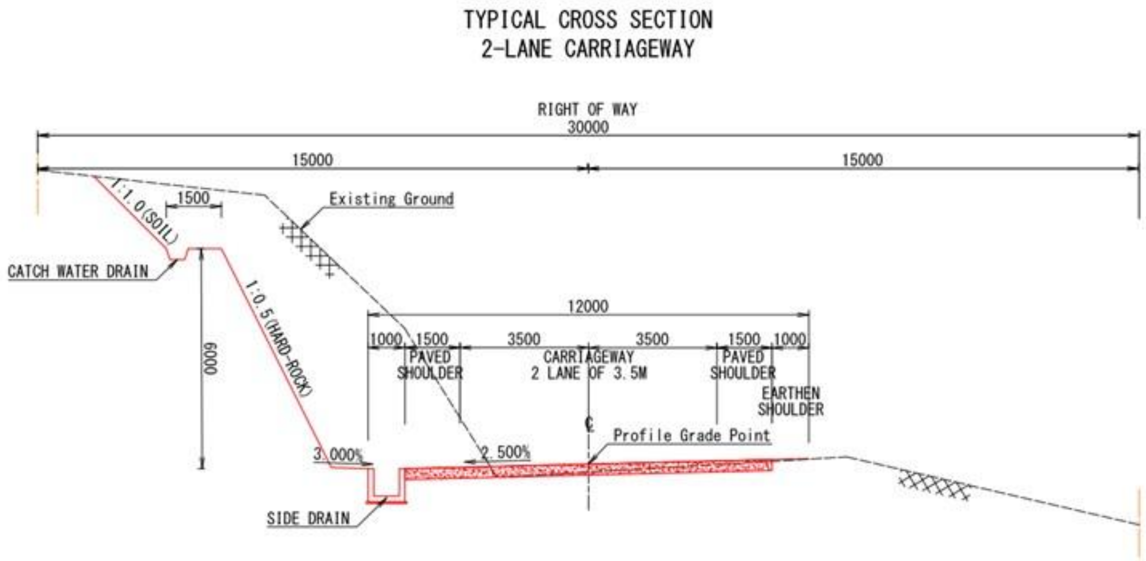
- Stretches passing through built-up areas shall normally be provided with 4-lane divided carriageway
- Where there are constraints of existing ROW width or difficulty in acquiring land along the existing alignment in built-up areas, the Authority may decided for construction of a bypass instead of 4-laning
- The geometric design of the project highway shall conform to the standards set out in this section as a minimum

The JICA Study Team pointed out discrepancies in cross sections between DPR and IRC:SP:73-2015 and discussed them with NHIDCL and the DPR consultant. The discrepancies are as follows.

① The width of the earthen shoulder of IRC is 1.0 m whereas that of DPR is 2.0 m
② The details of width of bridge standard cross section are not indicated

As the result of the consultation with NHIDCL and the DPR consultant, the cross sections proposed by the JICA Study Team as indicated below have been confirmed as final.

[17] IRC:SP:73-2015 Manual of Specifications & Standards for Two Laning of Highways with Paved Shoulder



Source: JICA Study Team

Figure 5-45: Typical Cross Section of Road

(5) Securing of Sight Distance

The road concerned is a route with the design speed of 60km/h. It passes through a mountainous area and thus includes curve radius and longitudinal gradient, which satisfy prescribed values. Moreover, the road must be designed to secure an appropriate sight distance for the visibility of drivers. The road safety must be ensured particularly at high elevations, where fogging is frequent.

a) Prescribed Value of Sight Distance

The following table shows the values of sight distance set forth in India and Japan.

Table 5-18: Standard Values of Sight Distance

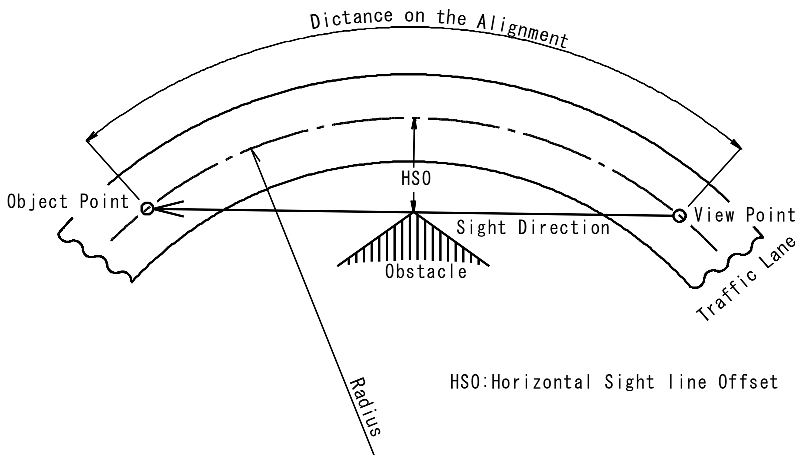
Design speed (km/h)	IRC (m)	JPN (m)	Value adopted (m)
80	120	110	120
60	90	75	**90**
40	45	40	45

Source: JICA Study Team

For the design speed of 60km/h, the sight distance (L) of 90m will be secured to satisfy both the Indian and Japanese standard values.

b) Securing of Sight Distance in Curve

An appropriate sight distance can be secured without problem in straight sections, but the line of sight is blocked by obstacles (mountains, buildings and trees) in curves. Figure5-46 shows the approach to sight distance in curves.



Source: JICA Study Team

Figure 5-46: Approach to Sight Distance in Curve

As illustrated in Figure 5-46, certain space is needed inside a curve to secure an appropriate sight distance. Any obstacles in such spaces must be removed. The distance necessary to secure such space is called "Horizontal Sight line Offset (HSO)".
On a mountainous road, the ground blocks the view of drivers, so the ground needs to be cut off in a larger quantity than what is simply necessary for the width of the road.

1) Necessary Setback Distance by HSO

The distance of a setback is determined in accordance with Formula xxx-1.

HSO= R(1-cos(D/2R) Formula xxx-1

Table 5-19 shows set back distances of HSO. This is the sight distance necessary for the Project road.

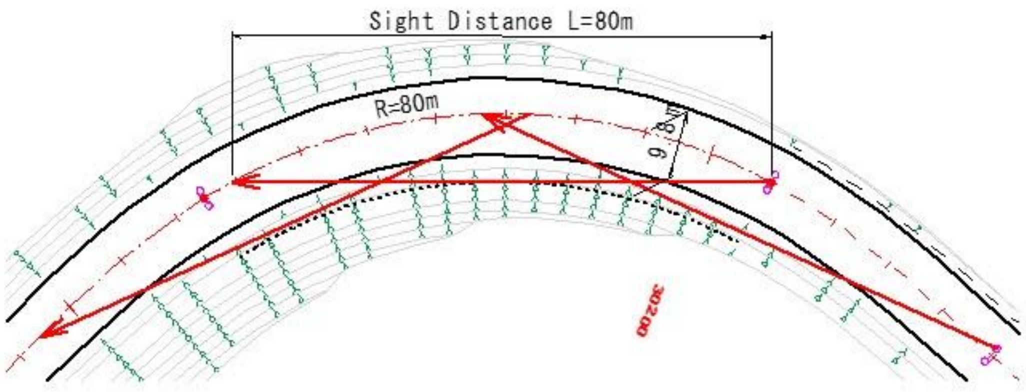
Table 5-19: Curve Radius and Setback Distance

Curve radius (m)	Setback distance (m)	Distance from the edge of road shoulder (m)
50	19.0	13.0
60	16.1	10.1
70	14.0	8.0
75	13.1	7.1
80	12.4	6.4
90	11.1	5.1
100	10.0	4.0
110	9.1	3.1
120	8.4	2.4
130	7.8	1.8
140	7.2	1.2

Source: JICA Study Team

Note) The viewpoint and object point should be set at the center of the road lane, rather than the center of the road. However the values above have been calculated with the starting and object points at the center of the road for simplicity.

For detailed design, it is desirable for the appropriate sight distance to be secured in reference to the setback distances in the table. As an example, the following table shows a case where the curve radius (R) is set at 80m and a setback is created.



Source: JICA Study Team

Figure 5-47: Image of the Setback Distance When R=60m

5.2.3 Bridge and Structure Design

(1) Design Standards

IRC 73-1980 is applied for the carriageway configuration of new bridges and box culverts. They are designed in accordance with IRC design standards as much as applicable. Major IRC design standards are listed in the table below.

Table 5-20: List of Major Design standards

Code No.	Title
IRC:5-1998	Standard Specification & Code of Practice for Road Bridges, Section -1 General Features of Design (Seventh Revision)
IRC:6-2014	Standard Specification & Code of Practice for Road Bridges, Section -2 Loads & Stress (Revised Edition)
IRC:21-2000	Standard Specification & Code of Practice for Road Bridges, Section -3 Cement Concrete Plain & Reinforced (Third Revision)
IRC:24-2010	Standard Specification & Code of Practice for Road Bridges, Steel Road Bridges (Limit State Method) (Third Revision)
IRC:78-1980	Standard Specification & Code of Practice for Road Bridges, Section -7 Foundation & Substructure (Revised Edition)
IRC:112-2011	Code of Practice on Concrete Road Bridges
IRC:SP:13-2004	Guidelines for the Design of Small Bridges and Culverts
MORTH	Standard Plans for 3.0 m to 10.0 m Span Reinforced Cement Concrete Solid Slab Structure with and without Footpaths for Highways, 1991
MORTH	Standard Plans for Highway Bridges R.C.C. T-Beam & Slab Superstructure – Span from 10 m to 24 m with 12 m width, 1991

Source: JICA Study Team

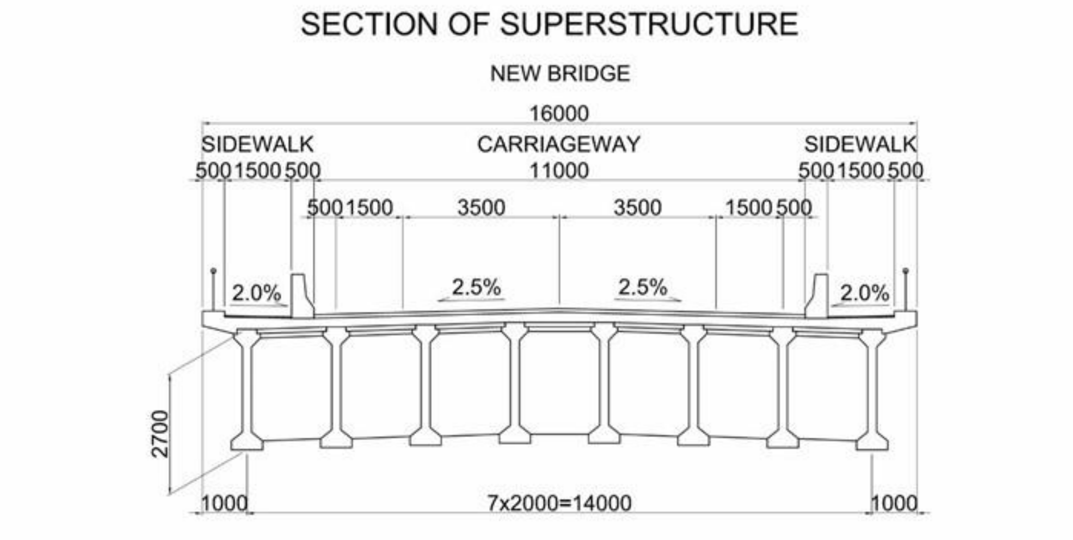
(2) Design Loads

Design loads and their combinations are determined in accordance with relevant IRC design standards. Major load conditions are as follows:

- Live load: Class 70R Loading (IRC 6)
- Live load combination: One lane of Class 70R or two lanes of Class A (IRC 6)
- Impact load: based on IRC 6
- Temperature: +5 to +40 degrees (IRC 6)
- Seismic load: Zone – V, Importance factor = 1.5 (IRC 6)

(3) Carriageway Configuration

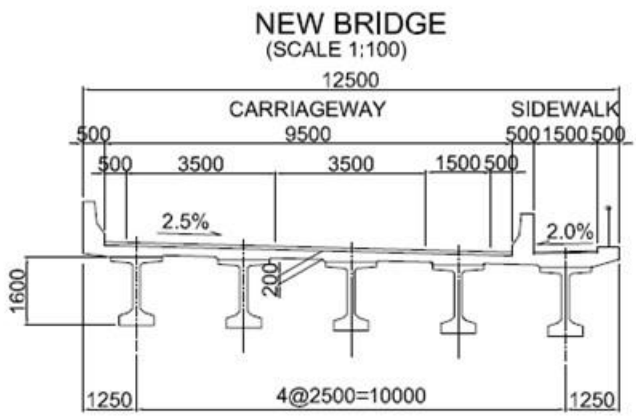
Based on the provisions of IRC73-2015, the carriageway configuration for a new bridge which carries 2-lane traffic lanes with sidewalks on both sides is 16 m. The example of a cross section of a bridge is shown in Figure 5-48. The width of the culvert is 11 m according to IRC 73-2016.



Source: JICA Study Team

Figure 5-48: Carriageway Configuration of Bridge

The carriageway width of the new bridge which will be constructed parallel to the existing bridge with insufficient carriageway is determined in accordance with IRC73-2015. The carriageway of the new bridge to support two lanes and walkway on one side is 12.5 m.



Source: JICA Study Team

Figure 5-49: Carriageway Configuration of Bridge

(4) Dawki Bridge

The main span of the superstructure is 150m, with main piers located on both sides of the river. The commonly applied structural types for this span are steel girder, PC girder and steel truss. Steel girder and PC girder types are desirable to harmonize the bridge with the surrounding scenic environment. Considering the poor road condition of NH40, transporting large blocks to construct the steel bridge from a factory to the site is very difficult.

The high piers enable a reasonable design of the PC frame in which girder and piers are rigidly connected without bearing supports on the piers. The PC frame is advantageous in its simplicity in construction, durability, and ease of maintenance, and it can cope with the influence of the curve of the horizontal road alignment.

Stable bearing layers are available at shallow positions from the ground surface, allowing the use of direct foundations. However, open well foundations are applied for construction in the river or at the slope which can reduce the size of area of excavation. Open wells can also prevent muddy water from flowing into waterways during construction.

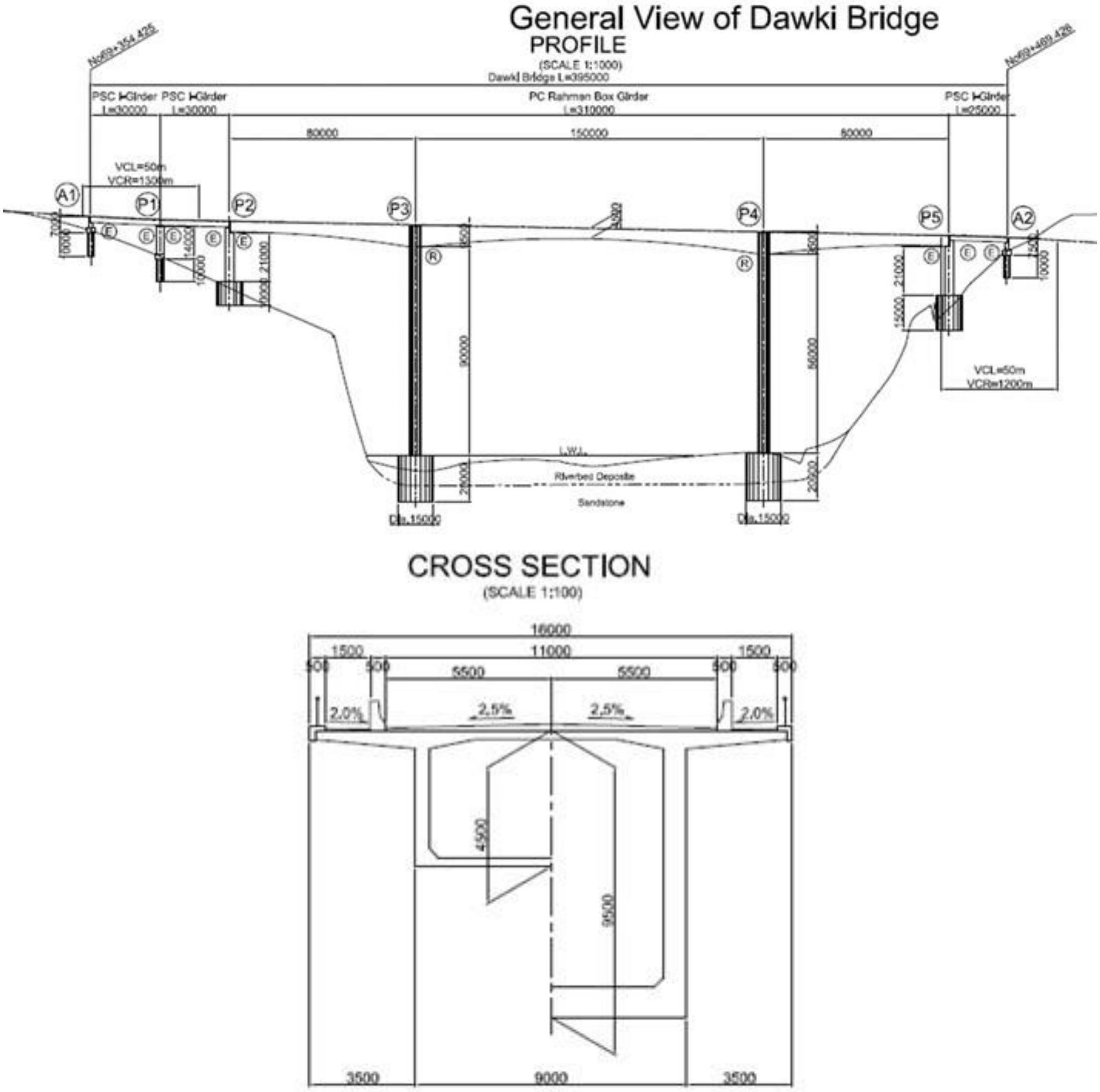
Because the approaches of the bridge are located along steep slopes, girder bridges are arranged for the approaches to minimize the earthwork at the slopes. In order to prevent muddy water produced during the construction of abutments and piers from flowing into the waterway, the usage of steel sheet piles is effective to temporarily close the sites.

Table 5-21: Comparison of Structural Types

	Steel Girder	PC Frame	Steel Truss
Span Arrangement	80+150+80	80+150+80	80+150+80
Design Problem	None	None	None
Construction Method	Cantilever Erection with Blocks	Cantilever Erection	Cantilever Erection
Transport of Materials and Machine	Transport of large blocks	Transport of small size materials	Transport of long members
Maintenance Difficulty	Steel members gradually rust. Repair is relatively easy.	As girder and piers are fixed to each other the maintenance is easy.	Due to many steel members, rust is more of a problem than the steel girder. Maintenance is difficult.
Construction Cost	Higher than PC Frame	Most economical	Highest
Construction Period	Short	Short	Long
Impact to Waterway	None	None	None
Conformity with Environment	Slender and good	Slender and good	Massive and inferior

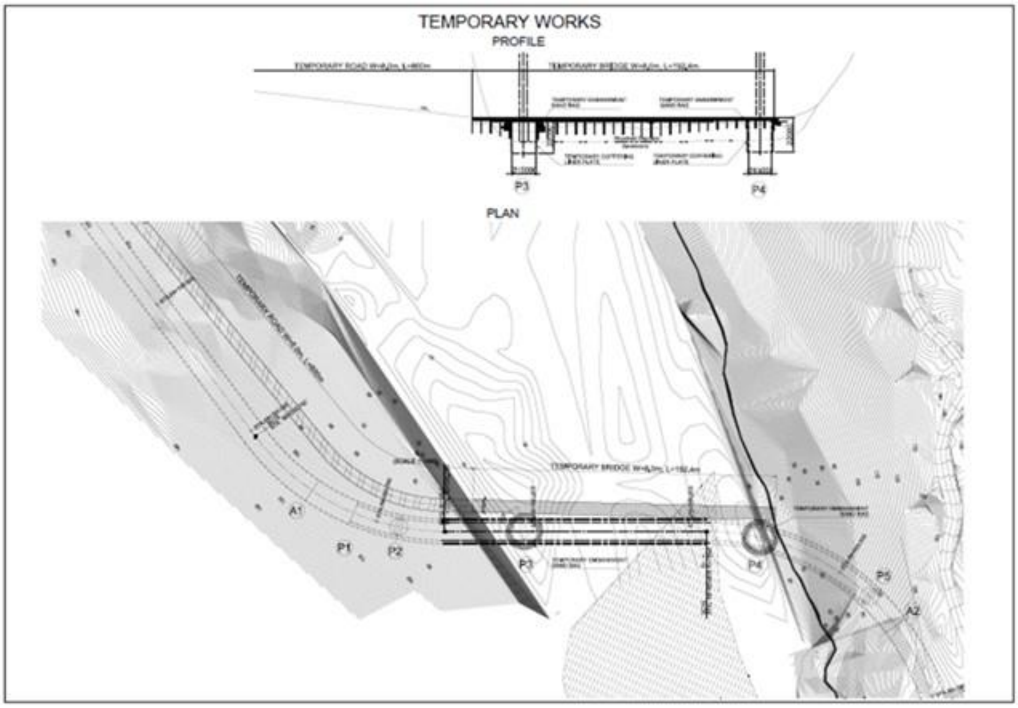
Source: JICA Study Team

The general view and plan of the construction procedure is shown below.



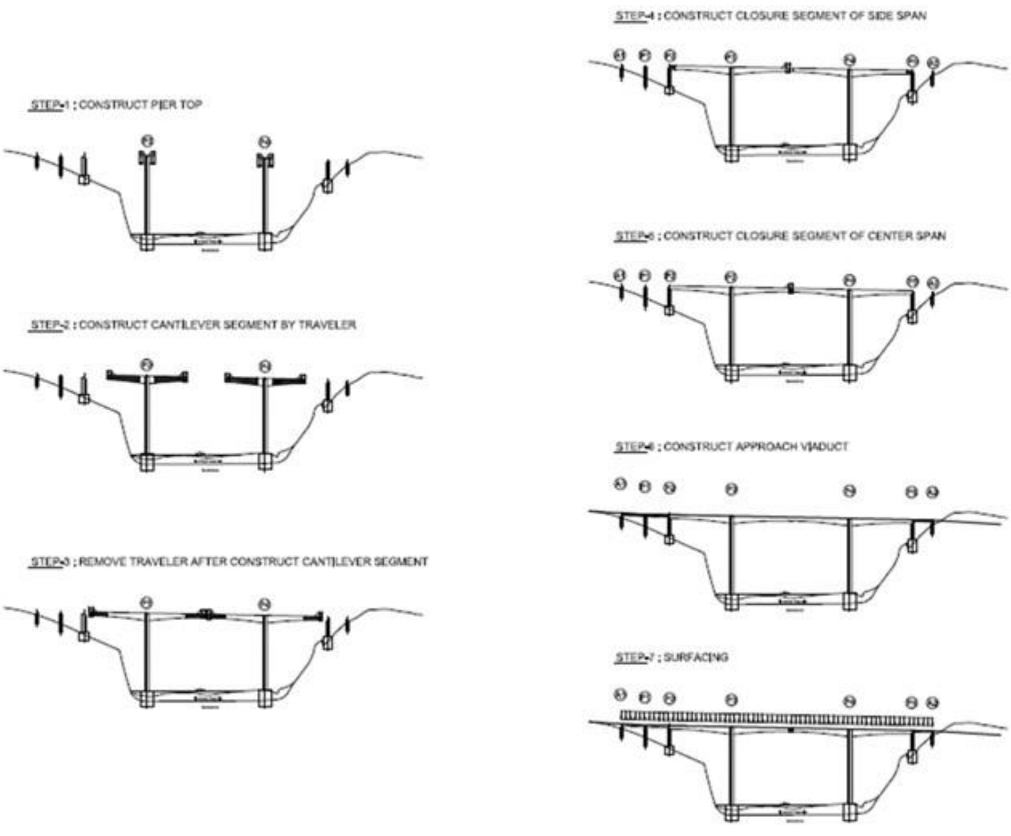
Source: JICA Study Team

Figure 5-50: General view of Dawki Bridge



Source: JICA Study Team

Figure 5-51: Plan for Temporary Works



Source: JICA Study Team

Figure 5-52: Plan for Construction Procedure

(5) Other Bridges

Because the longest span of other bridges is 35 m, the girder type which is simple in structure is the most appropriate from both economic and construction viewpoints. Although both steel and concrete structures are applicable, the present road passes mountainous areas with narrow road width making it difficult to transport steel structures from the factory to the construction site. The concrete girder option, for which main materials can be obtained locally, is reasonable.

The bridge situated near the starting point of Shillong is constructed parallel to the existing bridge. Considering the difficulty of obtaining a work yard of an appropriate size at the approach, the need to prioritize having a short construction period to minimize disturbance to the heaviest traffic on the project road, and difficulty of constructing intermediate piers in the deep valley, the steel box girder bridge is planned.

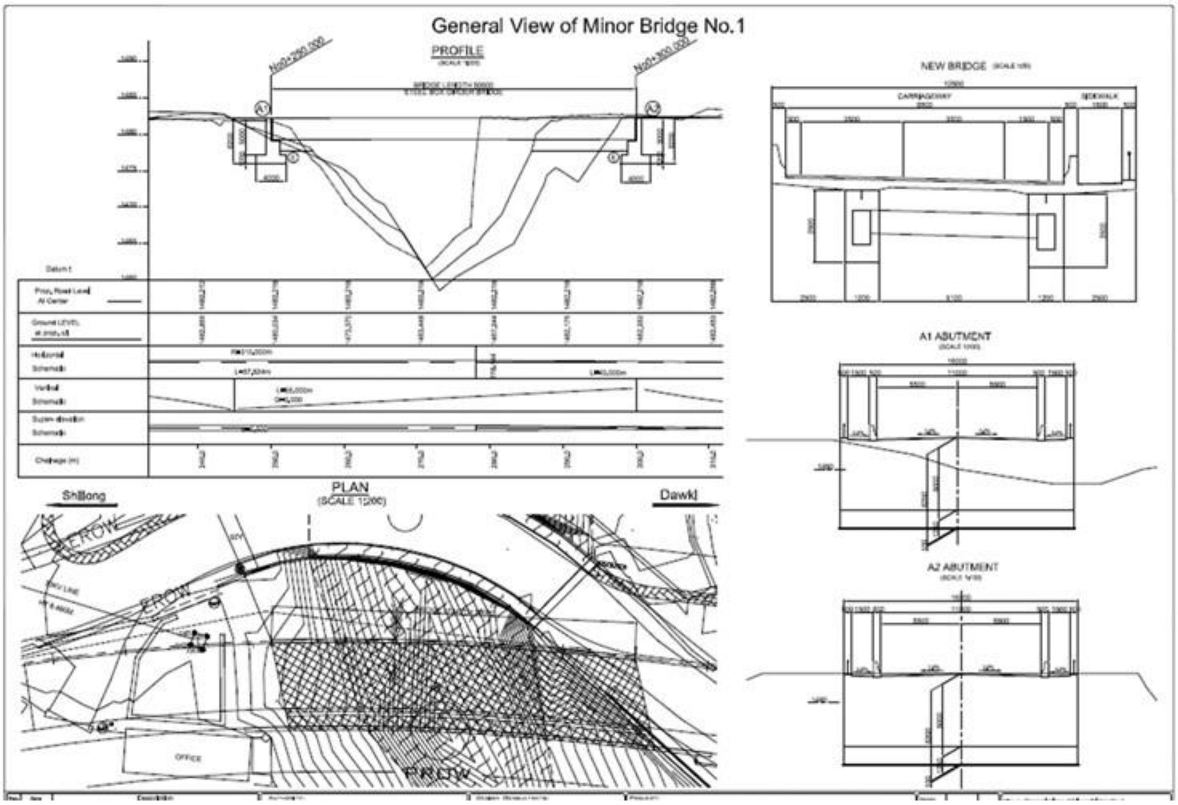
It is suitable that the bridges of up to 10 m in length which cross the waterways are planned as reinforced concrete slab bridges or box culverts. When box culverts are not economical for the deep waterways, the application of slab bridges is reasonable.

The stable bearing layers are available at a shallow level from the ground surface and the direct foundations are reasonable. If widening is needed to compensate for the insufficient carriageway of the existing bridge, the new structure is designed beside the existing bridge. Appropriate space between both substructures will be made to avoid negative influences on the existing structure during the construction of the new structure.

Table 5-22: Bridge Plan of NH40

No.	KP	Structural Type	Length (m)	New Alignment	Measurements
1	0+000	PC Box Girder	35	○	New Construction
2	0+260	Steel Box Girder	40		Widening (New Construction)
3	12+673	PC Girder	35	○	New Construction
4	12+997	RC Slab	34	○	New Construction
5	13+794	PC Girder	30	○	New Construction
6	14+380	PC Girder	25		Widening (New Construction)
7	18+185	RC;PC+RC Girder	46		Widening (New Construction)
8	18+810	PC Girder	25	○	New Construction
9	23+300	PC Girder	26		Widening (New Construction)
10	40+750	PC Girder	30	○	New Construction
11	43+690	PC Girder	30	○	New Construction
12	50+798	PC Girder	25		Rehabilitation
13	54+623	PC Girder	52		Rehabilitation
14	73+000	PC Frame Bridge	340	○	New Construction
15	73+810	Culvert	10		Widening

Source: JICA Study Team

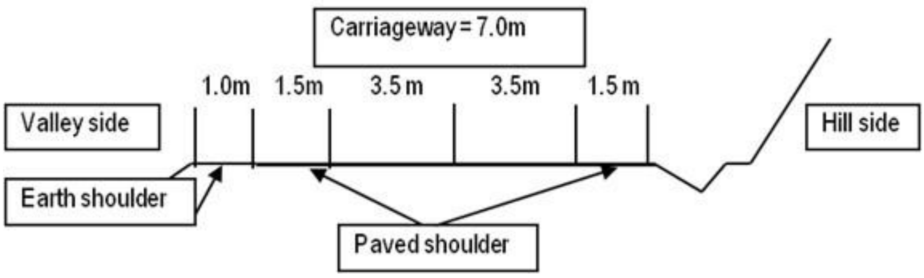


Source: JICA Study Team

Figure 5-53: Design of A Small Bridge

5.2.4 Road Widening Design

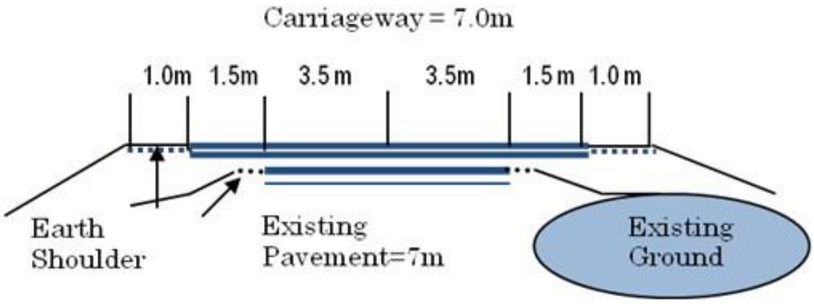
Where the situation allows, both sides of the existing pavement would be widened by applying basic principles of road widening design. However, there may be horizontal and vertical alignment changes. Thus, the widening design for the existing NH40 improvement would be, in most cases, on either side of the road depending on whether the design needs to realign to the center of the roadway or not. In some cases, the widening methods would be dictated by the topography. According to the design standard for mountainous and steep terrain, the total width of the two-lane paved roadway with paved shoulders is 11 m as shown below.



Source: JICA Study Team

Figure 5-54: Width of Two-lane Road

The standard widening method to be applied to the sections such as KP43+000-75+000, where the carriageway width is 7 m, would be as in the following figure.



Source: JICA Study Team

Figure 5-55: Standard Widening Method of Two-lane Road

As shown in Table 5-23, the existing NH40 has a wide range of roadway conditions, which require different improvement measures. Furthermore, there are seven bypass routes to improve NH40 proposed by the DPR, which have been approved by NHIDCL in principle. One of the main reasons is to avoid build-up areas, where the road goes through relatively mild terrain. The total proposed length of the bypasses is about 30 km, which is 35% of the existing NH40 road section. However, the study team pointed out some alignment issues with bypass #1, # 6 and #7, where realignment studies have been done together with a topographic survey.

Narrow Roadway with Steep Ground	Narrow Roadway with Deep Valley
	
Damaged Pavement	Closeup of pavement Damage
	
Narrow Roadway of one lane	Rock Cutting at a Quarry
	

Source: JICA Study Team

Figure 5-56: Present Conditions of NH40

Table 5-23: Present Conditions of NH40

No	Items	Unit	NH40 from Shillong to Dawki *[1]				
			0-18	28-43	43-75	75-82	82-84
			80-108	108-123	123-155	155-162	162-164
1	Number of lanes		2	1.5	2	1	2
2	Carriageway width	m	7	5	7	3.75	7
3	Shoulder width	Section average	0.5	0.5	0.4	0.5	0.5
4	Shoulder type	Paved or unpaved	unpaved	unpaved	unpaved	unpaved	unpaved
5	Average altitude	m	1710	1552	813	47	30
6	Average roughness	IRI	3.6	5.5	5	7	5.5
7	Total area of cracks	%	3.5	20	16	40	30
8	Raveled area	%	2	30	10	10	30
9	No. of pot holes	Per km	2	10	22	50	50
10	Edge break area	m^2/km	45	50	80	150	150
11	Ave. travel speed	km/h	43	40	43	18	15
12	Road capacity	PCU:IRC73-1980	10,000	5,000	10,000	1,000	10,000

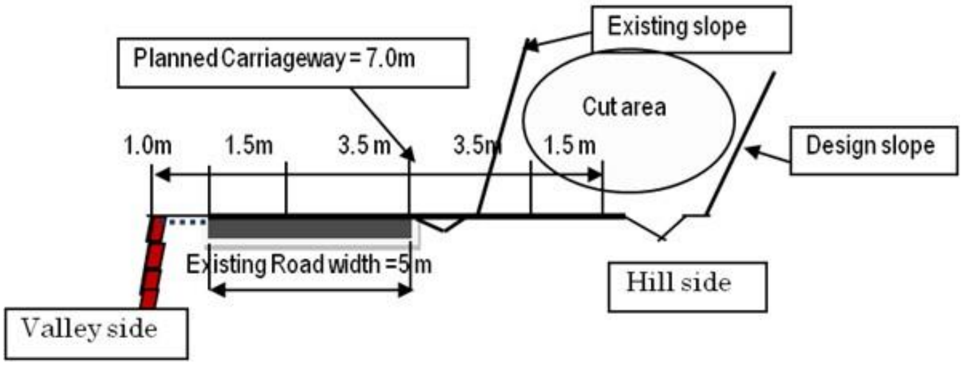
Source: JICA Study Team Phase 1
IRI: International Roughness Index
Note 1: (Upper: distance, lower: kilo-post)

Apart from the bypass route, it is technically and economically feasible to widen NH40 by cutting the hill side rather than embankments or retaining walls of any kind on the valley side of the existing road. The mountain where NH40 passes through in high altitude between Shillong and Dawki is mainly composed of hard rocks. Cutting hard rocks in general is difficult and costly, though it allows for the production of good quality rocks which can then be exported to neighboring countries.

Narrow road overhanging rocks	No space available on valley side
	
Quarry adjacent to road	Large scale quarry
	

Source: JICA Study Team

Figure 5-57: Cliff Section of Road and Quarries along NH40



Source: JICA Study Team

Figure 5-58: Widening from 5 m to 11 m

5.2.5 Slope Protection and Landslide Prevention Design

(1) Rock Classification for Cut Slope

The rocks along NH40 can be classified into tree types of rocks, namely Type A, Type B and Type C.

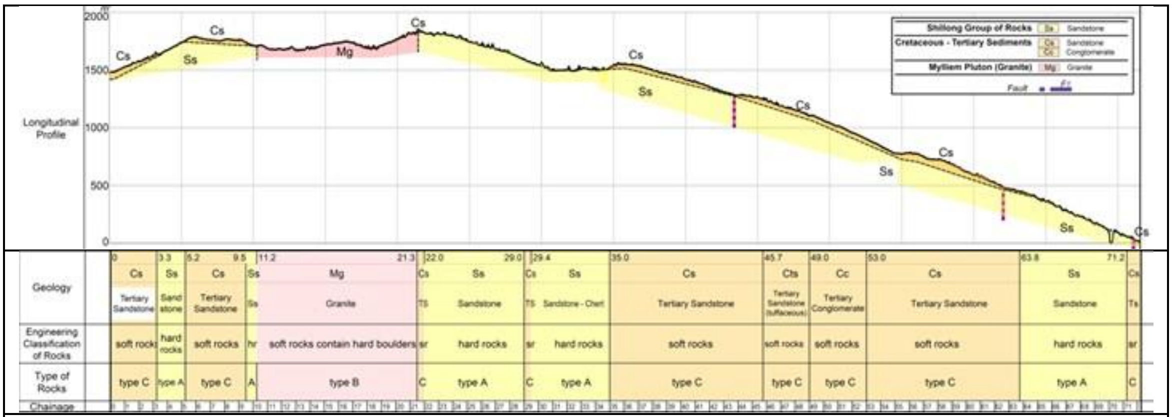
- Type A is hard rocks of Shillong Group of Rocks
- Type B is weathered Granite contains hard granite boulders.
- Type C is soft rocks of Cretaceous-Tertiary Sediments consist of sandstone, shale and conglomerate.

Locations of three types of rocks are shown on Table 5-24 and Figure 5-59.

Table 5-24: Location of Three Types of Rocks

Type of Rock	Geology		Location (KP)	Length
Type A	Shillong Group	(Ss)	03300 - 05200 09500 - 11200 22000 - 29000 29400 - 35000 63800 - 71200	1,900m 1,700m 700m 5,600m 7,400m
Type B	Mylliem Pluton (Granite)	(Mg)	11200 - 21300	10,100m
Type C	Cretaceous-Tertiary Sediments	(Cs)	00000 - 03300 05200 - 09500 21300 - 22000 29000 - 29400 35000 - 63800 71200 -	3,300m 4,300m 700m 400m 28,800m

Source: JICA Study Team



Source: JICA Study Team

Figure 5-59: Distribution of Three Types of Rocks

(2) Cut Slopes Stabilization

The gradient of cut slopes that are present along NH40 is all the same and is 1: 0.5 (64 degree) without bench. The present cut slopes in the Shillong Group (Type A) area seem to be stable as the rocks are hard and neither rock fall nor slope failure can be seen in the area. Small scale slope failures and rock falls can be seen in the cut slopes in the Cretaceous-Tertiary Sediments (Type C) areas. The cut slopes in Mylliem Pluton (Granite) (Type B) area seem to be almost stable. However, hard boulders in a relatively soft matrix resting on the surface of the cut slopes are frequently seen.

Table 5-25: Conditions of Present Cut Slopes

Type of Rock	Geology	Present Cut Slopes Configurations	Present Cut Slopes Conditions
Type A	Shillong Group	1:0.5 without benches, without surface protection	Stable
Type B	Mylliem Pluton (Granite)	1:0.5 without benches, without surface protection	Stable, Hard boulders can be seen.
Type C	Cretaceous-Tertiary Sediments	1:0.5 without benches, without surface protection	Surface erosion, rock falls, surface slide can be seen

Source: JICA Study Team

The cut slopes proposed by Transys Consulting Pvt. Ltd. in April 2016 are designed uniformly as bellow.

- Slope gradient 1 : 0.5
- Height of bench 6 m
- Width of bench 1.5 m

The proposed configuration of cut slopes would be stable in the Shillong Group of Rocks (Type A), but several cut slopes in Cretaceous-Tertiary Sediments (Type C) areas and Mylliem Pluton (Type B) areas would not be stable. The gradient of cut slopes in Cretaceous-Tertiary Sediments areas and Mylliem Pluton area should be gentler as shown in Table below.

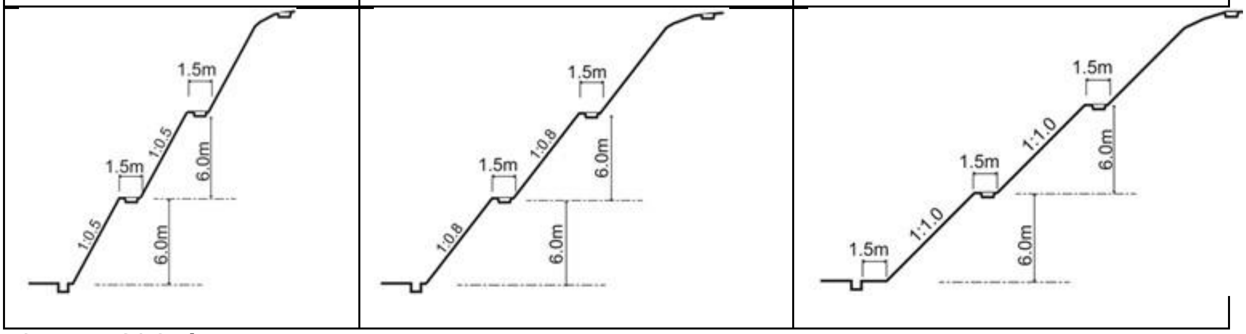
Table 5-26: Standard Gradient of Cut Slope

Type of Rock	Geology	Standard Gradient
Type A	Shillong Group	1: 0.5 (64 degrees)
Type B	Mylliem Pluton (Granite)	1: 0.8 (52 degrees)
Type C	Cretaceous-Tertiary Sediments	1: 1.0 (45 degrees)

Source: JICA Study Team

The figure below shows the recommended gradient of cut slopes with 6 m high and 1.5 m wide benches in accordance with geology.

Type A	Type B	Type C
Shillong Group	Mylliem Pluton (Granite)	Cretaceous-Tertiary Sediments
KP: 03300 - 05200 09500 - 11200 22000 - 29000 29400 - 35000 63800 - 71200	KP: 11200 - 21300	KP: 00000 - 03300 05200 - 09500 21300 - 22000 29000 - 29400 35000 - 63800 71200 -



Source: JICA Study Team

Figure 5-60: Standard Slope Gradient

<u>Different weathering grade in a cut slope</u>

In cases where highly weathered zones or soil exist in a cut slope, the slope gradient should be gentler than the standard gradient. This may often be the case in granite areas.

(3) Total Area of Cut Slope Surfaces

The DPR consultant calculated the surface area of the proposed cut slopes for every 10 m section. The table below shows the estimation of the area of the cut slope surfaces by rock types based on the calculation. Total surface area of the cut slopes in Type A, Type B and Type C rock are 563,216 m^2, 96,318 m^2, 420,425 m^2, respectively, and the total surface area of the cut slopes along NH40 is 1,079,959 m^2.

Table 5-27: Total Area of Cut Slope Surfaces by Type of Rocks

KP	Type A rock	Type B rock	Type C rock
00+000 – 03+300			48,738 m^2
03+300 – 05+200	4,105 m^2		
05+200 – 09+500			11,182 m^2
09+500 – 11+200	1,969 m^2		
11+200 – 21+300		96,318 m^2	
21+300 – 22+000			9,924 m^2
22+000 – 29+000	170,553 m^2		
29+000 – 29+400			1,659 m^2
29+400 – 35+000	161,633 m^2		
35+000 – 63+800			346,573 m^2
63+800 – 71+200	224,956 m^2		
71+200 – 71+500			2,349 m^2
Sub total	563,216 m^2	96,318 m^2	420,425 m^2
		Total	1,079,959 m^2

Source: JICA Study Team

(4) Cut Slopes Requiring Extra Precautions and Counter measures

Even if the cut slopes are formed with proper gradients, it is still possible for cut slopes to have problems such as surface erosion, small rock falls and small collapses. These problems on cut slopes are often characterized by rock types as shown in the table below. With regards to the rocks in the Shillong Group area, there are concerns about slope collapse because of abundant cracks, and difficulty in adjusting the shape of slopes because of hard rocks. The rocks in the Cretaceous-Tertiary Sediments areas have problems of slaking and erosion.

Table 5-28: Problems on Cut Slopes

Type of Rock	Geology	Problems on Cut Slopes
Type A	Shillong Group	- Rock falls, small collapses because of well-developed joints in rocks - Hard to adjust cut slope shape because of hard rocks
Type B	Mylliem Pluton (Granite)	- Different weathering in a cut slope - Boulders in soft matrix in a cut slope
Type C	Cretaceous-Tertiary Sediments	- Slaking - Erosion by surface water

Source: JICA Study Team

Countermeasures

a) Rock fall, small collapse because of substantial cracks in rocks

Rocks in the Shillong Group consist of hard rocks but abundant cracks, therefore the cut slopes with a gradient of 1:0.5 in crack-rich rocks can loosen and cause rock falls or collapses. Shotcrete may be the best method to prevent loosening on the slope surface.

b) Hard to adjust the cut slope shape because of hard rocks

Some rocks in the Shillong Group may be too hard to cut to adjust the shape of the slope. In such cases, it can be dealt with by cutting a slope without a bench and place shotcrete on the entire surface of the cut slope.

c) Slaking and erosion

Rocks in Cretaceous-Tertiary Sediments are generally soft and sensitive to slaking, and are susceptible to erosion. Accordingly, it is necessary to prevent slaking and water flow on the surface of cut slopes using the following methods.

- Prevention of water flow on slope surface: bench with drainage
- Prevention of slaking: vegetation

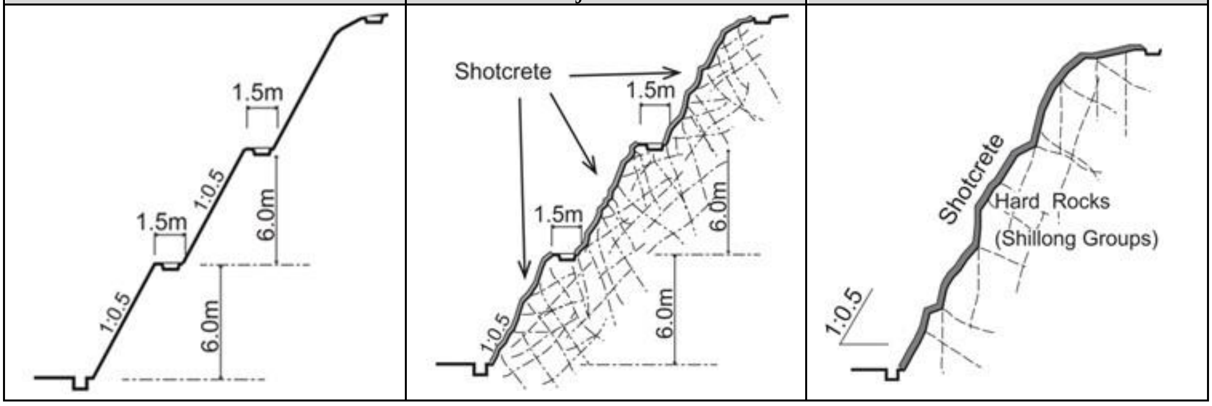
It could be difficult to plant vegetation on the surface of a cut slope in Cretaceous-Tertiary Sediments, since the rocks are acidic as they are tuffaceous. In order to plant vegetation on the acidic rocks, hydroseeding that uses slurry of seed and mulch could be the best way.

On a cut slope in areas such as Cretaceous-Tertiary Sediments areas where the groundwater level is high, water springs can be seen at the toe of the cut slope. This water spring would erode the bottom of the cut slope and make the cut slope unstable. For such cut slopes, placing gabions at the toe of the slopes is recommended to protect it from erosion.

(5) Recommendation for Cut Slopes along NH40

Figures below show the countermeasures to prevent the problems on cut slopes corresponding to different types of grounds.

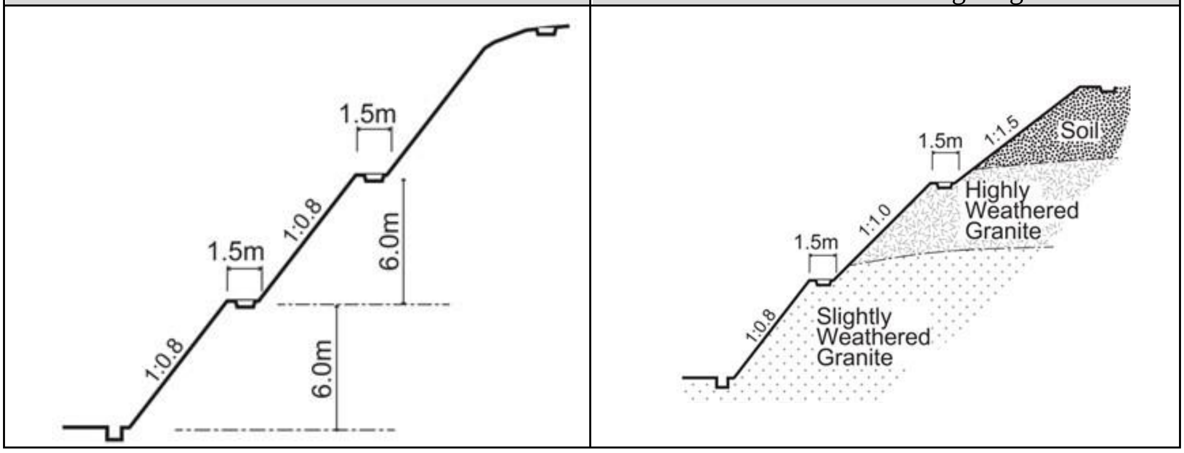
Type A		
Standards	Rocks with well-developed joints	Hard to adjust slope shape because of hard rocks



Source: JICA Study Team

Figure 5-61: Recommended Slope Protection Methods for Type A

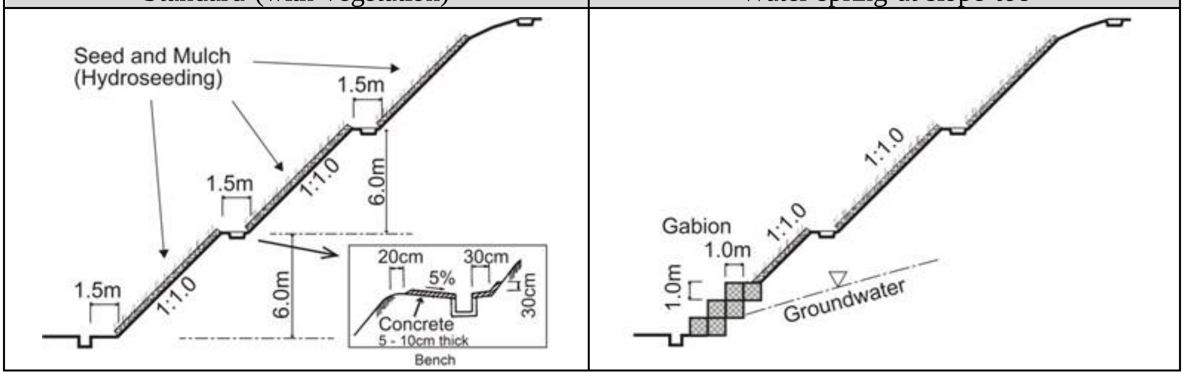
Type B	
Standard	Different weathering stages



Source: JICA Study Team

Figure 5-62: Recommended Slope Protection Methods for Type B

Type C	
Standard (with vegetation)	Water spring at slope toe



Source: JICA Study Team

Figure 5-63: Recommended Slope Protection Method for Type C

5.2.6 Pavement Design

For pavement design, some possible pavement structures are examined with CBR and traffic volume of large vehicles as design conditions before the most appropriate pavement structure is determined. In this survey, the pavement structure will be determined in consideration of these design conditions, as well as the water level on the site and requests from NHIDCL. The MORTH seeks long-term soundness of road pavements, instructing that concrete should be the first priority to be used for national road pavements. When deciding on asphalt pavement, on the other hand, design consultants are required to present the grounds for the decision such as climate and geographical conditions.

NH40 has a maximum vertical grade of 7% and minimum curve radius of 75m, so the construction work with a concrete pavement machine is not suitable, which is applicable to roads with the maximum vertical grade of 6% and minimum curve radius of 100m (according to manuals of the MLIT). From the perspective of operation and maintenance, on the other hand, the highway is in a rainy region and concrete pavement is more advantageous.

In consideration of these design conditions, together with the groundwater level underneath the road and information collected from a contractor which has undertaken construction work for mountainous roads in the northeastern region, such as the Shillong Bypass construction, a pavement structure that has advantages of both concrete and asphalt pavements has been selected.

(1) Design CBR

This survey has conducted CBR tests. The following table shows the survey results and design CBR in each section.

Table 5-29: Design CBR in Each Section

Section (KP)	Design CBR (%)	Average CBR (%)	Min. CBR (%)	Max. CBR (%)
20-30	3%	3.72	3.50	3.94
30-40		4.63	4.63	5.45
40-50		4.85	4.10	5.60
50-60	5%	5.12	3.98	6.25
60-70		6.13	5.15	7.10
70-80		6.40	6.34	6.45

Source: JICA Study Team

Different design CBRs have been set before and after the 50km point: 3% on the side of the starting point and 5% on the side of the ending point. The thickness of pavement will be determined in accordance with these design CBRs.

(2) Traffic Volume of Large Vehicles

The traffic volume of large vehicles is expressed in terms of million standard axles (msa). In this survey, however, the volume is based on msa calculated by the local consultant. The following table shows the msa values of the target vehicle types.

Table 5-30: Traffic Volume of Large Vehicles

Type of Vehicle	Adopted VDF
Bus	1.30
LCV	1.73
2-Axle Truck	6.38
3-Axle Truck	8.31
Total	17.72

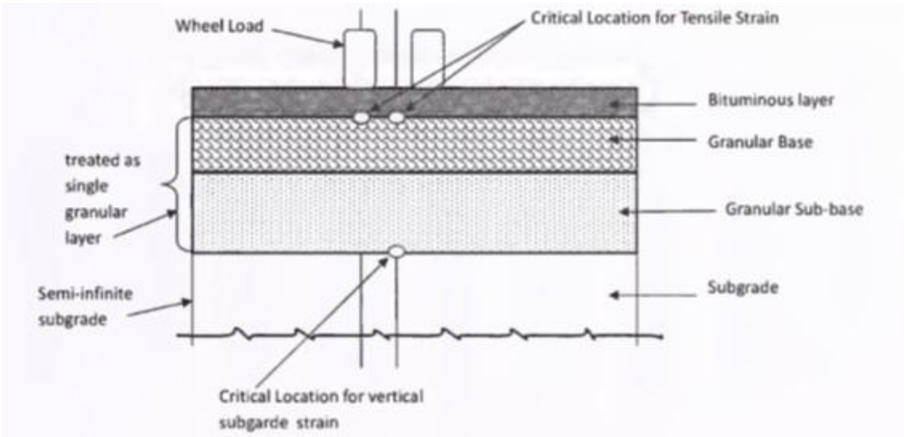
Source: JICA Study Team

For this route, 20 msa will be adopted.

(3) Standards for Pavement Design

According to Chapter 10 "Pavement Design" of IRC: 37-2012 (Tentative Guidelines for the Design of Flexible Pavement), Indian standards for road pavements are classified into six types, including the following five types. The pavement structures are classified as follows in terms of surface layer.

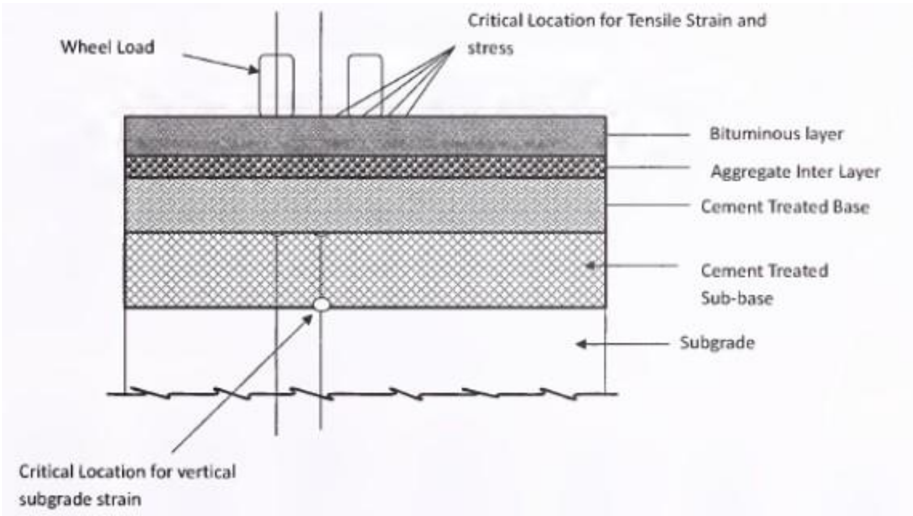
a) Structure consisting of granular base and granular subbase



Source: IRC37-2012

Figure 5-64: Asphalt Pavement (Basic Form)

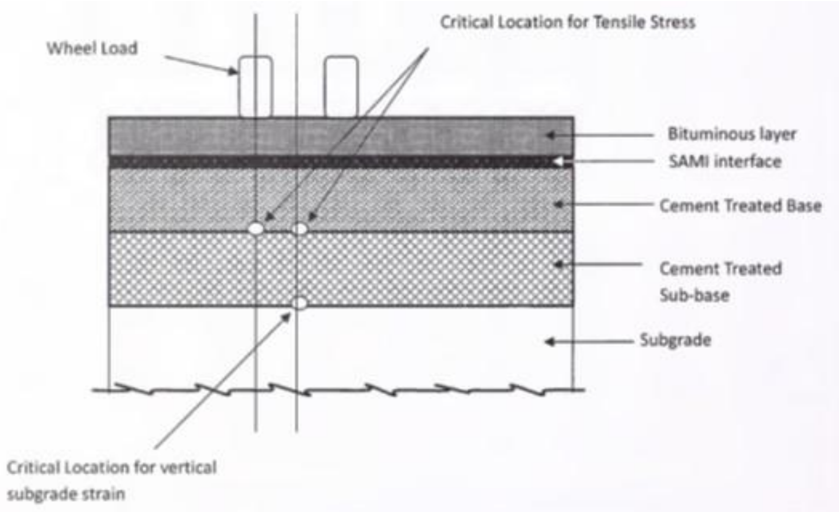
b) Structure consisting of crushed stone bed for crack prevention, cement treated cementitious base and cement treated cementitious subbase



Source: IRC37-2012

Figure 5-65: As + Cement Improvement (1)

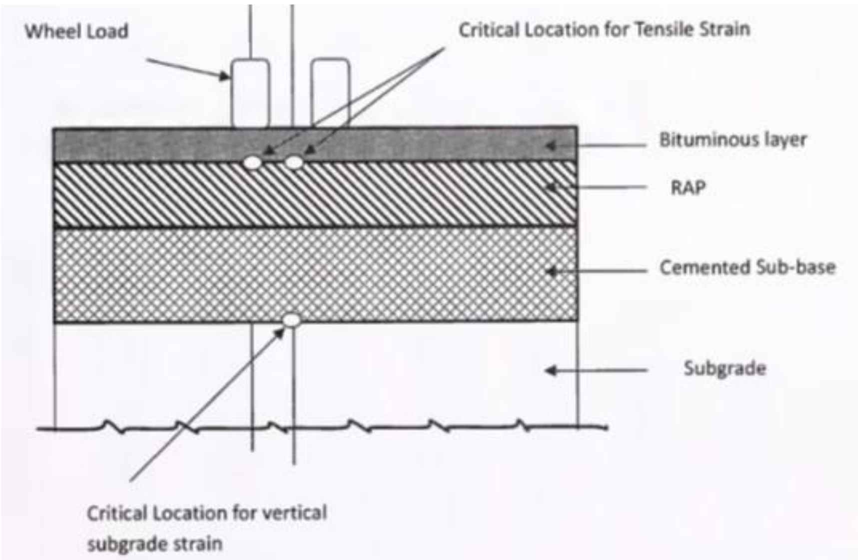
c) Structure consisting of cement treated cementitious base and cemented subbase, and SAMI interface



Source: IRC37-2012

Figure 5-66: As + Cement Improvement (2)

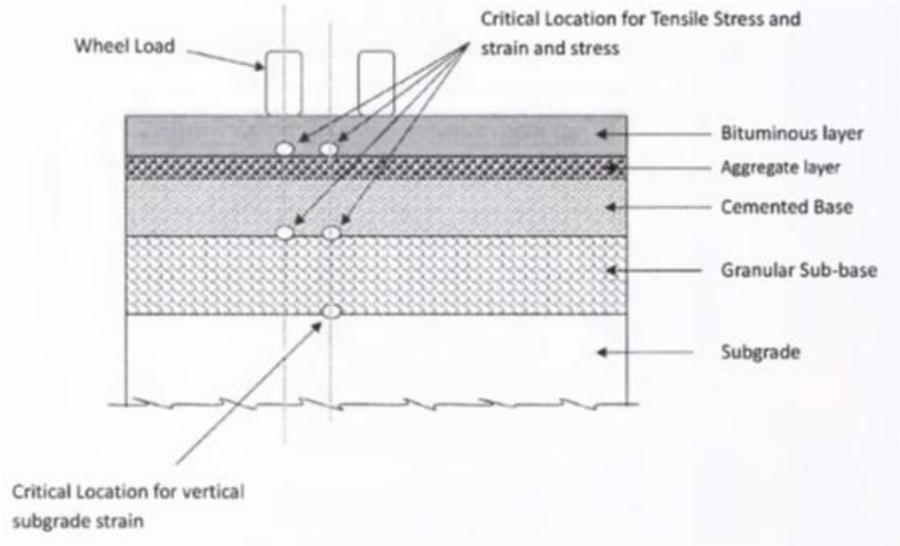
d) Structure consisting of reclaimed asphalt pavement (RAP) and cement roadbed of 250mm or more in thickness



Source: IRC37-2012

Figure 5-67: As + Cement Pavement (1)

e) Structure consisting of cement reinforced roadbed and crushed stone bed for crack prevention



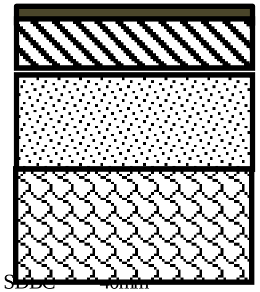
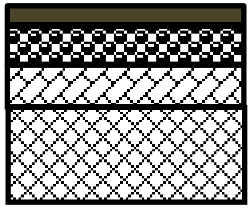
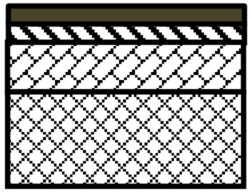
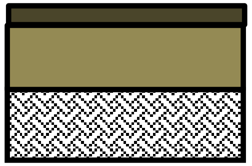
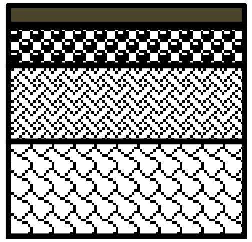
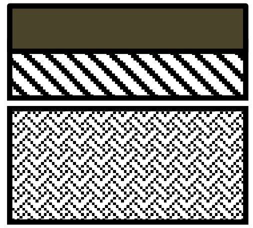
Source: IRC37-2012

Figure 5-68: As + Cement Pavement (2)

(4) Selection of Pavement

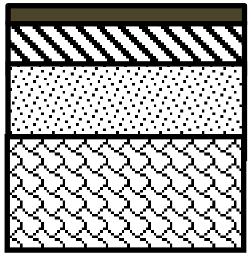
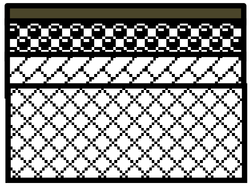
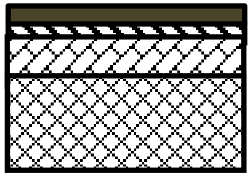
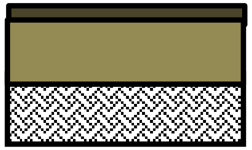
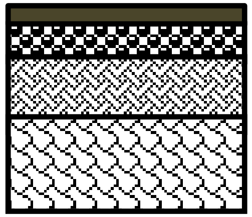
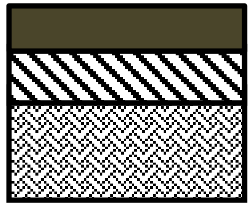
The pavement structures described above will be compared with one another. Since the values of design CBR are different before and after KP50+000 as shown in the geological survey results, the comparison results will be shown for CBR of 3% on the side of the starting point and 5% on the side of the ending point, respectively, as shown in Table5-31 and Table 5-32.

Table 5-31: Comparison of Pavement Structures (CBR 3%, Traffic = 20 msa)

Item	(i) Asphalt Pavement (basic form) 10.1 Granular Base and Granular Sub- base	(ii) As + Cement Improvement (1) 10.2 Bituminous Pavements with Cemented Base and Cemented subbase with Crack Relief Interlayer of Aggregate	(iii) As + Cement Improvement (2) 10.3 Cemented Base and Cemented Subbase with SAMI at the Interface of Cemented Base and the Bituminous Layer	(iv) As + Cement Pavement (1) 10.4 Foamed Bitumen/Bitumen Emulsion Treated RAP/Aggregates Over Cemented Sub-base	(v) As + Cement Pavement (2) 10.5 Cemented Base and Granular Sub-base with Crack Relief Layer of Aggregate Interlayer Above the Cemented Base	(vi) As + Cement Pavement 10.6 Bituminous Surfacing with Wet Mix Macadam Base and Cemented Sub-base
Structure	 SDBC 40mm DBM 120mm Granular base 250mm Granular Sub-base 380mm Total = 790mm	 SDBC 50mm Aggregate 100mm CT Base 120mm CT Sub-Base 250mm Total = 520mm	 SDBC 50mm CT Base 180mm CT Sub-Base 250mm Total = 480mm	 SDBC 40mm Treated RAP 200mm Cemented Sub-Base 200mm Total = 440mm	 SDBC 50mm Aggregate 100mm Cemented Base 240mm Granular Sub Base 250mm Total = 640mm	 SDBC 120mm DBM 150mm Cemented Sub-Base 300mm Total = 570mm
	Traffic =20 msa, CBR = 3 % * The figures of the IRC standards do not show macadam (crushed stone) pavement, but the illustrations in the table contain macadam pavement.					Traffic = 100 msa, CBR = 8 % (Calculated values are used: hypothetical values)
Features	• The surface asphalt layer will be the general pavement. • Roadbed improvement will not be performed, so the overall layers are thicker than those of improved forms.	• Cement treated layers will be applied to the base and subbase. • Cement treatment will reduce the thickness of the overall layers.	• Cement treated layers will be applied to the base and subbase. • Coarse aggregate will not be used but waterproof layer will be laid under SDBC as a buffer. • Cement treatment will enable to reduce the thickness of the overall layers.	• Reclaimed asphalt pavement (RAP) will be laid as intermediate layer. • Cement treatment will not be performed, but roadbed will be reinforced with cement.	• Course aggregate will be used for upper roadbed on cemented base. • Cement treatment will not be performed, but roadbed will be reinforced with cement.	• The asphalt pavement will be thicker by 120mm. • Cement treatment will not be performed, but roadbed will be reinforced with cement.
Assessment	• The standards recommend pavement using cement treatment,but the effect of preventing pavement damage due to groundwater cannot be gained from cement treatment. • Pavements (i) to (iii) are common structures, so the construction is relatively easy and cheap. • Pavement (iv) is reinforced with cement and thus can have high strength and evenness. It also has the waterproof effect against groundwater. However, the intermediate layer, RAP, is as thick as 170mm, and prone to rutting and thus is not ideal. • Pavement (v) is reinforced with cement and thus can have high strength and evenness. It also has the waterproof effect against groundwater. According to contractors, it is possible to perform construction work of cemented base in the steeply sloped chainage. • Pavement (vi) has a thick surface asphalt layer of 120mm and thus is prone to rutting and run-off of asphalt. • Cautions: India's standards do not provide any guidelines on prime coat or tack coat in between layers. Care must be taken when detailed design is drawn up.					
	Normal	Normal	Normal	No good	**Good**	No good

Source: JICA Study Team

Table 5-32: Comparison of Pavement Structures (CBR 5%, Traffic = 20 msa)

Item	(i) Asphalt Pavement (basic form) 10.1 Granular Base and Granular Sub- base	(ii) As + Cement Improvement (1) 10.2 Bituminous Pavements with Cemented Base and Cemented subbase with Crack Relief Interlayer of Aggregate	(iii) As + Cement Improvement (2) 10.3 Cemented Base and Cemented Subbase with SAMI at the Interface of Cemented Base and the Bituminous Layer	(iv) As + Cement Pavement (1) 10.4 Foamed Bitumen/Bitumen Emulsion Treated RAP/Aggregates Over Cemented Sub-base	(v) As + Cement Pavement (2) 10.5 Cemented Base and Granular Sub-base with Crack Relief Layer of Aggregate Interlayer Above the Cemented Base	(vi) As + Cement Pavement 10.6 Bituminous Surfacing with Wet Mix Macadam Base and Cemented Sub-base
Structure	 SDBC 40mm DBM 130mm Granular base 250mm Granular Sub-base 330mm Total = 750mm	 SDBC 50mm Aggregate 100mm CT Base 110mm CT Sub-Base 250mm Total = 510mm	 SDBC 50mm CT Base 170mm CT Sub-Base 250mm Total = 470mm	 SDBC 40mm Treated RAP 150mm Cemented Sub-Base 200mm Total = 390mm	 SDBC 50mm Aggregate 100mm Cemented Base 220mm Granular Sub Base 250mm Total = 620mm	 SDBC 120mm DBM 150mm Cemented Sub-Base 300mm Total = 570mm
	Traffic =20 msa, CBR = 5 % (The figures from the table are used: hypothetical values) * The figures of the IRC standards do not show macadam (crushed stone) pavement, but the illustrations in the table contain macadam pavement.					Traffic = 100 msa, CBR = 8 % (Calculated values are used: hypothetical values)
Features	• The surface asphalt layer will be the general pavement. • Roadbed improvement will not be performed, so the overall layers are thicker than those of improved forms.	• Cement treated layers will be applied to the base and subbase. • Cement treatment will reduce the thickness of the overall layers.	• Cement treated layers will be applied to the base and subbase. • Coarse aggregate will not be used but waterproof layer will be laid under SDBC as a buffer. • Cement treatment will reduce the thickness of the overall layers.	• Reclaimed asphalt pavement (RAP) will be laid as intermediate layer. • Cement treatment will not be performed, but roadbed will be reinforced with cement.	• Course aggregate will be used for upper roadbed on cemented base. • Cement treatment will not be performed, but roadbed will be reinforced with cement.	• The asphalt pavement will be thicker by 120mm. • Cement treatment will not be performed, but roadbed will be reinforced with cement.
Assessment	• The standards recommend pavement using cement treatment. But the effect of preventing pavement damage due to groundwater cannot be gained from cement treatment. • Pavements (i) to (iii) are common structures, so the construction is relatively easy and cheap. • Pavement (iv) is reinforced with cement and thus can have high strength and evenness. It also has the waterproof effect against groundwater. However, the intermediate layer, RAP, is as thick as 170mm, and prone to rutting and thus is not ideal. • Pavement (v) is reinforced with cement and thus can have high strength and evenness. It also has the waterproof effect against groundwater. According to contractors, it is possible to perform construction work of cemented base in the steeply sloped chainage. • Pavement (vi) has a thick surface asphalt layer of 120mm and thus is prone to rutting and run-off of asphalt. Cautions: India's standards do not provide any guidelines on prime coat or tack coat in between layers. Care must be taken when detailed design is drawn up.					
	Normal	Normal	Normal	No good	**Good**	No good

Source: JICA Study Team

Based on the comparison results, we recommend "(v) cement reinforced roadbed and crushed stone bed for crack prevention", which is very strong and is expected to have a waterproof effect.

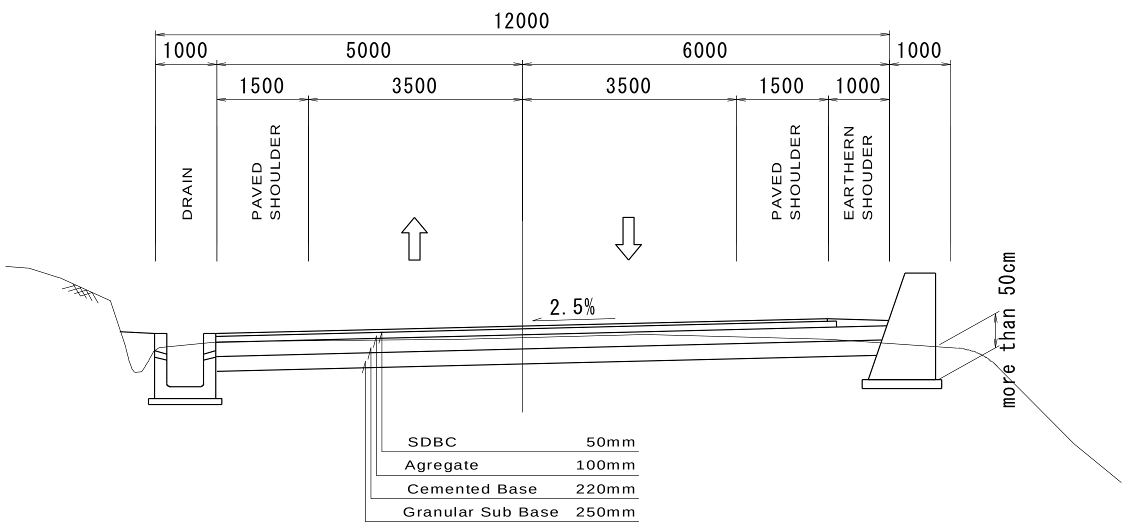
Table 5-33: Recommended Pavement Structure

CBR=3%		CBR=5%	
SDBC	50mm	SDBC	50mm
Aggregate	100mm	Aggregate	100mm
Cemented Base	240mm	Cemented Base	220mm
Granular Sub Base	250mm	Granular Sub Base	250mm
Total	640mm	Total	620mm

Source: JICA Study Team

(5) Typical cross section

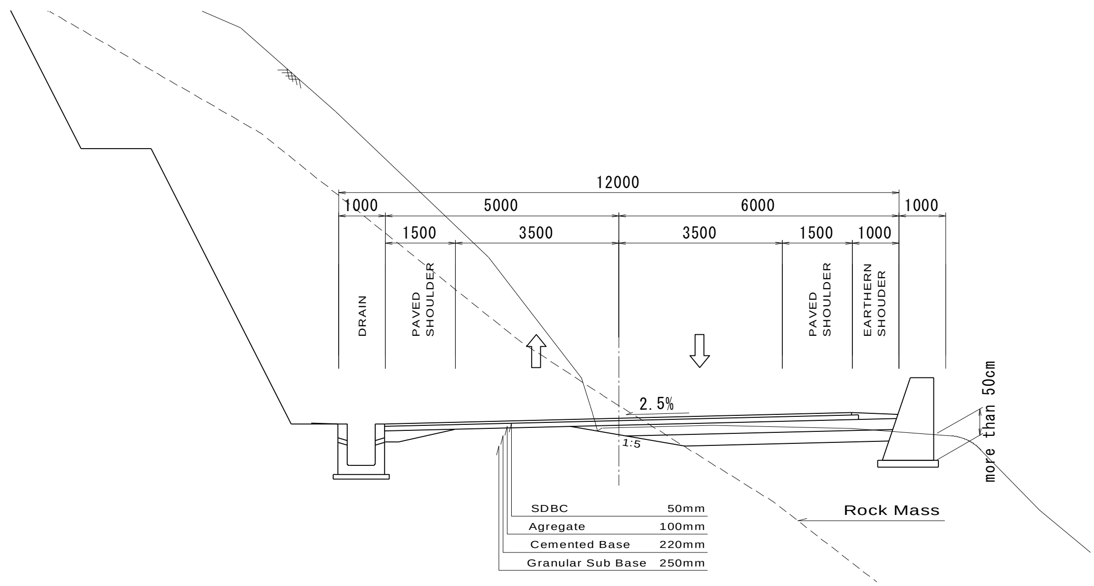
The following figure shows the typical cross section for CBR of 3%.



Source: JICA Study Team

Figure 5-69: Typical Cross-Section (General Part)

At areas where soil or rock material is cut out and the bedrock is located on the roadbed, it is expected that the ground underneath the pavement will be hard and strong. In consideration of this and the operability, we recommend that concrete roadbed should not be applied to such areas but unevenness should be adjusted with crushed stone as described in the figure below.



Source: JICA Study Team

Figure 5-70: Typical Cross Section (Areas with Bedrock)

5.2.7 Drainage Design

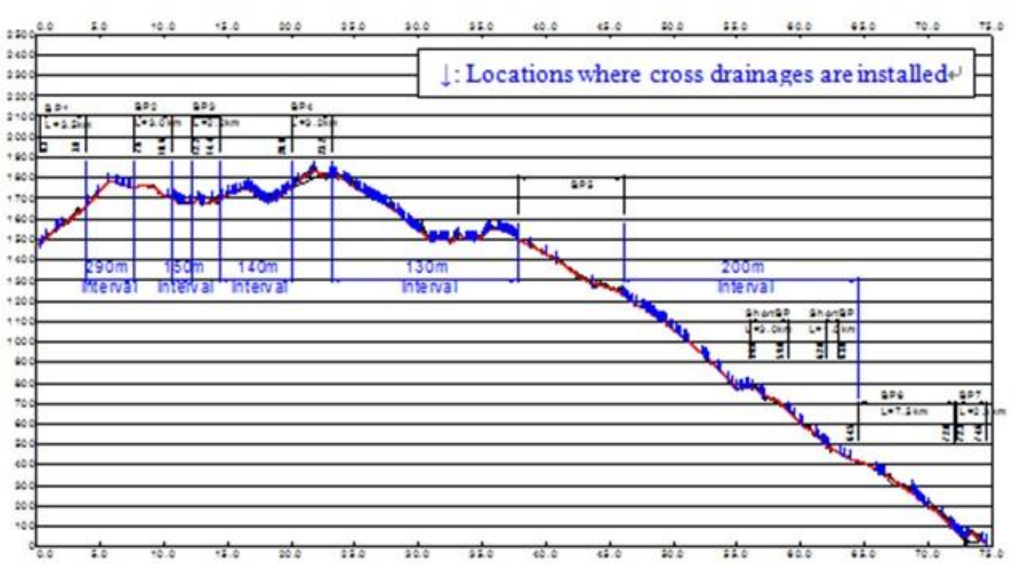
(1) Planning Policy for Drainage Design

For drainage design, the validity of existing designs will be examined in the following manner.

- For the present and planned cross drainages, work types, installation intervals and other aspects will be surveyed and compared, and features of each type will be sorted.
- Areas requiring drainage will be specified, and confirmation will be made to see if the planned cross drainage can handle the drainage volume.
- The route of bypass No. 6, and No. 7 (64+500 and afterwards) has been changed based on the latest proposal from JICA, and thus no drainage plan will be formulated. The survey team will set drainage areas and calculate the drainage volumes, and recommend that these areas and volumes should be reflected in detailed design and construction.

(2) State of the Existing Cross Drainages

The figure below shows the intervals of the exsting cross drainages in the previous plan. Transversal conduits are installed at intervals of 130 m to 200 m, except for bypass sections.



Source: JICA Study Team

Figure 5-71: Intervals of the Existing Conduits

The existing conduits were constructed with three work types, of which culverts account for more than 80%.

Table 5-34: Work Types Adopted for the Existing Cross drainages

Work Type	Locations Applied	Ratio
1-Pipe	212	83%
2-Pipes	6	2%
1-Box	37	12%

Source: JICA Study Team

(3) Planned Cross Drainage

The intervals, cross sections and work types of the cross drainages in the existing output drawings will be confirmed.

a) Intervals of planned cross drainages

Planned cross drainages are installed at intervals of 200 m to 340 m, except for bypass sections. Table 5-35 and 5-36 show the details of the installation intervals of the planned cross drainages. The planned conduits will be constructed with four work types, of which box culverts account for more than 60%.

Table 5-35: Work Types Adopted for the Planned Cross Drainages

Work Type	Locations Applied	Ratio
1-Box	174	64%
1-Pipes	89	33%
Slab	8	3%
Total	271	100%

Source: JICA Study Team

Table 5-36: Installation Intervals of the Planned Cross Drainages

Classification	Cul. No.	Chaiange	Chaiange Interval	Type	Span	Length (m)	Breadth or Diameter (mm)	High(mm)	Interval
Existing1		0+000							
ByPass1 L=3,500m	0+300								
	1	0+064	316	BOX	1x2x2	34.0	2000	2000	250m
	2	0+380	220	BOX	1x2x1.5	19.5	2000	1500	
	3	0+600	360	BOX	1x2x1.5	25.0	2000	1500	
	4	0+960	190	BOX	1x2x1.5	21.0	2000	1500	
	5	1+150	280	BOX	1x2x1.5	23.0	2000	1500	
	6	1+430	224	BOX	1x2x1.5	20.0	2000	1500	
	7	1+654	406	BOX	1x2x1.5	21.0	2000	1500	
	8	2+060	255	BOX	1x2x1.5	23.0	2000	1500	
	9	2+315	235	BOX	1x2x1.5	19.5	2000	1500	
	10	2+550	260	BOX	1x3x3	44.5	3000	3000	
	11	2+810	290	BOX	1x2x1.5	25.0	2000	1500	
	12	3+100	330	BOX	1x2x1.5	21.0	2000	1500	
	13	3+430	450	BOX	1x2x1.5	45.0	2000	1500	
	3+800								
Existing2 L=3,800m	14	3+880	705	BOX	1x2x1.5	19.5	2000	1500	340m
	15	4+585	515	BOX	1x2x1.5	19.5	2000	1500	
	16	5+100	190	BOX	1x2x1.5	21.0	2000	1500	
	17	5+290	260	BOX	1x2x1.5	25.5	2000	1500	
	18	5+550	685	BOX	1x2x1.5	19.5	2000	1500	
	19	6+235	220	BOX	1x2x1.5	19.5	2000	1500	
	20	6+455	205	BOX	1x2x1.5	19.5	2000	1500	
	21	6+660	220	BOX	1x2x1.5	19.5	2000	1500	
	22	6+880	380	BOX	1x2x1.5	21.0	2000	1500	
	23	7+260	1245	BOX	1x2x1.5	19.5	2000	1500	
	7+600								
ByPass2 L=3,000m	24	8+505	275	BOX	1x2x1.5	19.5	2000	1500	750m
	25	8+780	580	BOX	1x2x1.5	21.5	2000	1500	
	26	9+360	1360	BOX	1x2x1.5	35.0	2000	1500	
	10+600								
Existing3 L=1,600m	27	10+720	185	BOX	1x2x1.5	13.0	2000	1500	200m
	28	10+905	275	BOX	1x2x1.5	13.0	2000	1500	
	29	11+180	151	BOX	1x3x3	13.0	3000	3000	
	30	11+331	209	BOX	1x3x3	13.0	3000	3000	
	31	11+540	80	BOX	1x2x2	22.0	2000	2000	
	32	11+620	455	BOX	1x2x2	21.5	2000	2000	
	33	12+075	135	BOX	1x2x1.5	13.0	2000	1500	
	12+200								
ByPass3 L=2,200m	34	12+210	310	BOX	1x2x2	17.5	2000	2000	240m
	35	12+520	830	BOX	1x3x3	23.0	3000	3000	
	36	13+350	171	PIPE	1x1.2	22.5	1200		
	37	13+521	105	BOX	1x6x5	17.0	6000	5000	
	38	13+626	246	BOX	1x6x5	28.5	6000	5000	
	39	13+872	188	BOX	1x3x3	34.5	3000	3000	
	40	14+060	125	BOX	1x2x2	13.0	2000	2000	
	41	14+185	435	BOX	1x2x1.5	15.0	2000	1500	
	14+400								
Existing4 L=5,600m	42	14+620	355	BOX	1x2x1.5	13.0	2000	1500	290m
	43	14+975	325	BOX	1x5x4	13.0	5000	4000	
	44	15+300	210	BOX	1x2x1.5	13.0	2000	1500	
	45	15+510	145	BOX	1x2x1.5	13.0	2000	1500	
	46	15+655	315	BOX	1x2x1.5	13.5	2000	1500	
	47	15+970	240	BOX	1x2x1.5	13.0	2000	1500	
	48	16+210	177	BOX	1x2x1.5	13.0	2000	1500	
	49	16+387	143	BOX	1x2x1.5	14.0	2000	1500	
	50	16+530	265	PIPE	1x1.2	15.0	1200		
	51	16+795	275	BOX	1x2x1.5	23.0	2000	1500	
	52	17+070	165	BOX	1x2x1.5	13.0	2000	1500	
	53	17+235	170	BOX	1x2x1.5	13.0	2000	1500	
	54	17+405	255	BOX	1x2x1.5	13.5	2000	1500	
	55	17+660	190	BOX	1x2x1.5	13.5	2000	1500	
	56	17+850	1100	BOX	1x2x1.5	13.0	2000	1500	
	57	18+950	280	BOX	1x6x6	13.0	6000	6000	
	58	19+230	250	BOX	1x2x2	30.0	2000	2000	

Classification	Cul. No.	Chaiange	Chaiange Interval	Type	Span	Length (m)	Breadth or Diameter (mm)	High(mm)	Interval
Existing4	59	19+480	550	BOX	1x2x1.5	13.5	2000	1500	290m
	20+000								
ByPass4 L=3,200m	60	20+030	250	BOX	1x2x1.5	13.5	2000	1500	220m
	61	20+280	220	BOX	1x2x1.5	13.0	2000	1500	
	62	20+500	225	BOX	1x2x2	30.0	2000	2000	
	63	20+725	155	PIPE	1x1.2	15.0	1200		
	64	20+880	160	PIPE	1x1.2	20.0	1200		
	65	21+040	160	PIPE	1x1.2	37.5	1200		
	66	21+200	390	BOX	1x4x4	38.5	4000	4000	
	67	21+590	400	PIPE	1x1.2	17.5	1200		
	68	21+990	120	BOX	1x3x3	13.0	3000	3000	
	69	22+110	150	PIPE	1x1.2	17.5	1200		
	70	22+260	260	PIPE	1x1.2	17.5	1200		
	71	22+520	215	BOX	1x5x5	42.5	5000	5000	
	72	22+735	495	PIPE	1x1.2	15.0	1200		
	23+200								
Existing5 L=14,600m	73	23+230	250	PIPE	1x1.2	15.0	1200		200m
	74	23+480	150	PIPE	1x1.2	15.0	1200		
	75	23+630	220	PIPE	1x1.2	15.0	1200		
	76	23+850	200	BOX	1x2x1.5	13.5	2000	1500	
	77	24+050	185	BOX	1x2x1.5	13.5	2000	1500	
	78	24+235	220	BOX	1x2x1.5	13.0	2000	1500	
	79	24+455	205	BOX	1x2x1.5	13.0	2000	1500	
	80	24+660	230	SLAB	1x3.0	13.0	3000	3000	
	81	24+890	120	BOX	1x2x1.5	13.5	2000	1500	
	82	25+010	188	PIPE	1x1.2	15.0	1200		
	83	25+198	212	SLAB	1x6.0	14.0	6000	6000	
	84	25+410	190	BOX	1x2x1.5	13.0	2000	1500	
	85	25+600	220	BOX	1x2x1.5	14.0	2000	1500	
	86	25+820	130	BOX	1x2x1.5	13.0	2000	1500	
	87	25+950	150	BOX	1x2x1.5	13.0	2000	1500	
	88	26+100	245	BOX	1x2x1.5	13.5	2000	1500	
	89	26+345	155	BOX	1x2x1.5	13.0	2000	1500	
	90	26+500	170	BOX	1x2x1.5	14.0	2000	1500	
	91	26+670	130	BOX	1x2x1.5	13.5	2000	1500	
	92	26+800	90	BOX	1x2x1.5	13.5	2000	1500	
	93	26+890	135	BOX	1x2x1.5	13.5	2000	1500	
	94	27+025	125	BOX	1x2x1.5	13.0	2000	1500	
	95	27+150	170	SLAB	1x4.0	18.0	4000	4000	
	96	27+320	150	BOX	1x2x1.5	13.0	2000	1500	
	97	27+470	150	BOX	1x2x1.5	13.0	2000	1500	
	98	27+620	240	BOX	1x2x1.5	13.0	2000	1500	
	99	27+860	190	BOX	1x2x1.5	13.0	2000	1500	
	100	28+050	265	BOX	1x2x1.5	15.5	2000	1500	
	101	28+315	170	BOX	1x2x1.5	13.0	2000	1500	
	102	28+485	195	BOX	1x2x1.5	13.0	2000	1500	
	103	28+680	180	PIPE	1x1.2	15.0	1200		
	104	28+860	150	PIPE	1x1.2	15.0	1200		
	105	29+010	260	PIPE	1x1.2	17.5	1200		
	106	29+270	320	PIPE	1x1.2	15.0	1200		
	107	29+590	160	PIPE	1x1.2	15.0	1200		
	108	29+750	130	PIPE	1x1.2	15.0	1200		
	109	29+880	100	PIPE	1x1.2	15.0	1200		
	110	29+980	220	PIPE	1x1.2	15.0	1200		
	111	30+200	130	BOX	1x2x1.5	14.0	2000	1500	
	112	30+330	130	PIPE	1x1.2	15.0	1200		
	113	30+460	390	PIPE	1x1.2	15.0	1200		
	114	30+850	130	PIPE	1x1.2	15.0	1200		
	115	30+980	200	BOX	1x2x1.5	13.0	2000	1500	
	116	31+180	225	BOX	1x2x1.5	13.5	2000	1500	

Classification	Cul. No.	Chaiange	Chaiange Interval	Type	Span	Length (m)	Breadth or Diameter (mm)	High(mm)	Interval
Existing5 L=14,600m	117	31+405	185	BOX	1x2x1.5	13.0	2000	1500	**200m**
	118	31+590	450	BOX	1x2x1.5	13.0	2000	1500	
	119	32+040	650	PIPE	1x1.2	15.0	1200		
	120	32+690	775	PIPE	1x1.2	15.0	1200		
	121	33+465	215	PIPE	1x1.2	15.0	1200		
	122	33+680	170	PIPE	1x1.2	15.0	1200		
	123	33+850	115	PIPE	1x1.2	15.0	1200		
	124	33+965	225	PIPE	1x1.2	15.0	1200		
	125	34+190	140	PIPE	1x1.2	15.0	1200		
	126	34+330	510	PIPE	1x1.2	15.0	1200		
	127	34+840	245	PIPE	1x1.2	15.0	1200		
	128	35+085	110	PIPE	1x1.2	15.0	1200		
	129	35+195	355	PIPE	1x1.2	15.0	1200		
	130	35+550	160	BOX	1x2x1.5	13.5	2000	1500	
	131	35+710	360	BOX	1x2x1.5	13.5	2000	1500	
	132	36+070	125	BOX	1x2x1.5	13.0	2000	1500	
	133	36+195	225	BOX	1x2x1.5	13.5	2000	1500	
	134	36+420	180	BOX	1x2x1.5	14.0	2000	1500	
	135	36+600	170	BOX	1x2x1.5	13.5	2000	1500	
	136	36+770	150	SLAB	1x4.0	13.5	4000	4000	
	137	36+920	155	BOX	1x2x1.5	13.0	2000	1500	
	138	37+075	170	BOX	1x2x1.5	13.0	2000	1500	
	139	37+245	155	BOX	1x2x1.5	13.0	2000	1500	
	140	37+400	170	PIPE	1x1.2	15.0	1200		
	141	37+570	268	PIPE	1x1.2	20.0	1200		
	37+800								
ByPass5 L=8,300m	142	37+838	177	BOX	1x2x2	27.5	2000	2000	**180m**
	143	38+015	88	PIPE	1x1.2	15.0	1200		
	144	38+103	108	BOX	1x2x1.5	13.0	2000	1500	
	145	38+211	129	PIPE	1x1.2	15.0	1200		
	146	38+340	370	PIPE	1x1.2	15.0	1200		
	147	38+710	160	PIPE	1x1.2	15.0	1200		
	148	38+870	500	PIPE	1x1.2	15.0	1200		
	149	39+370	180	PIPE	1x1.2	15.0	1200		
	150	39+550	315	PIPE	1x1.2	17.5	1200		
	151	39+865	210	PIPE	1x1.2	17.5	1200		
	152	40+075	300	BOX	1x2x2	27.0	2000	2000	
	153	40+375	290	BOX	1x2x2	13.0	2000	2000	
	154	40+665	185	PIPE	1x1.2	15.0	1200		
	155	40+850	130	PIPE	1x1.2	15.0	1200		
	156	40+980	150	PIPE	1x1.2	15.0	1200		
	157	41+130	150	PIPE	1x1.2	15.0	1200		
	158	41+280	205	PIPE	1x1.2	15.0	1200		
	159	41+485	185	PIPE	1x1.2	15.0	1200		
	160	41+670	130	PIPE	1x1.2	15.0	1200		
	161	41+800	210	PIPE	1x1.2	15.0	1200		
	162	42+010	185	PIPE	1x1.2	15.0	1200		
	163	42+195	185	PIPE	1x1.2	15.0	1200		
	164	42+380	260	PIPE	1x1.2	15.0	1200		
	165	42+640	100	BOX	1x2x1.5	13.0	2000	1500	
	166	42+740	170	BOX	1x2x1.5	13.5	2000	1500	
	167	42+910	140	SLAB	1x6.0	13.5	6000	6000	
	168	43+050	125	BOX	1x2x1.5	13.0	2000	1500	
	169	43+175	365	SLAB	1x6.0	18.0	6000	6000	
	170	43+540	170	BOX	1x3x3	13.0	3000	3000	
	171	43+710	140	BOX	1x2x1.5	13.5	2000	1500	
	172	43+850	180	BOX	1x2x1.5	13.5	2000	1500	
	173	44+030	265	BOX	1x2x1.5	13.0	2000	1500	
	174	44+295	161	BOX	1x2x1.5	13.5	2000	1500	

Classification	Cul. No.	Chaiange	Chaiange Interval	Type	Span	Length (m)	Breadth or Diameter (mm)	High(mm)	Interval
ByPass5 L=8,300m	175	44+456	109	BOX	1x2x1.5	13.5	2000	1500	180m
	176	44+565	195	PIPE	1x1.2	15.0	1200		
	177	44+760	150	BOX	1x2x1.5	37.5	2000	1500	
	178	44+910	190	PIPE	1x1.2	15.0	1200		
	179	45+100	170	BOX	1x2x1.5	13.0	2000	1500	
	180	45+270	220	BOX	1x2x1.5	13.5	2000	1500	
	181	45+490	155	BOX	1x2x1.5	13.0	2000	1500	
	182	45+645	55	SLAB	1x4.0	14.0	4000	4000	
	183	45+700	220	BOX	1x2x1.5	15.0	2000	1500	
	184	45+920	150	PIPE	1x1.2	15.0	1200		
	185	46+070	180	PIPE	1x1.2	15.0	1200		
	46+100								
Existing6 L=18,400m	186	46+250	190	PIPE	1x1.2	15.0	1200		200m
	187	46+440	320	PIPE	1x1.2	15.0	1200		
	188	46+760	220	BOX	1x2x1.5	13.5	2000	1500	
	189	46+980	180	BOX	1x2x1.5	13.0	2000	1500	
	190	47+160	160	BOX	1x2x1.5	13.0	2000	1500	
	191	47+320	180	BOX	1x2x1.5	13.5	2000	1500	
	192	47+500	100	BOX	1x2x1.5	13.0	2000	1500	
	193	47+600	140	BOX	1x2x1.5	13.0	2000	1500	
	194	47+740	120	BOX	1x2x1.5	13.0	2000	1500	
	195	47+860	140	BOX	1x2x1.5	13.5	2000	1500	
	196	48+000	60	BOX	1x2x1.5	13.0	2000	1500	
	197	48+060	45	BOX	1x2x1.5	14.0	2000	1500	
	198	48+105	180	BOX	1x2x1.5	14.0	2000	1500	
	199	48+285	200	BOX	1x2x1.5	13.0	2000	1500	
	200	48+485	150	BOX	1x3x3	18.5	3000	3000	
	201	48+635	235	BOX	1x2x1.5	22.5	2000	1500	
	202	48+870	260	BOX	1x2x1.5	13.5	2000	1500	
	203	49+130	285	BOX	1x4x4	65.0	4000	4000	
	204	49+415	110	BOX	1x4x4	13.0	4000	4000	
	205	49+525	317	BOX	1x2x1.5	13.0	2000	1500	
	206	49+842	153	BOX	1x4x4	13.0	4000	4000	
	207	49+995	135	BOX	1x2x1.5	13.0	2000	1500	
	208	50+130	470	BOX	1x2x1.5	13.0	2000	1500	
	209	50+600	235	BOX	1x2x1.5	13.0	2000	1500	
	210	50+835	555	BOX	1x2x1.5	13.5	2000	1500	
	211	51+390	260	BOX	1x2x2	23.0	2000	2000	
	212	51+650	250	BOX	1x2x1.5	13.0	2000	1500	
	213	51+900	250	BOX	1x2x1.5	13.0	2000	1500	
	214	52+150	90	BOX	1x2x1.5	13.5	2000	1500	
	215	52+240	460	BOX	1x2x2	20.0	2000	2000	
	216	52+700	360	BOX	1x2x1.5	16.0	2000	1500	
	217	53+060	110	BOX	1x3x3	13.0	3000	3000	
	218	53+170	70	PIPE	1x1.2	15.0	1200		
	219	53+240	110	PIPE	1x1.2	15.0	1200		
	220	53+350	600	PIPE	1x1.2	15.0	1200		
	221	53+950	315	BOX	1x2x2	13.0	2000	2000	
	222	54+265	605	BOX	1x2x2	13.5	2000	2000	
	223	54+870	155	BOX	1x2x1.5	15.5	2000	1500	
	224	55+025	245	BOX	1x3x3	13.0	3000	3000	
	225	55+270	140	BOX	1x2x1.5	13.0	2000	1500	
	226	55+410	70	BOX	1x2x1.5	13.0	2000	1500	
	227	55+480	310	BOX	1x2x2	13.5	2000	2000	
	228	55+790	110	BOX	1x2x2	27.5	2000	2000	
	229	55+990	210	BOX	1x2x1.5	13.0	2000	1500	
	230	56+110	200	BOX	1x2x1.5	13.0	2000	1500	
	231	56+310	70	BOX	1x2x1.5	13.0	2000	1500	
	232	56+380	210	BOX	1x2x1.5	13.0	2000	1500	

Classification	Cul. No.	Chaiange		Chaiange Interval	Type	Span	Length (m)	Breadth or Diameter (mm)	High(mm)	Interval
Existing6 L=18,400m	233	56+590	56,590	75	BOX	1x2x1.5	13.0	2000	1500	200m
	234	56+665	56,665	190	BOX	1x2x2	45.0	2000	2000	
	235	56+855	56,855	95	BOX	1x2x2	40.0	2000	2000	
	236	56+950	56,950	200	BOX	1x2x2	13.0	2000	2000	
	237	57+150	57,150	125	BOX	1x2x1.5	13.0	2000	1500	
	238	57+275	57,275	105	PIPE	1x1.2	15.0	1200		
	239	57+380	57,380	150	PIPE	1x1.2	20.0	1200		
	240	57+530	57,530	150	PIPE	1x1.2	15.0	1200		
	241	57+680	57,680	120	PIPE	1x1.2	15.0	1200		
	242	57+800	57,800	130	PIPE	1x1.2	15.0	1200		
	243	57+930	57,930	250	PIPE	1x1.2	37.5	1200		
	244	58+180	58,180	210	BOX	1x2x2	24.0	2000	2000	
	245	58+390	58,390	150	BOX	1x2x2	26.0	2000	2000	
	246	58+540	58,540	180	BOX	1x2x2	13.0	2000	2000	
	247	58+720	58,720	120	PIPE	1x1.2	15.0	1200		
	248	58+840	58,840	410	PIPE	1x1.2	15.0	1200		
	249	59+250	59,250	395	PIPE	1x1.2	25.0	1200		
	250	59+645	59,645	195	PIPE	1x1.2	15.0	1200		
	251	59+840	59,840	250	PIPE	1x1.2	22.5	1200		
	252	60+090	60,090	365	PIPE	1x1.2	17.5	1200		
	253	60+455	60,455	145	PIPE	1x1.2	15.0	1200		
	254	60+600	60,600	395	PIPE	1x1.2	15.0	1200		
	255	60+995	60,995	115	PIPE	1x1.2	17.5	1200		
	256	61+110	61,110	108	PIPE	1x1.2	15.0	1200		
	257	61+218	61,218	111	PIPE	1x1.2	22.5	1200		
	258	61+329	61,329	146	PIPE	1x1.2	15.0	1200		
	259	61+475	61,475	90	PIPE	1x1.2	15.0	1200		
	260	61+565	61,565	145	PIPE	1x1.2	17.5	1200		
	261	61+710	61,710	170	SLAB	1x6.0	13.0	6000	6000	
	262	61+880	61,880	215	PIPE	1x1.2	15.0	1200		
	263	62+095	62,095	205	BOX	1x2x2	50.0	2000	2000	
	264	62+300	62,300	130	BOX	1x2x1.5	13.5	2000	1500	
	265	62+430	62,430	200	PIPE	1x1.2	15.0	1200		
	266	62+630	62,630	130	BOX	1x2x2	13.5	2000	2000	
	267	62+760	62,760	105	BOX	1x2x2	13.0	2000	2000	
	268	62+865	62,865	190	PIPE	1x1.2	20.0	1200		
	269	63+055	63,055	195	PIPE	1x1.2	22.5	1200		
	270	63+250	63,250	410	PIPE	1x1.2	15.0	1200		
	271	63+660	63,660	840	PIPE	1x1.2	15.0	1200		
	64+500									

Source: JICA Study Team

b) Adoption of Box Culvert

Comparing the present and planned drainage conduits, the latter has wider installation intervals and larger inner sections. The plan adopts box culverts with a drainage function higher than that of the present conduits.

In general, a box culvert has higher drainage capacity than a pipe culvert with the same cross-sectional area. The table below shows a comparison of drainage capacities of a box culvert and pipe culvert with the same cross-sectional area. The table suggests that a box culvert can handle 1.3 times more drainage water than a pipe culvert with the same cross-sectional area can. This is because drainage water touches a wider surface area with pipes and friction slows down the speed of water drainage, compared to culvert boxes.

Table 5-37: Comparison of Possible Water Flow Volumes

Type and size	Area (m2)	Drainage gradient (%)	Drainage volume (m3/s)
1-Box 1700mmx1700mm	2.89	0.5	10.21 (1.3)
2-Pipe D1350mm	2.86		7.65 (1.0)

Source: JICA Study Team

c) Minimum Diameter of Culvert

The present transversal culverts are 900 mm and 1,000 mm in diameter. The planned culverts will be 1,200 mm in diameter. This is favorable because it complies with with RC: SP: 42-2014.

practice for the major concessionaires to avoid pipe culverts for new major projects like Ganga/Yamuna expressway. However, for many other new projects in India, hume pipes having minimum diameter of 1200 mm are being used.

The required size of the culvert is decided on the basis of hydrologic, hydraulic and structural analysis. However, the minimum size of the culvert is fixed on the basis of ease in maintenance, movement of fish, debris etc. For upgrading projects, hume pipe culverts having diameter less than 900 mm are to be replaced with a minimum diameter 1200 mm as recommended by IRC:SP:13.

Source: IRC: SP: 42:2014

Figure 5-72: Minimum Diameter of Transversal Culvert

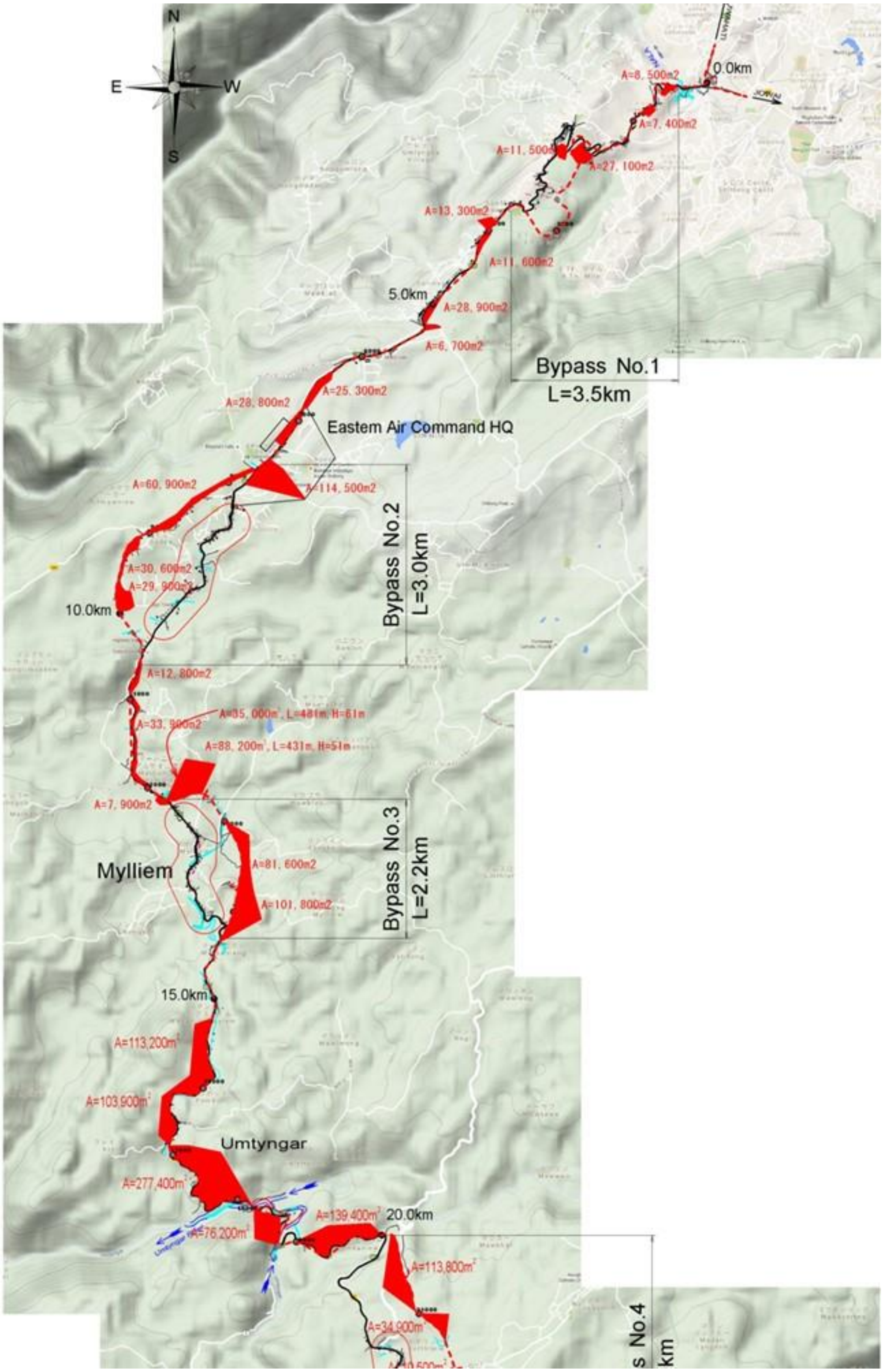
(4) Examination of Drainage Capacity of the Planned Cross Drainages

a) Examination of Outflow Volume

The outflow volume has been calculated at 271 points of the planned cross drainage in Sections 0+000 to 64+500, except bypass #6, and the drainage capacity of the conduits has been examined.

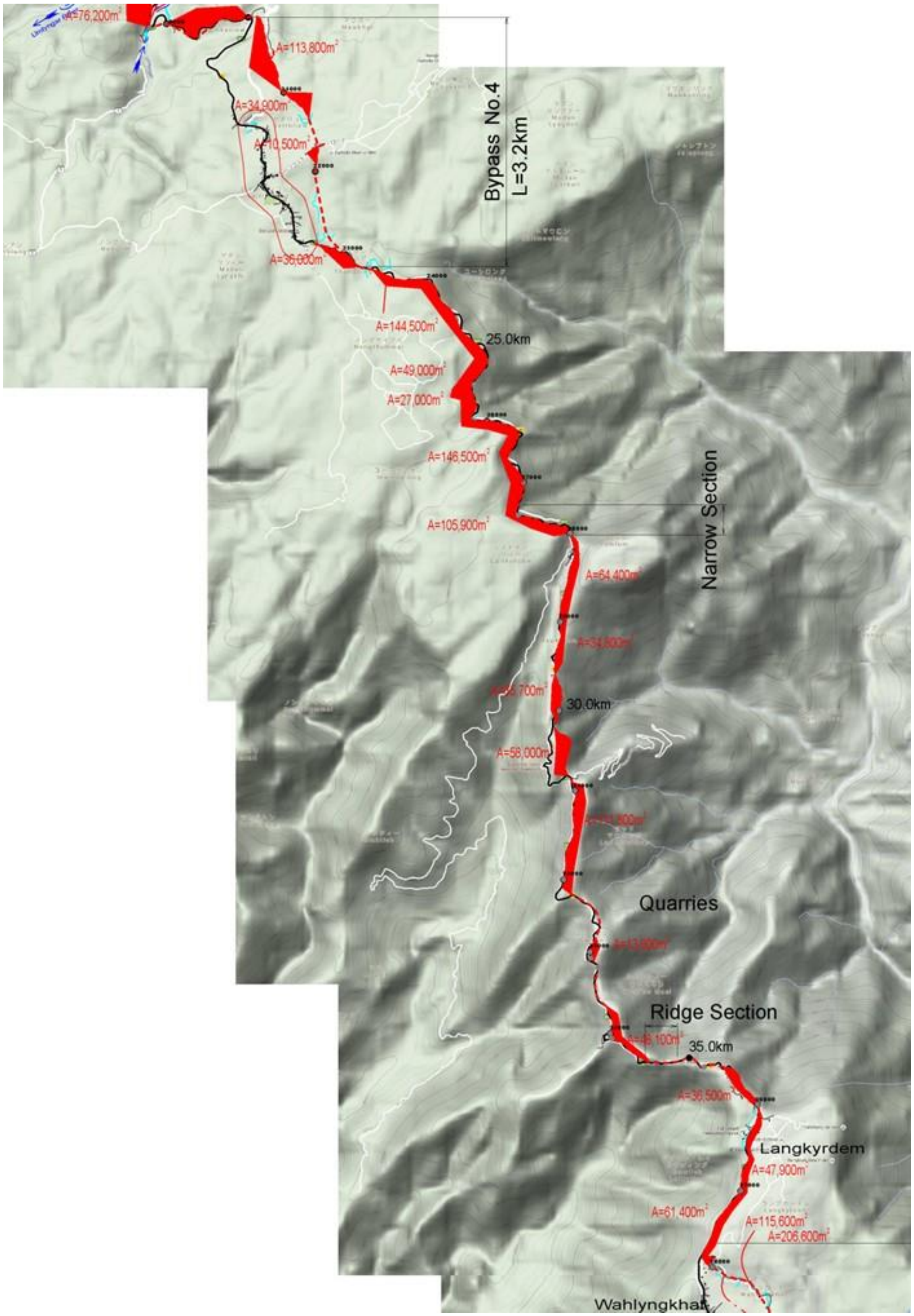
(i) The outflow volume for the catchment area to be covered by the planned cross drainage was calculated (the present road and bypass sections).
(ii) The water flow volume which the planned cross drainages can handle was calculated in accordance with the inner section of the conduits (drainage gradient: 1/1,000)
(iii) The above (i) and (ii) were compared.

The water flow volume of the planned cross drainage has been calculated with Manning's formula. Figures below show the catchment area of the planned cross drainages.



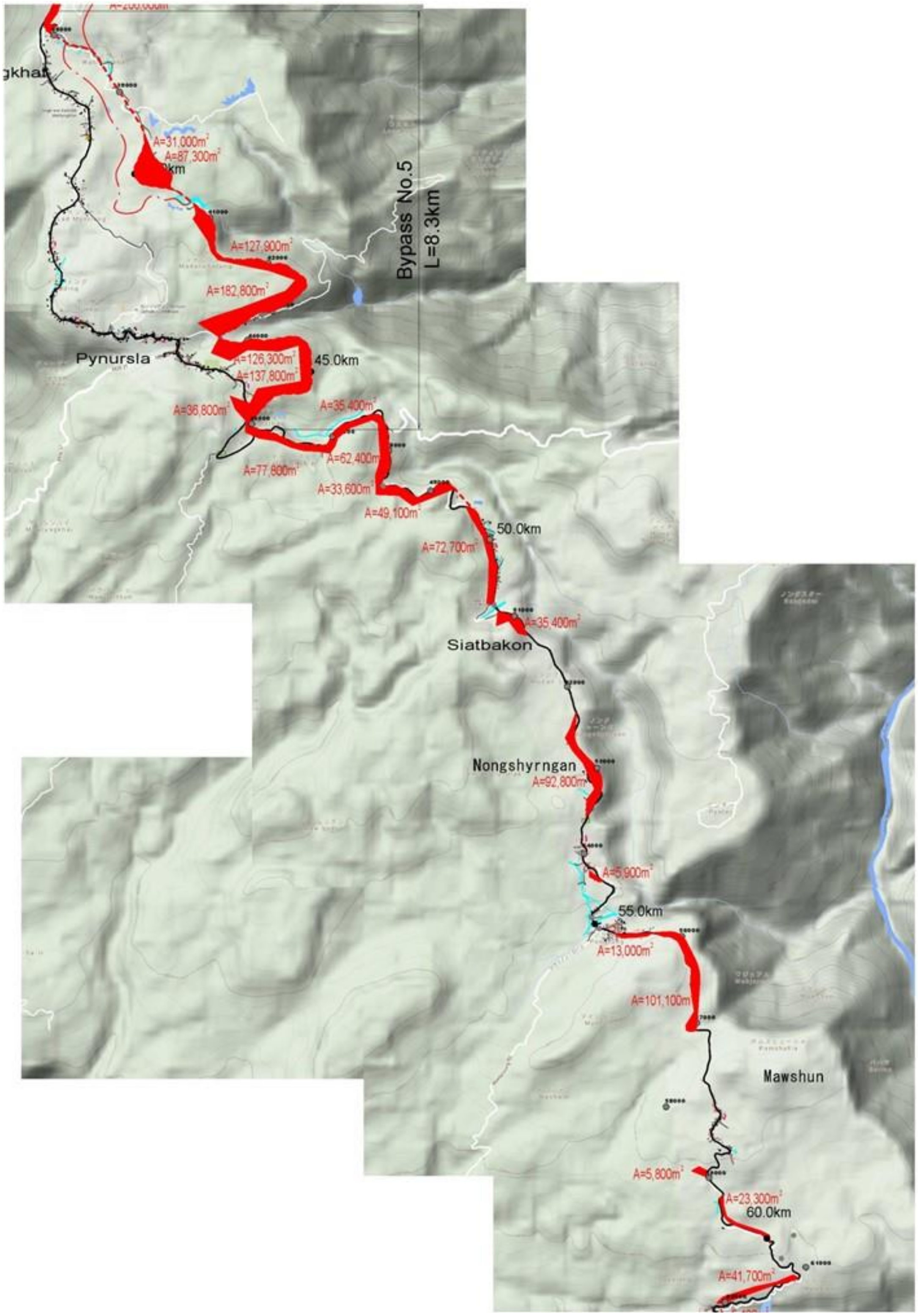
Source: JICA Study Team

Figure 5-73: Catchment Area (1)



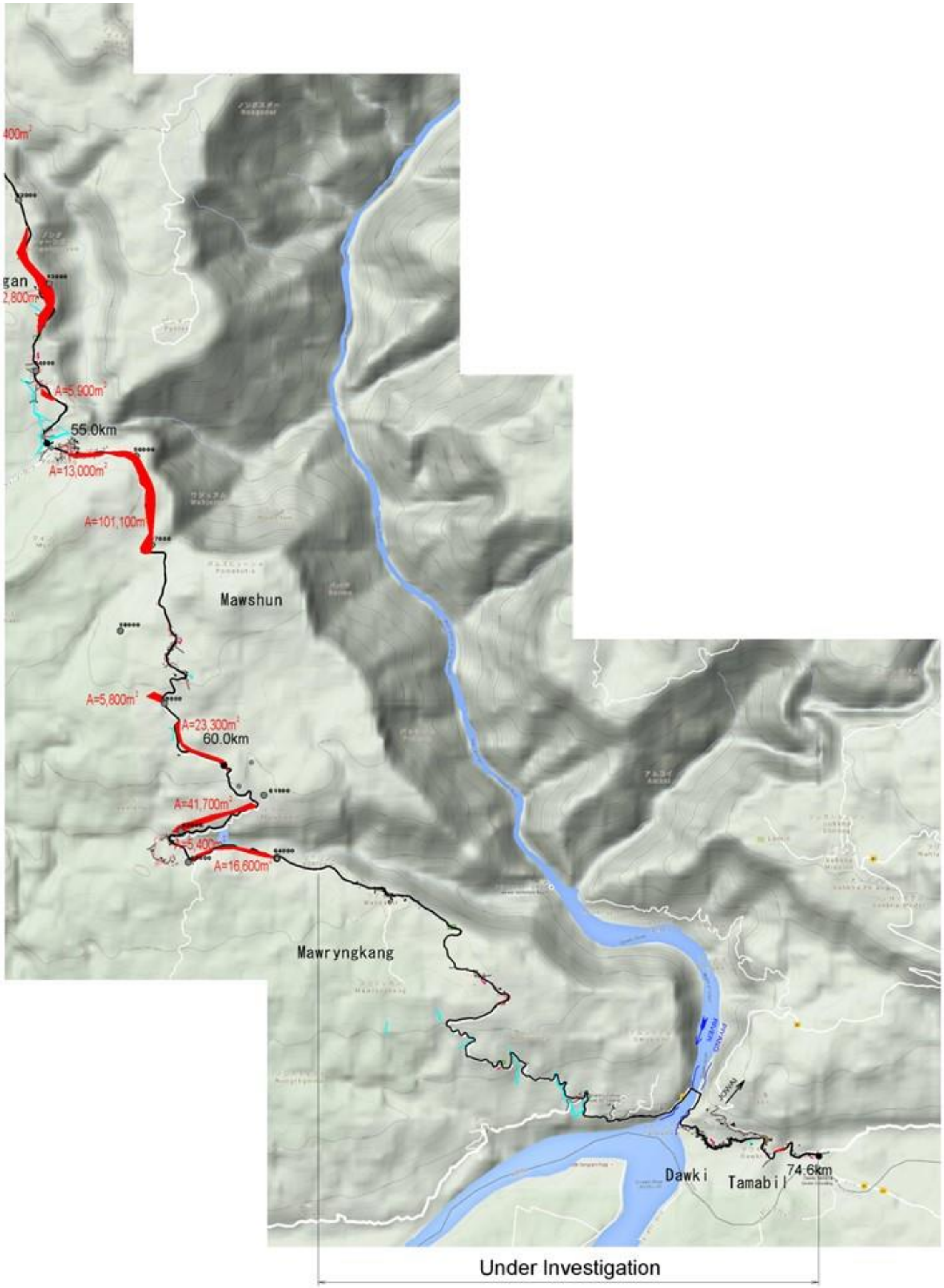
Source: JICA Study Team

Figure 5-74: Catchment Area (2)



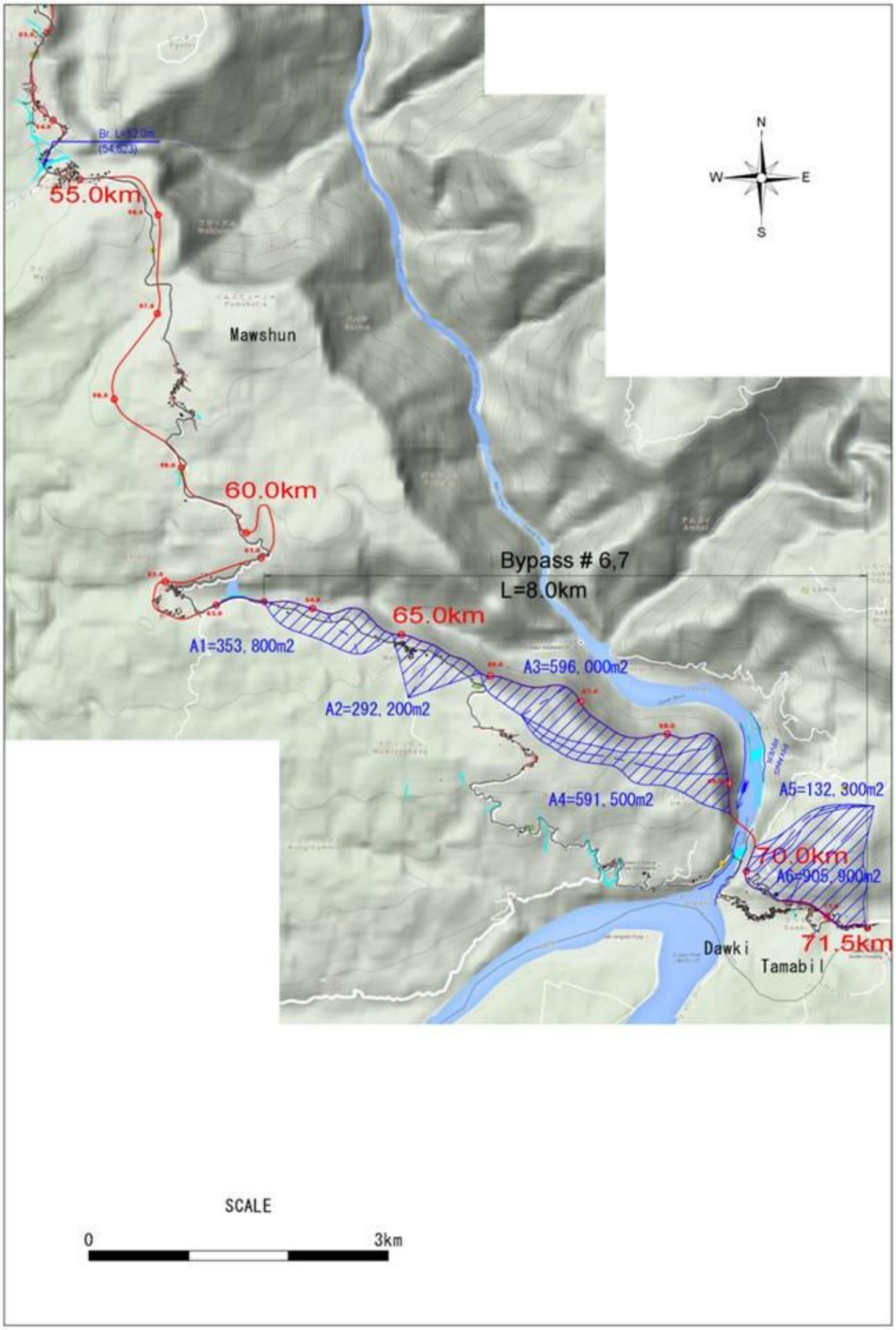
Source: JICA Study Team

Figure 5-75: Catchment Area (3)



Source: JICA Study Team

Figure 5-76: Catchment Area (4)



Source: JICA Study Team

Figure 5-77: Catchment Area (5)

The table below shows the calculation results of the outflow volume.

Table 5-38: Calculation Results of the Outflow Volume

NO.	Chainage (Project Alignment)	Catchment Area (m2)	Length of Tributary (m)	Difference of elevation (m)	tc (h)	T (h)	F50 (mm/h)	I50 (cm/h)	P	Q50 (m3/s)	Remark
Existing1											
ByPass1											
1	370	4,300	70	20.0	0.014	1.000	600	118.36	0.80	1.13	A=8,500m2
2	470	4,300	70	20.0	0.014	1.000	600	118.36	0.80	1.13	
3	750	7,400	70	10.0	0.018	1.000	600	117.87	0.80	1.94	
4	1,560	9,000	180	20.0	0.041	1.000	600	115.24	0.80	2.30	
5	1,670	9,000	180	20.0	0.041	1.000	600	115.24	0.80	2.30	A=27,100m2
6	1,700	9,000	180	20.0	0.041	1.000	600	115.24	0.80	2.30	
7	1,940	5,800	85	10.0	0.023	1.000	600	117.34	0.80	1.51	A=11,500m2
8	1,930	5,800	85	10.0	0.023	1.000	600	117.34	0.80	1.51	
										14.14	
Existing2											
9	3,870	6,650	170	40.0	0.030	1.000	600	116.55	0.80	1.72	A=13,300m2
10	3,880	6,650	170	40.0	0.030	1.000	600	116.55	0.80	1.72	
11	4,000	11,600	359	29.0	0.079	1.000	600	111.17	0.80	2.87	A=11,600m2
12	4,800	14,900	365	19.0	0.095	1.000	600	109.56	0.80	3.63	
13	5,660	6,700	171	15.0	0.043	1.000	600	115.00	0.80	1.71	A=6,700m2
14	6,450	12,600	232	20.0	0.055	1.000	600	113.71	0.80	3.18	A=25,300m2
15	6,680	12,600	232	20.0	0.055	1.000	600	113.71	0.80	3.18	
16	6,890	9,600	78	5.0	0.027	1.000	600	116.87	0.80	2.49	
17	7,180	9,600	78	5.0	0.027	1.000	600	116.87	0.80	2.49	A=28,800m2
17	7,280	9,600	78	5.0	0.027	1.000	600	116.87	0.80	2.49	
18	7,680	114,500	582	20.0	0.160	1.000	600	103.44	0.80	26.32	A=114,500m2
										51.82	
ByPass2											
BPII 1	7,700 - 9,060	60,900	78	5.0	0.027	1.000	600	116.87	0.80	15.82	A=60,900m2
BPII 2	9,060 - 9,800	30,600	55	5.0	0.018	1.000	600	117.89	0.80	8.02	A=30,600m2
BPII 3	9,800 - 10,000	29,900	110	20.0	0.023	1.000	600	117.26	0.80	7.79	A=29,900m2
										31.62	
Existing3											
19	10,620	4,300	121	8.0	0.037	1.000	600	115.70	0.80	1.11	
20	10,720	4,300	121	8.0	0.037	1.000	600	115.70	0.80	1.11	A=12,800m2
21	10,910	4,300	121	8.0	0.037	1.000	600	115.70	0.80	1.11	
22	11,120	4,800	141	5.0	0.053	1.000	600	113.95	0.80	1.22	
23	11,200	4,800	141	5.0	0.053	1.000	600	113.95	0.80	1.22	
24	11,340	4,800	141	5.0	0.053	1.000	600	113.95	0.80	1.22	
25	11,400	4,800	141	5.0	0.053	1.000	600	113.95	0.80	1.22	A=33,900m2
26	11,550	4,800	141	5.0	0.053	1.000	600	113.95	0.80	1.22	
27	11,630	4,800	141	5.0	0.053	1.000	600	113.95	0.80	1.22	
28	12,080	4,800	141	5.0	0.053	1.000	600	113.95	0.80	1.22	
29	12,220	7,900	151	5.0	0.057	1.000	600	113.48	0.80	1.99	A=7,900m2
										13.82	
ByPass3											
BPIII 1	12,300 - 12,450	35,000	481	61.0	0.084	1.000	600	110.74	0.80	8.61	A=35,000m2
BPIII 2	12,450 - 12,650	88,200	431	51.0	0.079	1.000	600	111.22	0.80	21.80	A=88,200m2
BPIII 3	13,000 - 13,750	81,600	80	10.0	0.021	1.000	600	117.52	0.80	21.31	A=81,600m2
BPIII 4	13,750 - 14,378	101,800	100	10.0	0.027	1.000	600	116.81	0.80	26.42	A=101,800m2
										78.15	

NO.	Chainage (Project Alignment)	Catchment Area (m2)	Length of Tributary (m)	Difference of elevation (m)	tc (h)	T (h)	F50 (mm/h)	I50 (cm/h)	P	Q50 (m3/s)	Remark
Existing4											
30	15,300	22,600	155	40.0	0.027	1.000	600	116.89	0.80	5.87	
31	15,360	22,600	155	40.0	0.027	1.000	600	116.89	0.80	5.87	
32	15,530	22,600	155	40.0	0.027	1.000	600	116.89	0.80	5.87	A=113,200m2
33	15,660	22,600	155	40.0	0.027	1.000	600	116.89	0.80	5.87	
34	15,990	22,600	155	40.0	0.027	1.000	600	116.89	0.80	5.87	
35	16,280	17,300	100	30.0	0.018	1.000	600	117.89	0.80	4.53	
36	16,360	17,300	100	30.0	0.018	1.000	600	117.89	0.80	4.53	
37	16,400	17,300	100	30.0	0.018	1.000	600	117.89	0.80	4.53	A=103,900m2
38	16,540	17,300	100	30.0	0.018	1.000	600	117.89	0.80	4.53	
39	16,730	17,300	100	30.0	0.018	1.000	600	117.89	0.80	4.53	
40	16,870	17,300	100	30.0	0.018	1.000	600	117.89	0.80	4.53	
41	17,110	25,200	402	35.0	0.084	1.000	600	110.68	0.80	6.20	
42	17,250	25,200	402	35.0	0.084	1.000	600	110.68	0.80	6.20	
43	17,340	25,200	402	35.0	0.084	1.000	600	110.68	0.80	6.20	
44	17,380	25,200	402	35.0	0.084	1.000	600	110.68	0.80	6.20	
45	17,420	25,200	402	35.0	0.084	1.000	600	110.68	0.80	6.20	
46	17,590	25,200	402	35.0	0.084	1.000	600	110.68	0.80	6.20	A=277,400m2
47	17,680	25,200	402	35.0	0.084	1.000	600	110.68	0.80	6.20	
48	17,870	25,200	402	35.0	0.084	1.000	600	110.68	0.80	6.20	
49	17,950	25,200	402	35.0	0.084	1.000	600	110.68	0.80	6.20	
50	18,020	25,200	402	35.0	0.084	1.000	600	110.68	0.80	6.20	
51	18,080	25,200	402	35.0	0.084	1.000	600	110.68	0.80	6.20	
52	18,440	25,400	320	100.0	0.043	1.000	600	115.03	0.80	6.49	
53	18,610	25,400	320	100.0	0.043	1.000	600	115.03	0.80	6.49	A=76,200m2
54	18,760	25,400	320	100.0	0.043	1.000	600	115.03	0.80	6.49	
55	18,880	12,700	210	116.0	0.025	1.000	600	117.07	0.80	3.30	
56	19,020	12,700	210	40.0	0.038	1.000	600	115.63	0.80	3.26	
57	19,210	12,700	210	40.0	0.038	1.000	600	115.63	0.80	3.26	
58	19,240	12,700	210	40.0	0.038	1.000	600	115.63	0.80	3.26	
59	19,460	12,700	210	40.0	0.038	1.000	600	115.63	0.80	3.26	A=139,400m2
60	19,520	12,700	210	40.0	0.038	1.000	600	115.63	0.80	3.26	
61	19,630	12,700	210	40.0	0.038	1.000	600	115.63	0.80	3.26	
62	19,730	12,700	210	40.0	0.038	1.000	600	115.63	0.80	3.26	
63	19,810	12,700	210	40.0	0.038	1.000	600	115.63	0.80	3.26	
64	19,990	12,700	210	40.0	0.038	1.000	600	115.63	0.80	3.26	
										176.88	
ByPass4											
BPIII 1	20,200	12,700	210	40.0	0.038	1.000	600	115.63	0.80	3.26	A=139,400m2
BPIII 2	20,200 - 21,000	113,800	1,800	20.0	0.590	1.000	600	75.48	0.80	19.09	A=113,800m2
BPIII 3	21,000 - 21,475	34,900	184	10.0	0.055	1.000	800	151.62	0.80	11.76	A=34,900m2
	21,700 - 21,900	10,500	184	10.0	0.055	1.000	800	151.62	0.80	3.54	A=10,500m2
BPIII 4	22,970	18,000	141	10.0	0.041	1.000	800	153.75	0.80	6.15	A=36,000m2
BPIII 5	23,200	18,000	141	10.0	0.041	1.000	800	153.75	0.80	6.15	
										49.95	

NO.	Chainage (Project Alignment)	Catchment Area (m2)	Length of Tributary (m)	Difference of elevation (m)	tc (h)	T (h)	F50 (mm/h)	I50 (cm/h)	P	Q50 (m3/s)	Remark
Existing5											
65	23,350	16,100	100	20.0	0.021	1.000	800	156.72	0.80	5.61	
66	23,450	16,100	100	20.0	0.021	1.000	800	156.72	0.80	5.61	
67	23,580	16,100	100	20.0	0.021	1.000	800	156.72	0.80	5.61	
68	24,200	16,100	100	20.0	0.021	1.000	800	156.72	0.80	5.61	
69	24,280	16,100	100	20.0	0.021	1.000	800	156.72	0.80	5.61	A=144,500m2
70	24,460	16,100	100	20.0	0.021	1.000	800	156.72	0.80	5.61	
71	24,620	16,100	100	20.0	0.021	1.000	800	156.72	0.80	5.61	
72	24,700	16,100	100	20.0	0.021	1.000	800	156.72	0.80	5.61	
73	24,900	16,100	100	20.0	0.021	1.000	800	156.72	0.80	5.61	
74	25,040	16,300	140	40.0	0.024	1.000	800	156.30	0.80	5.66	
75	25,240	16,300	140	40.0	0.024	1.000	800	156.30	0.80	5.66	A=49,000m2
76	25,380	16,300	140	40.0	0.024	1.000	800	156.30	0.80	5.66	
77	25,430	27,000	517	50.0	0.098	1.000	800	145.71	0.80	8.74	A=27000m2
78	25,640	16,300	100	50.0	0.015	1.000	800	157.68	0.80	5.71	
79	25,840	16,300	100	50.0	0.015	1.000	800	157.68	0.80	5.71	
80	26,060	16,300	100	50.0	0.015	1.000	800	157.68	0.80	5.71	
81	26,190	16,300	100	50.0	0.015	1.000	800	157.68	0.80	5.71	
82	26,390	16,300	100	50.0	0.015	1.000	800	157.68	0.80	5.71	A=146,500m2
83	26,440	16,300	100	50.0	0.015	1.000	800	157.68	0.80	5.71	
84	26,600	16,300	100	50.0	0.015	1.000	800	157.68	0.80	5.71	
85	26,760	16,300	100	50.0	0.015	1.000	800	157.68	0.80	5.71	
86	26,900	16,300	100	50.0	0.015	1.000	800	157.68	0.80	5.71	
87	27,050	10,600	100	60.0	0.014	1.000	800	157.84	0.80	3.72	
88	27,140	10,600	100	60.0	0.014	1.000	800	157.84	0.80	3.72	
89	27,200	10,600	100	60.0	0.014	1.000	800	157.84	0.80	3.72	
90	27,240	10,600	100	60.0	0.014	1.000	800	157.84	0.80	3.72	
91	27,280	10,600	100	60.0	0.014	1.000	800	157.84	0.80	3.72	A=105,900m2
92	27,350	10,600	100	60.0	0.014	1.000	800	157.84	0.80	3.72	
93	27,400	10,600	100	60.0	0.014	1.000	800	157.84	0.80	3.72	
94	27,480	10,600	100	60.0	0.014	1.000	800	157.84	0.80	3.72	
95	27,710	10,600	100	60.0	0.014	1.000	800	157.84	0.80	3.72	
96	27,980	10,600	100	60.0	0.014	1.000	800	157.84	0.80	3.72	
97	28,310	10,700	70	30.0	0.012	1.000	800	158.12	0.80	3.76	
98	28,440	10,700	70	30.0	0.012	1.000	800	158.12	0.80	3.76	
99	28,570	10,700	70	30.0	0.012	1.000	800	158.12	0.80	3.76	A=64,400m2
100	28,740	10,700	70	30.0	0.012	1.000	800	158.12	0.80	3.76	
101	28,880	10,700	70	30.0	0.012	1.000	800	158.12	0.80	3.76	
102	28,930	10,700	70	30.0	0.012	1.000	800	158.12	0.80	3.76	
103	29,140	5,800	70	30.0	0.012	1.000	800	158.12	0.80	2.04	
104	29,250	5,800	70	20.0	0.014	1.000	800	157.81	0.80	2.03	
105	29,320	5,800	70	20.0	0.014	1.000	800	157.81	0.80	2.03	A=34,800m2
106	29,480	5,800	70	20.0	0.014	1.000	800	157.81	0.80	2.03	
107	29,530	5,800	70	20.0	0.014	1.000	800	157.81	0.80	2.03	
108	29,670	5,800	70	20.0	0.014	1.000	800	157.81	0.80	2.03	
109	29,700	6,000	70	15.0	0.015	1.000	800	157.56	0.80	2.10	
110	29,810	6,000	70	15.0	0.015	1.000	800	157.56	0.80	2.10	
111	29,900	6,000	70	15.0	0.015	1.000	800	157.56	0.80	2.10	A=35,700m2
112	30,000	6,000	70	15.0	0.015	1.000	800	157.56	0.80	2.10	
113	30,060	6,000	70	15.0	0.015	1.000	800	157.56	0.80	2.10	
114	30,120	6,000	70	15.0	0.015	1.000	800	157.56	0.80	2.10	
115	30,200 - 30,900	58,000	149	30.0	0.028	1.000	1,000	194.48	0.80	25.07	A=58,000m2

N0.	Chainage (Project Alignment)	Catchment Area (m2)	Length of Tributary (m)	Difference of elevation (m)	tc (h)	T (h)	F50 (mm/h)	I50 (cm/h)	P	Q50 (m3/s)	Remark
116	30,920	6,200	92	20.0	0.019	1.000	1,000	196.27	0.80	2.70	
117	30,980	6,200	92	20.0	0.019	1.000	1,000	196.27	0.80	2.70	
118	31,090	6,200	92	20.0	0.019	1.000	1,000	196.27	0.80	2.70	
119	31,140	6,200	92	20.0	0.019	1.000	1,000	196.27	0.80	2.70	
120	31,210	6,200	92	20.0	0.019	1.000	1,000	196.27	0.80	2.70	
121	31,290	6,200	92	20.0	0.019	1.000	1,000	196.27	0.80	2.70	
122	31,340	6,200	92	20.0	0.019	1.000	1,000	196.27	0.80	2.70	
123	31,420	6,200	92	20.0	0.019	1.000	1,000	196.27	0.80	2.70	
124	31,600	6,200	92	20.0	0.019	1.000	1,000	196.27	0.80	2.70	A=111,800m2
125	31,640	6,200	92	20.0	0.019	1.000	1,000	196.27	0.80	2.70	
126	31,720	6,200	92	20.0	0.019	1.000	1,000	196.27	0.80	2.70	
127	31,780	6,200	92	20.0	0.019	1.000	1,000	196.27	0.80	2.70	
128	31,840	6,200	92	20.0	0.019	1.000	1,000	196.27	0.80	2.70	
129	31,900	6,200	92	20.0	0.019	1.000	1,000	196.27	0.80	2.70	
130	31,960	6,200	92	20.0	0.019	1.000	1,000	196.27	0.80	2.70	
131	32,020	6,200	92	20.0	0.019	1.000	1,000	196.27	0.80	2.70	
132	32,080	6,200	92	20.0	0.019	1.000	1,000	196.27	0.80	2.70	
133	32,230	6,200	92	20.0	0.019	1.000	1,000	196.27	0.80	2.70	
134	32,930	6,900	100	20.0	0.021	1.000	1,000	195.90	0.80	3.00	A=13,800m2
135	33,030	6,900	100	20.0	0.021	1.000	1,000	195.90	0.80	3.00	
136	33,760	4,000	75	20.0	0.015	1.000	1,000	197.04	0.80	1.75	
137	33,880	4,000	75	20.0	0.015	1.000	1,000	197.04	0.80	1.75	
138	33,920	4,000	75	20.0	0.015	1.000	1,000	197.04	0.80	1.75	
139	33,970	4,000	75	20.0	0.015	1.000	1,000	197.04	0.80	1.75	
140	34,070	4,000	75	20.0	0.015	1.000	1,000	197.04	0.80	1.75	
141	34,140	4,000	75	20.0	0.015	1.000	1,000	197.04	0.80	1.75	A=48,100m2
142	34,170	4,000	75	20.0	0.015	1.000	1,000	197.04	0.80	1.75	
143	34,220	4,000	75	20.0	0.015	1.000	1,000	197.04	0.80	1.75	
144	34,300	4,000	75	20.0	0.015	1.000	1,000	197.04	0.80	1.75	
145	34,430	4,000	75	20.0	0.015	1.000	1,000	197.04	0.80	1.75	
146	34,510	4,000	75	20.0	0.015	1.000	1,000	197.04	0.80	1.75	
147	34,520	4,000	75	20.0	0.015	1.000	1,000	197.04	0.80	1.75	
148	35,330	7,300	75	5.0	0.026	1.000	1,200	234.01	0.80	3.80	
149	35,430	7,300	75	5.0	0.026	1.000	1,200	234.01	0.80	3.80	
150	35,540	7,300	75	5.0	0.026	1.000	1,200	234.01	0.80	3.80	A=36,500m2
151	35,580	7,300	75	5.0	0.026	1.000	1,200	234.01	0.80	3.80	
152	36,180	7,300	75	5.0	0.026	1.000	1,200	234.01	0.80	3.80	
153	36,290	4,400	65	5.0	0.022	1.000	1,200	234.90	0.80	2.30	
154	36,390	4,400	65	5.0	0.022	1.000	1,200	234.90	0.80	2.30	
155	36,440	4,400	65	5.0	0.022	1.000	1,200	234.90	0.80	2.30	
156	36,460	4,400	65	5.0	0.022	1.000	1,200	234.90	0.80	2.30	
157	36,520	4,400	65	5.0	0.022	1.000	1,200	234.90	0.80	2.30	
158	36,610	4,400	65	5.0	0.022	1.000	1,200	234.90	0.80	2.30	A=47,900m2
159	36,660	4,400	65	5.0	0.022	1.000	1,200	234.90	0.80	2.30	
160	36,800	4,400	65	5.0	0.022	1.000	1,200	234.90	0.80	2.30	
161	36,840	4,400	65	5.0	0.022	1.000	1,200	234.90	0.80	2.30	
162	36,960	4,400	65	5.0	0.022	1.000	1,200	234.90	0.80	2.30	
163	37,000	4,400	65	5.0	0.022	1.000	1,200	234.90	0.80	2.30	
164	37,040	6,100	65	5.0	0.022	1.000	1,200	234.90	0.80	3.18	
165	37,080	6,100	65	5.0	0.022	1.000	1,200	234.90	0.80	3.18	
166	37,070	6,100	65	5.0	0.022	1.000	1,200	234.90	0.80	3.18	
167	37,250	6,100	65	5.0	0.022	1.000	1,200	234.90	0.80	3.18	
168	37,320	6,100	65	5.0	0.022	1.000	1,200	234.90	0.80	3.18	A=61,400m2
169	37,360	6,100	65	5.0	0.022	1.000	1,200	234.90	0.80	3.18	
170	37,400	6,100	65	5.0	0.022	1.000	1,200	234.90	0.80	3.18	
171	37,490	6,100	65	5.0	0.022	1.000	1,200	234.90	0.80	3.18	
172	37,640	6,100	65	5.0	0.022	1.000	1,200	234.90	0.80	3.18	
173	37,710	6,100	65	5.0	0.022	1.000	1,200	234.90	0.80	3.18	
										389.00	

NO.	Chainage (Project Alignment)	Catchment Area (m2)	Length of Tributary (m)	Difference of elevation (m)	tc (h)	T (h)	F50 (mm/h)	I50 (cm/h)	P	Q50 (m3/s)	Remark
ByPass5							1,200		0.80		
BPV 1	37,800 - 38,700	31,000	581	60.0	0.105	1.000	1,200	217.26	0.80	14.97	A=31,000m2
BPV 2	39,600 - 40,400	87,300	160	20.0	0.036	1.000	1,200	231.66	0.80	44.94	A=87,300m2
BPV 3	40,900 - 42,400	127,900	90	20.0	0.019	1.000	1,200	235.63	0.80	66.97	A=127,900m2
BPV 4	42,400 - 43,600	182,800	120	10.0	0.034	1.000	1,200	232.17	0.80	94.31	A=182,800m2
BPV 5	43,700 - 44,600	126,300	100	10.0	0.027	1.000	1,200	233.61	0.80	65.57	A=126,300m2
BPV 6	44,600 - 45,900	137,800	120	10.0	0.034	1.000	1,200	232.17	0.80	71.09	A=137,800m2
174	45,970	36,800	347	25.0	0.081	1.000	1,200	222.05	0.80	18.16	A=36,800m2
										376.01	
Existing6											
175	46,260	11,100	60	30.0	0.010	1.000	1,200	237.64	0.80	5.86	
176	46,320	11,100	60	30.0	0.010	1.000	1,200	237.64	0.80	5.86	
177	46,410	11,100	60	30.0	0.010	1.000	1,200	237.64	0.80	5.86	A=77,800m2
178	46,540	11,100	60	30.0	0.010	1.000	1,200	237.64	0.80	5.86	
179	46,710	11,100	60	30.0	0.010	1.000	1,200	237.64	0.80	5.86	
180	46,990	11,100	60	30.0	0.010	1.000	1,200	237.64	0.80	5.86	
181	47,100	11,800	230	40.0	0.042	1.000	1,200	230.34	0.80	6.04	
182	47,490	11,800	230	40.0	0.042	1.000	1,200	230.34	0.80	6.04	A=35,400m2
183	47,660	11,800	230	40.0	0.042	1.000	1,200	230.34	0.80	6.04	
184	47,750	7,800	347	40.0	0.067	1.000	1,200	224.83	0.80	3.90	
185	47,840	7,800	347	40.0	0.067	1.000	1,200	224.83	0.80	3.90	
186	47,940	7,800	347	40.0	0.067	1.000	1,200	224.83	0.80	3.90	
187	48,010	7,800	347	40.0	0.067	1.000	1,200	224.83	0.80	3.90	A=62,400m2
188	48,080	7,800	347	40.0	0.067	1.000	1,200	224.83	0.80	3.90	
189	48,200	7,800	347	40.0	0.067	1.000	1,200	224.83	0.80	3.90	
190	48,340	7,800	347	40.0	0.067	1.000	1,200	224.83	0.80	3.90	
191	48,400	7,800	347	40.0	0.067	1.000	1,200	224.83	0.80	3.90	
192	48,460	8,400	165	30.0	0.032	1.000	1,200	232.57	0.80	4.34	
193	48,540	8,400	165	30.0	0.032	1.000	1,200	232.57	0.80	4.34	A=33,600m2
194	48,650	8,400	165	30.0	0.032	1.000	1,200	232.57	0.80	4.34	
195	48,740	8,400	165	30.0	0.032	1.000	1,200	232.57	0.80	4.34	
196	48,880	9,900	313	60.0	0.051	1.000	1,200	228.31	0.80	5.02	
197	49,000	9,900	313	60.0	0.051	1.000	1,200	228.31	0.80	5.02	
198	49,070	9,900	313	60.0	0.051	1.000	1,200	228.31	0.80	5.02	A=49,100m2
199	49,240	9,900	313	60.0	0.051	1.000	1,200	228.31	0.80	5.02	
200	49,380	9,900	313	60.0	0.051	1.000	1,200	228.31	0.80	5.02	
201	49,800	12,200	67	20.0	0.013	1.000	1,200	236.88	0.80	6.42	
202	49,900	12,200	67	20.0	0.013	1.000	1,200	236.88	0.80	6.42	
203	50,220	12,200	67	20.0	0.013	1.000	1,200	236.88	0.80	6.42	A=72,700m2
204	50,370	12,200	67	20.0	0.013	1.000	1,200	236.88	0.80	6.42	
205	50,440	12,200	67	20.0	0.013	1.000	1,200	236.88	0.80	6.42	
206	50,500	12,200	67	20.0	0.013	1.000	1,200	236.88	0.80	6.42	

NO.	Chainage (Project Alignment)	Catchment Area (m2)	Length of Tributary (m)	Difference of elevation (m)	tc (h)	T (h)	F50 (mm/h)	I50 (cm/h)	P	Q50 (m3/s)	Remark
207	50,970	11,800	98	20.0	0.020	1.000	1,200	235.19	0.80	6.17	
208	51,060	11,800	98	20.0	0.020	1.000	1,200	235.19	0.80	6.17	A=35,400m2
209	51,210	11,800	98	20.0	0.020	1.000	1,200	235.19	0.80	6.17	
210	52,300	11,600	75	20.0	0.015	1.000	1,200	236.45	0.80	6.10	
211	52,390	11,600	75	20.0	0.015	1.000	1,200	236.45	0.80	6.10	
212	52,520	11,600	75	20.0	0.015	1.000	1,200	236.45	0.80	6.10	
213	52,690	11,600	75	20.0	0.015	1.000	1,200	236.45	0.80	6.10	A=92,800m2
214	53,440	11,600	75	20.0	0.015	1.000	1,200	236.45	0.80	6.10	
215	53,550	11,600	75	20.0	0.015	1.000	1,200	236.45	0.80	6.10	
216	53,620	11,600	75	20.0	0.015	1.000	1,200	236.45	0.80	6.10	
217	53,730	11,600	75	20.0	0.015	1.000	1,200	236.45	0.80	6.10	
218	54,330	3,000	41	10.0	0.010	1.000	1,200	237.68	0.80	1.58	A=5,900m2
219	54,650	3,000	41	10.0	0.010	1.000	1,200	237.68	0.80	1.58	
220	55,250	2,200	40	5.0	0.012	1.000	1,000	197.55	0.80	0.97	
221	55,410	2,200	40	5.0	0.012	1.000	1,000	197.55	0.80	0.97	
222	55,660	2,200	40	5.0	0.012	1.000	1,000	197.55	0.80	0.97	A=13,000m2
223	55,810	2,200	40	5.0	0.012	1.000	1,000	197.55	0.80	0.97	
224	55,850	2,200	40	5.0	0.012	1.000	1,000	197.55	0.80	0.97	
225	55,660	2,200	40	5.0	0.012	1.000	1,000	197.55	0.80	0.97	
226	55,810	14,500	20	5.0	0.006	1.000	1,000	198.89	0.80	6.41	
227	55,860	14,500	20	5.0	0.006	1.000	1,000	198.89	0.80	6.41	
228	56,160	14,500	20	5.0	0.006	1.000	1,000	198.89	0.80	6.41	
229	56,230	14,500	20	5.0	0.006	1.000	1,000	198.89	0.80	6.41	A=101,100m2
230	56,760	14,500	20	5.0	0.006	1.000	1,000	198.89	0.80	6.41	
231	56,940	14,500	20	5.0	0.006	1.000	1,000	198.89	0.80	6.41	
232	57,100	14,500	20	5.0	0.006	1.000	1,000	198.89	0.80	6.41	
233	58,970	5,800	155	10.0	0.045	1.000	1,000	191.32	0.80	2.47	A=5,800m2
234	59,200	5,900	20	5.0	0.006	1.000	1,000	198.89	0.80	2.61	
235	59,500	5,900	20	5.0	0.006	1.000	1,000	198.89	0.80	2.61	A=23,300m2
236	60,080	5,900	20	5.0	0.006	1.000	1,000	198.89	0.80	2.61	
237	60,150	5,900	20	5.0	0.006	1.000	1,000	198.89	0.80	2.61	
238	61,220	7,000	20	10.0	0.004	1.000	1,000	199.15	0.80	3.10	
239	61,440	7,000	20	10.0	0.004	1.000	1,000	199.15	0.80	3.10	
240	61,720	7,000	20	10.0	0.004	1.000	1,000	199.15	0.80	3.10	A=41,700m2
241	61,850	7,000	20	10.0	0.004	1.000	1,000	199.15	0.80	3.10	
242	61,960	7,000	20	10.0	0.004	1.000	1,000	199.15	0.80	3.10	
243	62,110	7,000	20	10.0	0.004	1.000	1,000	199.15	0.80	3.10	
244	63,090	1,800	20	10.0	0.004	1.000	1,000	199.15	0.80	0.80	
245	63,290	1,800	20	10.0	0.004	1.000	1,000	199.15	0.80	0.80	A=5,400m2
246	63,390	1,800	20	10.0	0.004	1.000	1,000	199.15	0.80	0.80	
247	63,490	8,300	20	5.0	0.006	1.000	1,000	198.89	0.80	3.67	A=16,600m2
248	63,890	8,300	20	5.0	0.006	1.000	1,000	198.89	0.80	3.67	
										327.78	

NO.	Chainage (Project Alignment)	Catchment Area (m2)	Length of Tributary (m)	Difference of elevation (m)	tc (h)	T (h)	F50 (mm/h)	I50 (cm/h)	P	Q50 (m3/s)	Remark
ByPass6											
A1	63,500	353,800	530	20.0	0.144	1.000	600	104.93	0.80	82.49	
A2	65,000	292,200	580	60.0	0.104	1.000	600	108.65	0.80	70.55	
A3	66,000	596,000	530	130.0	0.070	1.000	600	112.16	0.80	148.55	
A4	68,400	591,500	2,200	250.0	0.281	1.000	600	93.66	0.80	123.11	
A5	69,300	132,300	1,410	150.0	0.205	1.000	600	99.60	0.80	29.28	
A6	70,000	905,900	1,300	190.0	0.170	1.000	600	102.55	0.80	206.43	
										660.43	

Source: JICA Study Team

The table below shows the examination results of the drainage capacity of the planned cross drainages.

Table 5-39: Examination of Drainage Capacity of the Planned Cross Drainages (1)

Classification	Cul. No.	Chaiange	Chaiange Interval	Type	Span	Rate of Flow (%)	Hydraulic Radius(m)	Roughness	Bed Slope	Q	Velocity
Existing1		0+000									
	0+300										
ByPass1 L=3,500m	1	0+064	316	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	2	0+380	220	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	3	0+600	360	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	4	0+960	190	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	5	1+150	280	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	6	1+430	224	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	7	1+654	406	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	8	2+060	255	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	9	2+315	235	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	10	2+550	260	BOX	1x3x3	100%	0.923	0.013	0.1	20.755	2.306
	11	2+810	290	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	12	3+100	330	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	13	3+430	450	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	3+800									81.384	Judgement
									Q=	14.140	Ok
Existing2 L=3,800m	14	3+880	705	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	15	4+585	515	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	16	5+100	190	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	17	5+290	260	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	18	5+550	685	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	19	6+235	220	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	20	6+455	205	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	21	6+660	220	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	22	6+880	380	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	23	7+260	1245	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	7+600									48.717	Judgement
									Q=	51.820	Out
ByPass2 L=3,000m	24	8+505	275	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	25	8+780	580	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	26	9+360	1360	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	10+600									14.615	Judgement
									Q=	31.620	Out
Existing3 L=1,600m	27	10+720	185	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	28	10+905	275	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	29	11+180	151	BOX	1x3x3	100%	0.923	0.013	0.1	20.755	2.306
	30	11+331	209	BOX	1x3x3	100%	0.923	0.013	0.1	20.755	2.306
	31	11+540	80	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	32	11+620	455	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	33	12+075	135	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	12+200									70.205	Judgement
									Q=	13.820	Ok
ByPass3 L=2,200m	34	12+210	310	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	35	12+520	830	BOX	1x3x3	100%	0.923	0.013	0.1	20.755	2.306
	36	13+350	171	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	37	13+521	105	BOX	1x6x6	100%	1.714	0.013	0.1	104.528	3.484
	38	13+626	246	BOX	1x6x6	100%	1.714	0.013	0.1	104.528	3.484
	39	13+872	188	BOX	1x3x3	100%	0.923	0.013	0.1	20.755	2.306
	40	14+060	125	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	41	14+185	435	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	14+400									270.768	Judgement
									Q=	78.150	Ok
Existing4 L=5,600m	42	14+620	355	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	43	14+975	325	BOX	1x5x4	100%	1.404	0.013	0.1	60.986	3.049
	44	15+300	210	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	45	15+510	145	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	46	15+655	315	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	47	15+970	240	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	48	16+210	177	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	49	16+387	143	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	50	16+530	265	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	51	16+795	275	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	52	17+070	165	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	53	17+235	170	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	54	17+405	255	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	55	17+660	190	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	56	17+850	1100	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	57	18+950	280	BOX	1x6x6	100%	1.846	0.013	0.1	131.787	3.661
	58	19+230	250	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760

Classification	Cul. No.	Chaiange	Chaiange Interval	Type	Span	Rate of Flow (%)	Hydraulic Radius(m)	Roughness	Bed Slope	Q	velocity
Existing4	59	19+480	550	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	20+000									269.267	Judgement
									Q=	176.880	Ok
ByPass4 L=3,200m	60	20+030	250	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	61	20+280	220	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	62	20+500	225	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	63	20+725	155	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	64	20+880	160	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	65	21+040	160	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	66	21+200	390	BOX	1x4x4	100%	1.231	0.013	0.1	44.699	2.794
	67	21+590	400	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	68	21+990	120	BOX	1x3x3	100%	0.923	0.013	0.1	20.755	2.306
	69	22+110	150	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	70	22+260	260	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	71	22+520	215	BOX	1x5x5	100%	1.538	0.013	0.1	81.044	3.242
	72	22+735	495	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	23+200									172.032	Judgement
									Q=	49.950	Ok
Existing5 L=14,600m	73	23+230	250	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	74	23+480	150	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	75	23+630	220	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	76	23+850	200	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	77	24+050	185	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	78	24+235	220	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	79	24+455	205	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	80	24+660	230	SLAB	1x3.0	100%	0.923	0.013	0.1	20.755	2.306
	81	24+890	120	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	82	25+010	188	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	83	25+198	212	SLAB	1x6.0	100%	1.846	0.013	0.1	131.787	3.661
	84	25+410	190	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	85	25+600	220	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	86	25+820	130	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	87	25+950	150	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	88	26+100	245	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	89	26+345	155	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	90	26+500	170	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	91	26+670	130	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	92	26+800	90	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	93	26+890	135	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	94	27+025	125	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	95	27+150	170	SLAB	1x4.0	100%	1.231	0.013	0.1	44.699	2.794
	96	27+320	150	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	97	27+470	150	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	98	27+620	240	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	99	27+860	190	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	100	28+050	265	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	101	28+315	170	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	102	28+485	195	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	103	28+680	180	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	104	28+860	150	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	105	29+010	260	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	106	29+270	320	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	107	29+590	160	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	108	29+750	130	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	109	29+880	100	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	110	29+980	220	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	111	30+200	130	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	112	30+330	130	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	113	30+460	390	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	114	30+850	130	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	115	30+980	200	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	116	31+180	225	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624

Classification	Cul. No.	Chaiange	Chaiange Interval	Type	Span	Rate of Flow (%)	Hydraulic Radius(m)	Roughness	Bed Slope	Q	velocity
Existing5 L=14,600m	117	31+405	185	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	118	31+590	450	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	119	32+040	650	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	120	32+690	775	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	121	33+465	215	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	122	33+680	170	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	123	33+850	115	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	124	33+965	225	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	125	34+190	140	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	126	34+330	510	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	127	34+840	245	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	128	35+085	110	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	129	35+195	355	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	130	35+550	160	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	131	35+710	360	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	132	36+070	125	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	133	36+195	225	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	134	36+420	180	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	135	36+600	170	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	136	36+770	150	SLAB	1x4.0	100%	1.231	0.013	0.1	44.699	2.794
	137	36+920	155	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	138	37+075	170	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	139	37+245	155	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	140	37+400	170	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	141	37+570	268	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	37+800								Q=	457.199 389.000	Judgement Ok
ByPass5 L=8,300m	142	37+838	177	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	143	38+015	88	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	144	38+103	108	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	145	38+211	129	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	146	38+340	370	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	147	38+710	160	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	148	38+870	500	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	149	39+370	180	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	150	39+550	315	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	151	39+865	210	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	152	40+075	300	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	153	40+375	290	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	154	40+665	185	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	155	40+850	130	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	156	40+980	150	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	157	41+130	150	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	158	41+280	205	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	159	41+485	185	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	160	41+670	130	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	161	41+800	210	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	162	42+010	185	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	163	42+195	185	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	164	42+380	260	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	165	42+640	100	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	166	42+740	170	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	167	42+910	140	SLAB	1x6.0	100%	1.846	0.013	0.1	131.787	3.661
	168	43+050	125	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	169	43+175	365	SLAB	1x6.0	100%	1.846	0.013	0.1	131.787	3.661
	170	43+540	170	BOX	1x3x3	100%	0.923	0.013	0.1	20.755	2.306
	171	43+710	140	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	172	43+850	180	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	173	44+030	265	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	174	44+295	161	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624

Classification	Cul. No.	Chaiange	Chaiange Interval	Type	Span	Rate of Flow (%)	Hydraulic Radius(m)	Roughness	Bed Slope	Q	velocity
ByPass5 L=8,300m	175	44+456	109	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	176	44+565	195	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	177	44+760	150	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	178	44+910	190	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	179	45+100	170	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	180	45+270	220	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	181	45+490	155	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	182	45+645	55	SLAB	1x4.0	100%	1.231	0.013	0.1	44.699	2.794
	183	45+700	220	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	184	45+920	150	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	185	46+070	180	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	46+100									447.105	Judgement
									Q=	376.010	Ok
Existing6 L=18,400m	186	46+250	190	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	187	46+440	320	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	188	46+760	220	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	189	46+980	180	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	190	47+160	160	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	191	47+320	180	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	192	47+500	100	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	193	47+600	140	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	194	47+740	120	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	195	47+860	140	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	196	48+000	60	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	197	48+060	45	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	198	48+105	180	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	199	48+285	200	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	200	48+485	150	BOX	1x3x3	100%	0.923	0.013	0.1	20.755	2.306
	201	48+635	235	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	202	48+870	260	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	203	49+130	285	BOX	1x4x4	100%	1.231	0.013	0.1	44.699	2.794
	204	49+415	110	BOX	1x4x4	100%	1.231	0.013	0.1	44.699	2.794
	205	49+525	317	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	206	49+842	153	BOX	1x4x4	100%	1.231	0.013	0.1	44.699	2.794
	207	49+995	135	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	208	50+130	470	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	209	50+600	235	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	210	50+835	555	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	211	51+390	260	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	212	51+650	250	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	213	51+900	250	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	214	52+150	90	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	215	52+240	460	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	216	52+700	360	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	217	53+060	110	BOX	1x3x3	100%	0.923	0.013	0.1	20.755	2.306
	218	53+170	70	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	219	53+240	110	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	220	53+350	600	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	221	53+950	315	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	222	54+265	605	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	223	54+870	155	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	224	55+025	245	BOX	1x3x3	100%	0.923	0.013	0.1	20.755	2.306
	225	55+270	140	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	226	55+410	70	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	227	55+480	310	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	228	55+790	110	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	229	55+990	210	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	230	56+110	200	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	231	56+310	70	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	232	56+380	210	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624

Classification	Cul. No.	Chaiange	Chaiange Interval	Type	Span	Rate of Flow (%)	Hydraulic Radius(m)	Roughness	Bed Slope	Q	velocity
Existing6 L=18,400m	233	56+590	75	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	234	56+665	190	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	235	56+855	95	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	236	56+950	200	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	237	57+150	125	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	238	57+275	105	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	239	57+380	150	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	240	57+530	150	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	241	57+680	120	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	242	57+800	130	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	243	57+930	250	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	244	58+180	210	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	245	58+390	150	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	246	58+540	180	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	247	58+720	120	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	248	58+840	410	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	249	59+250	395	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	250	59+645	195	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	251	59+840	250	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	252	60+090	365	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	253	60+455	145	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	254	60+600	395	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	255	60+995	115	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	256	61+110	108	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	257	61+218	111	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	258	61+329	146	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	259	61+475	90	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	260	61+565	145	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	261	61+710	170	SLAB	1x6.0	100%	1.846	0.013	0.1	131.787	3.661
	262	61+880	215	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	263	62+095	205	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	264	62+300	130	BOX	1x2x1.5	100%	0.545	0.013	0.1	4.872	1.624
	265	62+430	200	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	266	62+630	130	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	267	62+760	105	BOX	1x2x2	100%	0.615	0.013	0.1	7.040	1.760
	268	62+865	190	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	269	63+055	195	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	270	63+250	410	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	271	63+660	#REF!	PIPE	1x1.2	100%	0.306	0.013	0.1	1.250	1.106
	64+500									633.266	Judgement
									Q=	376.010	Ok

Source: JICA Study Team

The examination of the drainage capacity of the planned cross drainages found that the outflow volume exceeds the permissible water flow volume of the conduits at the section (Existing 2) where the existing route is expanded and the section with bypass #2. This suggests that the planned cross drainage must be reviewed. It is also desirable to re-examine other sections with topographic maps with higher accuracy.

(5) Drainage Plan

a) Securing of Gradient for Drainage

To increase the drainage volume, the cross-sectional area needs to be increased. Sloping the conduits is another way to do so. This section will outline the relation between the gradient of a conduit and drainage volume, and the gradient appropriate for the improvement plan will be examined.

If a conduit has only a gentle gradient, earth, sand, and rubbish will accumulate in the conduit, lowering the drainage volume. However, the construction of a steep conduit is complicated; therefore it is important to set an appropriate gradient to ensure the necessary drainage volume is attained and to maintain the conduit.
Table below shows the relations between the drainage gradient and volume.

Table 5-40: Relations between Drainage Gradient and Drainage Volume

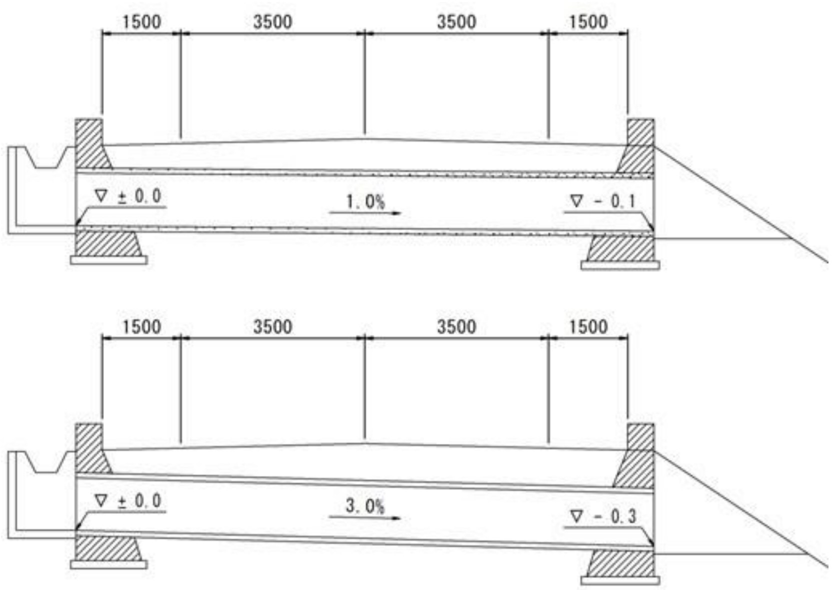
Diameter (mm)	900		1000		1200	
Section (m²)	0.636		0.785		1.131	
Wetted Perimeter (m)	2.768		3.076		3.691	
Hydraulic Radius (m)	0.230		0.255		0.306	
Rouphness	0.013		0.013		0.013	
Bed Slope (%)	Q (m3/s)	Velocity (m/s)	Q (m3/s)	Velocity (m/s)	Q (m3/s)	Velocity (m/s)
0.500	1.298	2.041	1.719	2.189	2.796	2.472
1.000	1.836	2.886	2.431	3.096	3.954	3.496
1.500	2.248	3.534	2.978	3.792	4.842	4.282
2.000	2.596	4.081	3.438	4.378	5.591	4.944
2.500	2.903	4.563	3.844	4.895	6.251	5.528
3.000	3.180	4.998	4.211	5.362	6.848	6.055
3.500	3.434	5.399	4.549	5.792	7.396	6.540
4.000	3.672	5.772	4.863	6.192	7.907	6.992
4.500	3.894	6.122	5.158	6.567	8.387	7.416
5.000	4.105	6.453	5.437	6.922	8.840	7.817

Source: JICA Study Team

The table indicates that the drainage volume increases roughly by 10% as the gradient increased by 0.5%. The survey team proposes as shown below that the difference in elevation at the inflow and outflow sides should be set at 10-30cm and the gradient at a pitch of 10cm.

- The plan and construction work will be made easier by limiting the bed height of the water course at the inflow and outflow sides.
- Construction work will be made less complicated by setting the height difference at around 10 cm.
- i = 3% or less (the height difference is 30 cm) in consideration of the construction process.

The figure below shows the gradient of the conduits when the difference in elevation is set at 10 cm and 30cm, respectively. However, if the drainage gradient is determined in accordance with the ground height at the inflow and outflow sides, it should conform to the ground height.



Source: JICA Study Team

Figure 5-78: Sloping of the Transversal Conduit

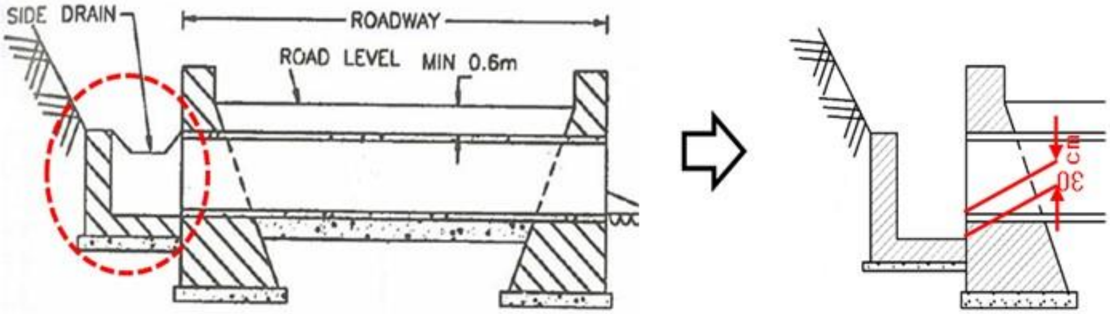
b) Mud collection by drainage basin

Currently, earth and sand has accumulated in some parts of the cross drainage, undermining the drainage function of the conduits. To solve this problem, drainage basins should be installed along the cross drainage in a manner that the bottom of these basins will be placed lower than the conduits by around 30 cm.

Source: JICA Study Team

Figure 5-79: Accumulated Earth in Drainage

Drainage basins placed along the cross drainage will maintain the drainage function of the conduits as earth and sand settle in the basins. As earth and sand in the basins need to be removed regularly, stairs will be installed so that maintenance workers can descend from the roadway to the basins. Such drainage facilities with stairs take into consideration the operation and maintenance procedures.



Source: JICA Study Team

Figure 5-80: Mud Collection Function of Drainage Basin

c) Side ditch

Water on the road surface will be drained via side ditches to the cross drainage. Currently, the conduits are placed at intervals of 200 - 340 m, so the cross section of side ditches needs to be large enough to handle water on the road, which is 12 m in width and 340 m in length.

Catchment area: A = 12 m × 340 m
= 4,080 m^2

The table below shows the drainage volume for various rainfall amounts. The drainage volume will be 2.21 m^3/s at a maximum.

Table 5-41: Drainage Volume on the Road Surface

Type	Length (m)	Width (m)	Catchment Area (m2)	Length of Tributary (m)	F50 (mm/h)	P	Q50 (m3/s)	Remark
1	340	12.0	4,080	150	600	0.90	1.11	
2	340	12.0	4,080	150	800	0.90	1.48	
3	340	12.0	4,080	150	1,000	0.90	1.84	
4	340	12.0	4,080	150	1,200	0.90	2.21	

Source: JICA Study Team

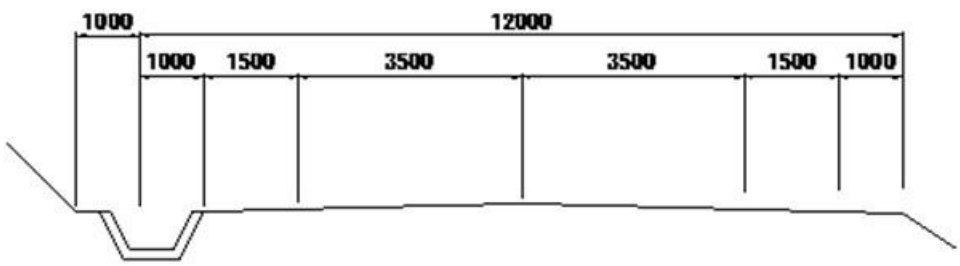
The table below shows the drainage capacity when side ditches take the form of an inverted trapezoid. Because the road gradient takes i = 1.0% or greater in most of the chainages, if the drainage gradient has i = 1.0% or greater with 700 mm×70 mm, the drainage volume of 2.31 m^3/s can be secured.

Table 5-42: Possible Water Flow Volume of Inverted Trapezoid Side Ditch

Trapezoid Setion

Base Width(mm)	500			700			900		
High(mm)	500			700			900		
1 : m	0.5			0.5			0.5		
Area(m^2)	0.375			0.735			1.215		
Wetted Perimeter (m)	1.618			2.265			2.912		
Hydraulic Radius (m)	0.232			0.324			0.417		
coefficient of roughness	0.015			0.015			0.015		
	I	Q	V	I	Q	V	I	Q	V
Drainage Gradiant	0.500	0.667	1.779	0.500	1.636	2.226	0.500	3.198	2.632
	1.000	0.943	2.515	1.000	2.314	3.148	1.000	4.522	3.722
	1.500	1.155	3.081	1.500	2.834	3.855	1.500	5.539	4.559
	2.000	1.334	3.557	2.000	3.272	4.452	2.000	6.396	5.264
	2.500	1.491	3.977	2.500	3.658	4.977	2.500	7.150	5.885
	3.000	1.634	4.357	3.000	4.007	5.452	3.000	7.833	6.447
	3.500	1.765	4.706	3.500	4.329	5.889	3.500	8.461	6.963
	4.000	1.887	5.031	4.000	4.627	6.296	4.000	9.045	7.444
	4.500	2.001	5.336	4.500	4.908	6.678	4.500	9.593	7.896
	5.000	2.109	5.625	5.000	5.174	7.039	5.000	10.112	8.323

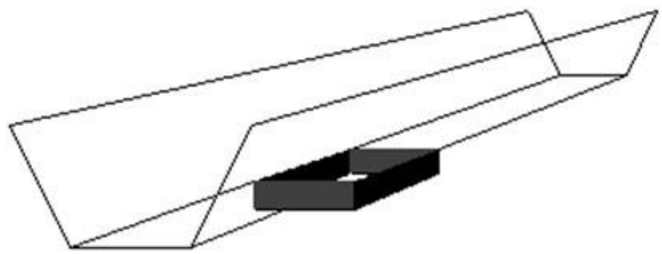
Source: JICA Study Team



Source: JICA Study Team

Figure 5-81: Cross Section of Side Ditch

As it is not just earth and sand but also fallen leaves and other rubbish that accumulate in the side ditches, drainage basins should be installed at an interval of about 100 m to collect this rubbish.



Source: JICA Study Team

Figure 5-82: Image of Drainage Basin in Side Ditch

5.2.8 Traffic Safety Facilities Plan

The GOI formulated the National Road Safety Policy 2015 and has been grappling with traffic accident reduction, and has made road safety as the highest priority of the nation. However, the death toll is still increasing year by year due to the rapid increase of the number of vehicles.

Breaking down road traffic deaths in India, it is important to note that 28.2% took place on NH, though the length of NH only accounts for 1.91% of the total road network, and 53.7% took place on rural highways. There is no need to stress the importance of road safety considerations for the design of the project road.

The JICA Study Team will conduct a road safety audit to ensure a safe road design referring to the Indian manual[18] and propose the most optimum measures which also incorporate Japanese road safety technologies.

Mountain roads meander through woods with poor visibility and increase the risk of head-on collisions with oncoming vehicles or falling off a cliff. The following sections explain some examples of road safety apparatus arrangements. One of the issues of road safety apparatus in India is vandalism. Vandalism countermeasures must be incorporated especially for mountain roads with sparse traffic. Generally, the combination of low-priced reflective chevrons, delineators, and road studs is effective, while expensive apparatus like self-luminous types are prone to theft. The JICA Study Team will propose a road safety design after coordination with relevant organizations.

[18] IRC:SP:88-2010 Manual on Road Safety Audit

(1) Basic principles

Road traffic safety measures refer to methods and measures for keeping people safe and preventing deaths and serious injuries, and also protecting properties using the road network from damage. The users of a road include drivers and passengers, cyclists, pedestrians and bus passengers. The objective of road safety strategies focuses on the prevention of serious injuries and deaths in spite of human errors, and safe road design provides a road environment that ensures vehicle speeds will be within reasonable limits which mitigate risks of such injuries and deaths. One of the ways to make a road safe would be to design the road geometry with consideration for all road users. Another way is to provide safety facilities along the roadway wherever conflict points exist.

Traffic control devices, road safety devices, and roadside furniture which can be used to increase safety on a road are things such as traffic signs, road markings, object markers, hazard markers, road studs, delineators, safety barriers, pedestrian guardrails, boundary stones, km stones, etc. Guidelines given in IRC include IRC:25, IRC:26, IRC:35, IRC:67, IRC:79, IRC:103, etc.[19]

Table 5-43: IRC Guidelines for Design of Traffic Safety Facilities

IRC Code	Title
IRC:25-1967	Type Designs for Boundary Stones
IRC:26-1967	Type Design for 200-Meter Stones
IRC:35-1997	Code of Practice for Road Markings
IRC:67-2012	Code of Practice for Road Signs
IRC:79-1981	Recommended Practice for Road Delineators
IRC:103-1988	Guidelines for Pedestrian Facilities

Source: JICA Study Team

(2) Traffic Signs

Traffic signs are often seen along the roadway to promote the safety and smooth flow of traffic. Every road user should know the signs on the road and their meanings. They give advance information about road conditions ahead, and also give orders, warning or guidance to drivers or riders. Drivers must look out for them when on the road, as an advance warning sign of a sharp curve ahead together with a speed limit or no overtaking sign would keep drivers and other road users safe.

Road signs in the Republic of India are similar to those used in some parts of the United Kingdom, except that they are bilingual. Most urban roads and SH have signs in the state language and English. NH has signs in the state language, Hindi and English as of 2012.

There are several kinds of road signs along the NH40 from Shillong to Dawki, however, most are poorly maintained. Some of the signs are shown in the photos below.

[19] Source: IRC:SP:73-2015: Manual of Specifications & Standards for Two Laning of Highways with Paved Shoulder

No overtaking	Speed limit	Right turn ahead
		
Pedestrian crossing	**Various signs in Village**	**Information sign**
		

Source: JICA Study Team

Figure 5-83: Existing Traffic Signs along NH40

Road signs are classified into three categories: regulatory signs, warning signs and information signs.

Regulatory signs are used to inform road users of certain rules and regulations to improve safety and smooth flow of traffic. These include signs such as speed limits, no turns, stop or no parking, which give notice of specific obligations, restrictions, and prohibitions for drivers to comply with.

Warning signs are used to caution the road users of the certain hazardous conditions on or alongside of the road so that road users become cautious and take proper actions for maintaining safety in advance. These signs include steep grades, sharp curves, falling rocks, narrow bridges, etc.

Information signs are used to provide information and to guide road users along the route. The information could be names of places, directions to destinations, route distance to places so that drivers can easily drive and safely travel with comfort. The following figures indicate regulatory, warning and informative signs.

Regulatory Signs

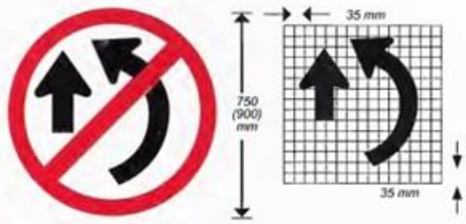


Fig. 14.23 Overtaking Prohibited

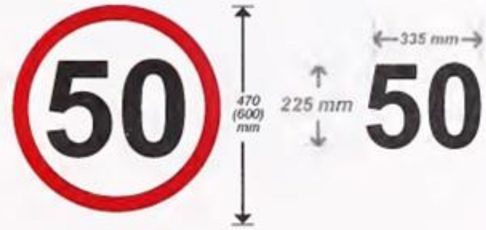


Fig. 14.37 Maximum Speed Limit

(Cautionary) Warning Signs

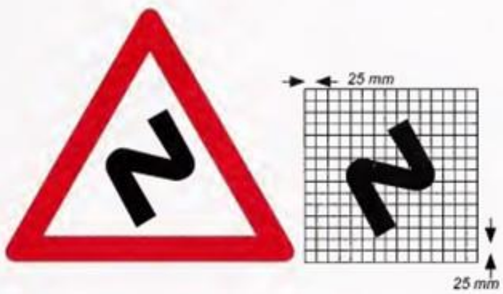


Fig. 15.07 Series of Bends

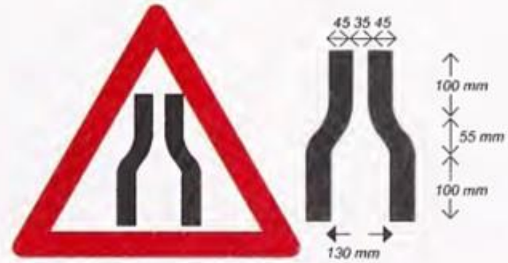


Fig. 15.23 Narrow Road Ahead

Information Signs

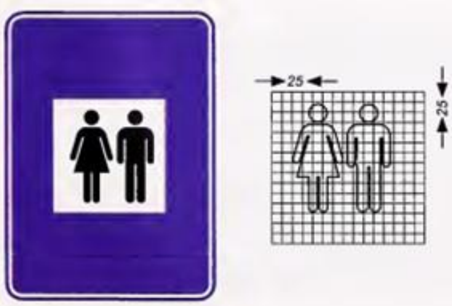


Fig. 17.05 Toilet

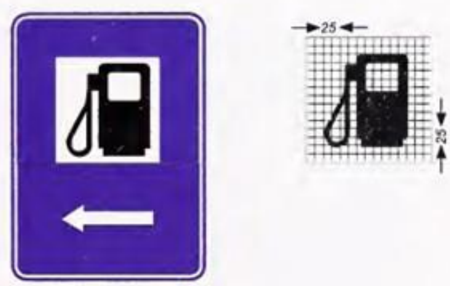


Fig. 17.06 Filling Station(Fuel Pump)

Source: JICA Study Team based on IRC67-2012 Code of Practice for Road Signs

Figure 5-84: Examples of Different Types of Traffic Signs

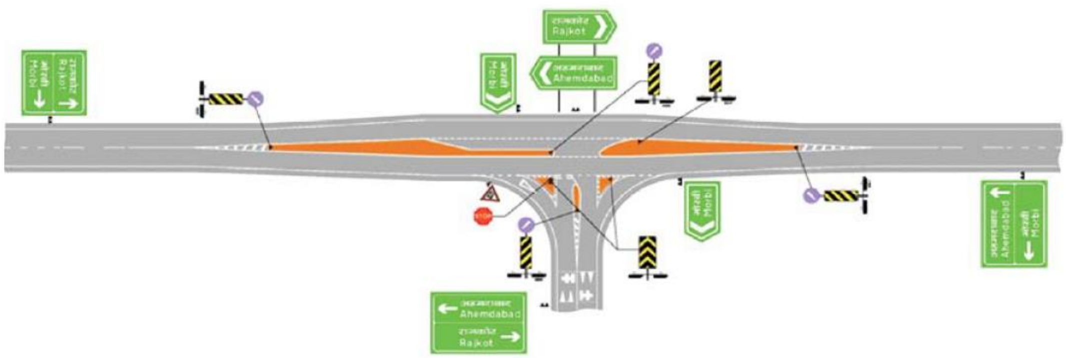


Fig. 9.2 Directional Information Sign for a Junction

Source: IRC:SP:73-2015

Figure 5-85: Arrangement of Directional Information Signs for a Junction

The actual application of various signs along NH40 depends on the roadway conditions such as design speed, horizontal and vertical alignment, roadway structures and other factors that determine the types and numbers of signs. Among them, the number of information signs at the intersection (or diversions of the road) according to the present design is summarized in the following table.

Table 5-44: Major Intersections and Diversions

Location	Intersection	Diversion & connection	Remarks
0+580		T-shape	Minor connections to local roads
0+740		T-shape	Minor connections to local roads
1+240		T-shape	Minor connections to local roads
2+000	T-shape		Channelized T-shape intersection
3+500		T-shape	Connection to a local road
5+250	4-leg intersection		To Shillong Peak
6+860		Y-shape	Entrance to a facility
7+380	T-intersection		Connction to a local road
7+700	4-leg intersection		To bypass #2 (minor to Elephant falls)
9+100		T-shape	Next to a grade separated structure
10+470		Y-shape	Bypass #2 merge
11+000		Y-shape	Divert to a village road
11+150		Y-shape	Divert to a village road
11+800		T-shape	Connection to a village road (two connections)
12+290		Y-shape	NH40 and New Road, Bypass #3
13+340		T-shape	Connection to a village road
14+300		Y-shape	NH40 and New Road, Bypass #3
18+520	T-intersection		Connection to NH40
19+850	T-intersection		Connection to NH40
22+640		T-shape	Connection to NH40
37+670		Y-shape	Connection to Bypass #5 (connection to NH40)
43+350	4-leg intersection		Connection to a rural road to Shillong

45+780		T-shape	Connection to NH40
54+680		T-shape	Connection to a local road
56+720	4-leg intersection		Connection to NH40
58+710		T-shape	Connection to NH40
62+290	4-leg intersection		Connection to a local road
62+850		T-shape	Connection to a local road
64+510		T-shape	Connection to NH40
73+700	T-intersection		Channelized T-shape intersection to NH40(E)
75+120	T-intersection		Channelized T-shape intersection to NH40
Total number	11 (6 T-shape)	20	Five 4-leg intersections, 19 T-shape intersections, and 7 Y-shape intersections

Source: JICA Study Team

Each four-leg intersection needs four information sign boards and four direction sign boards whereas T-shape intersections and Y-shape intersections or diversions need three information sign boards and four direction sign boards at each location. The total number of information sign boards is ninety-eight (5x4 + 26x3 = 98) and 124 (31x4) direction sign boards along NH40.

(3) Road Markings

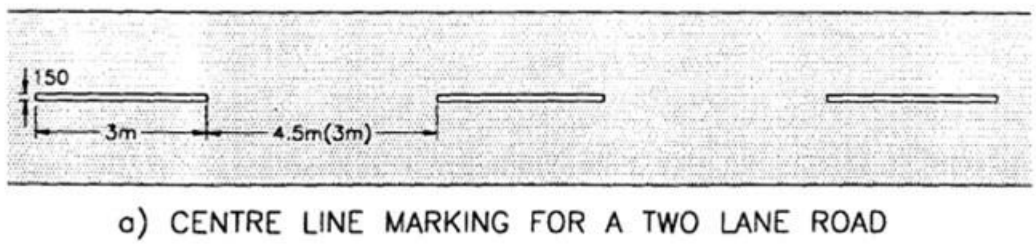
Road markings are used as a means of controlling and guiding traffic. They are highly important on rural roads and intersections as they promote road safety and facilitate smooth and harmonious flow of traffic along guided paths of travel. They also supplement the messages conveyed by road signals and signs. In some cases, they are used alone to convey certain regulations, information or warnings that cannot otherwise be effectively made known to the road users. Road surface markings are the devices on a paved road surface used to convey official information, provide guidance and information to drivers and pedestrians. Uniformity of the markings is an important factor in minimizing confusion and uncertainty about their meaning.

The main functions of road markings are to guide the safe and smooth flow of traffic such as a) segregation of traffic, b) stop and go, c) give way instruction, d) overtaking or not, e) inter-vehicle distance, f) parking zone or no parking, g) speed indication, h) direction, i) pedestrian crossing, and j) type of vehicles allowed.

Road markings play a useful and important role in traffic management, and they should convey the required information to the driver without distracting his attention from the carriageway. The marking should be visible day and night, using clear and vivid colors with retro-reflective materials such as glass beads. Usually the color white, either solid or dotted, is used for carriageway, edge and center-lines, directions, and messages. Yellow is used for regulations or warnings to the driver. Some of the usage of the markings for the rural roads is as follows:

a) Center line

The center line separates the opposing streams of traffic and facilitates their movements. Usually no center line is provided for roads with a width of less than 5 m and for roads having more than four lanes with the central verge. The center line may be marked with a single broken line, single solid line, double broken line, or double solid line depending upon the road, traffic and regulations. A center line marking is provided to demarcate the center of a carriageway and to separate traffic in opposite directions.



Source: IRC35-1997 Code of Practice for Road Markings

Figure 5-86: Center Line Marking for a Two Lane Road

The expected volume of the center line along NH40 would be the same as the total section length of two lane portions of NH40 that is 66.3 km (75.00 – 8.7 kp) based on the character of the project, widening of existing road and new construction of the road.

b) Traffic lane lines

The division of the carriageway into separate lanes for traffic traveling in the same direction on either side of the center-line or median strip helps to promote travel in proper lanes and curb the meandering tendency of the drivers, thereby promoting safety and ensuring maximum capacity. Traffic lane lines are broken lines which permit lane changing with caution. The traffic lane lines shall normally be single broken lines, with a width of 100 mm. Its use is basically for multilane roadways. The traffic lane line would be applied to the section of four-lane road, which is 8.7 km.

c) Pavement edge lines (both sides)

Pavement edge lines are used to indicate the edges of carriageways which have no curbs. They serve as a visual guidance for the drivers, indicating to them the limits within which the driver can safely drive. They are especially useful during conditions of adverse weather and poor visibility. Normally the paved shoulder is less strong compared with the main pavement, therefore the edge lines are used to promote travel on the main pavement itself. Edge lines are in the form of a single continuous line placed at the edge and outside of the carriageway. The expected volume of the edge line along NH40 would be the same as the total section length of NH40 multiplied by two, which is 150 km.

d) Route direction arrows

In addition to the warning lines on approaches to intersections, directional arrows should be used to guide drivers in advance towards the correct lane to be taken when approaching busy intersections, whether signal controlled or not. Because of the low angle at which such markings are viewed, these must be elongated in the direction of the traffic flow to provide adequate legibility to the driver. Normally four arrows should be used in a sequence in each lane. The direction arrow nearest to the intersection should be 15 m from the stop line or the entrance to the junction. The second arrow should be placed 15 m before the first arrow and similarly for third and fourth arrow.

e) Word message

Word messages are sometimes used for alarming drivers of hazard sections together with signs and warning boards.

f) No-overtaking marking

No passing zones are established on roads where there is no central median and traffic is allowed in both directions and sight distance is not enough for overtaking. It may be marked by a solid yellow line along the center or a double yellow line. In the case of a double yellow line, the left line may be a solid barrier line, while the right line may be either a broken line or a solid line. These solid lines are also called barrier lines. When a solid line is to the right of the broken line, the passing restriction shall apply only to the opposing traffic.

(4) Road studs

The reflective pavement markers (road studs) should be installed to improve visibility during night and wet weather conditions. Road studs should be the prismatic retro-reflective type conforming to ASTM (American Society for Testing and Materials) D 4280.

There are alternative road studs to be used at locations such as hazard areas where normal road studs are not so effective especially during foggy weather conditions. Solar road studs are flashing solar cell powered, LED maintenance-free lighting devices to delineate road edges and center lines. Embedded in the road surface, they are an electronic improvement to the traditional cateyes. The intense brightness of the LEDs makes them easily visible at distances of about 900 m under favorable conditions.

Figure 5-42 shows NH40 in the high mountain area during normal and foggy conditions. The visibility with fog is extremely low that markings, warning signs, together with road studs could provide a better road environment under adverse weather conditions such as a fog.

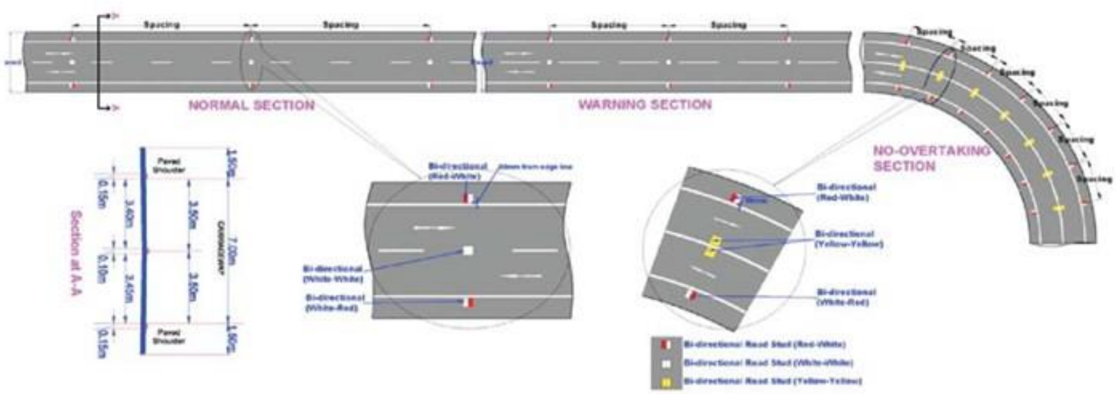


Fig. 9.3 Longitudinal Marking & Roads Studs for a Two Lane Road

Source: IRC:SP:73-2015 Manual of Specifications & Standards for Two Laning of Highways with Paved Shoulder

Figure 5-87: Arrangement of Road Studs for Two Lane Road

(5) Safety Barriers

Safety barriers, also known in North America as guard rails and in Britain as crash barriers, keep vehicles within the roadway and prevent vehicles from colliding with dangerous obstacles such as boulders, buildings, walls or large drains. Guard rails are also installed on the roadside to prevent errant vehicles from traversing steep slopes, entering deep water, or jumping into a deep valley. Safety barriers are installed within medians of divided highways to prevent errant vehicles from entering the opposing carriageway of traffic and to help reduce head-on collisions.

A variety of guardrails are used along NH40 where steep hills and deep valleys are prevalent. It necessitates the use of the rigid type guardrails of different shapes to prevent vehicles from running out of the roadway. Figure 5-40 shows some of the examples of safety barriers.

While barriers are normally designed to minimize injury to vehicle occupants (driver and passengers), injuries do occur in collisions with guard rails. They should only be installed where a collision with the barriers is likely to be less severe than a collision with the hazard behind it. Where possible, it is preferable to remove, relocate or modify a hazard, rather than shield it with a barrier. To provide safe roadside conditions, hazardous elements such as fixed obstacles or steep slopes can be placed outside of the clear zone[20] in order to reduce or eliminate the need for roadside protection.

Common sites for installation of safety barrier includes, a) bridge ends, b) steep slopes near roadway limits, c) at drainage crossings or culverts where steep or vertical drops are present, d) near large signs / illumination poles or other roadside elements which may pose hazards, e) near deep valley locations, and f) along a high embankment (above 3 m according to IRC).

Barriers are divided into three groups, based on the amount they deflect when struck by a vehicle and the mechanism the barrier uses to resist the impact forces.

Flexible barriers include guard cables and weak post corrugated guide rail systems. These are referred to as flexible barriers because they will deflect 1.6 m to 2.6 m (5.2 ft to 8.5 ft) when struck by a typical passenger car or light truck. Impact energy is dissipated through tension in the rail elements, deformation of the rail elements, posts, soil and vehicle bodywork, and friction between the rail and vehicle.

Semi-rigid barriers include the box beam guide rail and heavy post blocked out corrugated guide rail. Impact energy is dissipated through deformation of the rail elements, posts, soil and vehicle bodywork, and friction between the rail and vehicle. Box beam systems also spread the impact force over a number of posts due to the stiffness of the steel tube.

Rigid barriers are usually constructed of reinforced concrete. A permanent concrete barrier will only deflect a negligible amount when struck by a vehicle. Instead, the shape of a concrete barrier is designed to redirect a vehicle into a path parallel to the barrier. This means they can be used to protect traffic from hazards very close behind the barrier, and generally require very little maintenance. Impact energy is dissipated through redirection and deformation of the vehicle itself. Jersey barriers also lift the vehicle as the tires ride up on the angled lower section. The disadvantage is there is a higher likelihood of rollover with a small car than the single slope or step barriers. Impact forces are resisted by a combination of the rigidity and mass of the barrier. Deflection is usually negligible.

(6) Road Delineators

Road delineators are classified under three types, a) roadway indicators, b) hazard markers, and c) object markers.[21] Each of these serve a slightly different purpose.

Roadway indicators are intended to delineate the edges of the roadway so as to guide drivers through the alignment ahead, particularly where it might be confusing for some reason. The objective of hazard makers is to define obstructions like guard-rails and abutments adjacent to the carriageway, for instance at culverts and bridges which are narrower than the roadway width at approaches. Object markers are used to indicate hazards and obstructions within the vehicle flow path, for example channelizing islands close to the intersections.

[20] A lateral distance in which a motorist on a recoverable slope may travel outside of the roadway and return their vehicle safely to the roadway.

[21] IRC:79-1981 Recommended Practice for Road Delineators

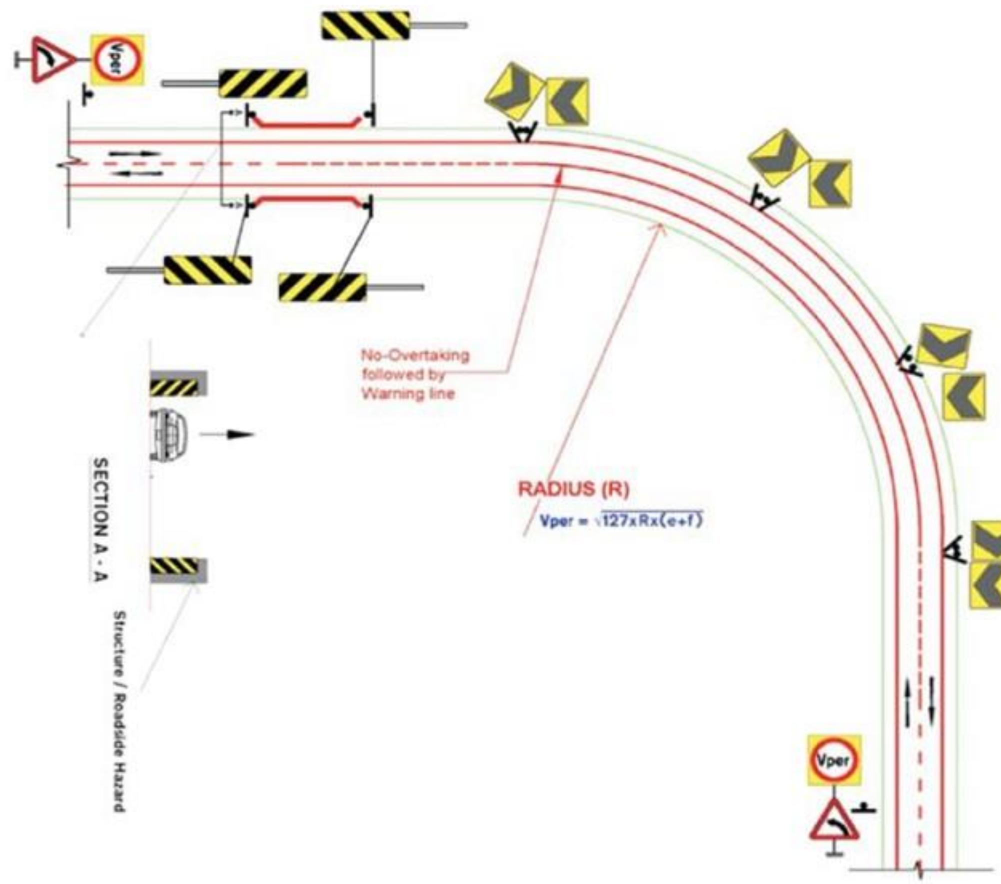


Fig. 9.1 Curve Delineation for Two Lane Road

Source: IRC:SP:73-2015

Figure 5-88: Arrangement of Curve Delineators for Two Lane Road

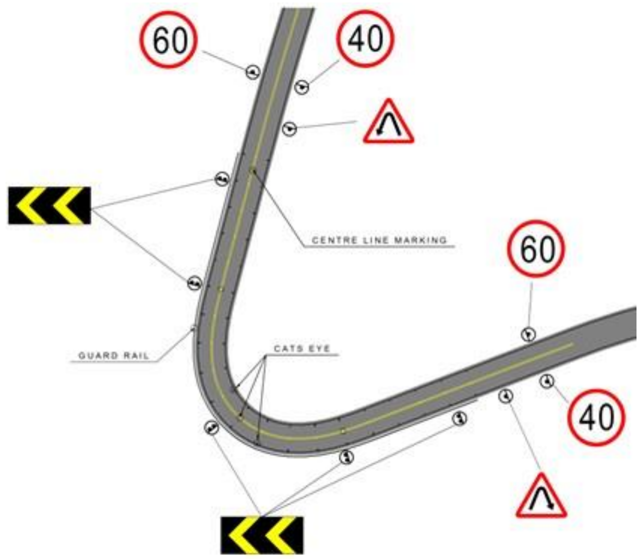
(7) Safety Measures for Hazardous Spots on NH40

Hazardous spots should employ a combination of signs, reflectors and warning boards to inform drivers of dangerous spots such as a steep curve, gradient or environmental hazards. The existing NH40 is located in the mountainous area on Shillong Plateau. The road is located at a very high altitude, between approximately 1,500 m and 1,800 m for the first half (roughly 35 km) then starts to descend until it is at less than 100 m elevation for the second half (roughly 45 km) as described in Table 5-23: Present conditions of NH40. Naturally, the horizontal alignment is very difficult as well as vertical grade. A small radius is used for the section in very steep mountainous areas.

The preliminary design was proposed in order to improve the alignment based on the current design standard. However, there are some sections that do not comply with the newly proposed standard by IRC. Those sections adopt previous standards as mentioned in the section 5.2.2 Road Geometric Design. In the reviewed preliminary design there are 3 locations of 50m radius and 13 locations of less than 75m radius (refer to Table 5-48: Locations with Sharp Horizontal Curves in Reviewed DPR Design) where special measures are required together with a recommended posted speed limit of 40 km/h to promote safety of traffic. Other sections where the radius of the curvature is less than 150 m are still considered relatively sharp horizontal curves, and there is a need to inform and warn drivers of the road conditions ahead as indicated in the Table 5-47: Location with Sharp Horizontal Curves.

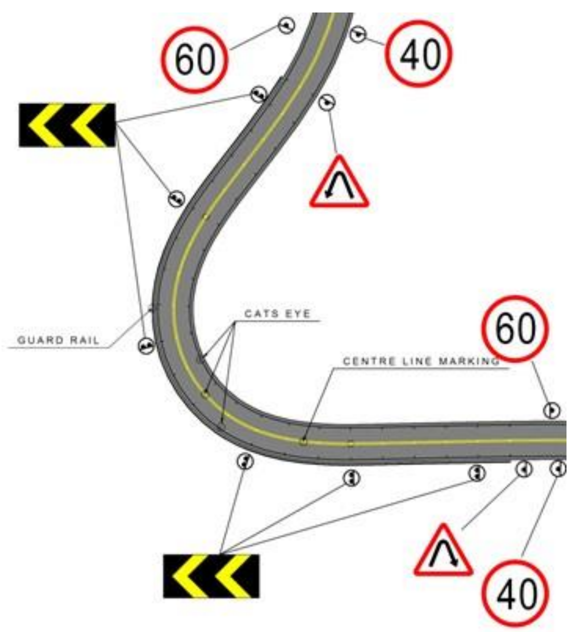
The measures include a combination of signs, markings, warning sign boards, road studs and guardrails. The following figures show the examples of such applications.

The total numbers of speed limit signs would be 228 (57 x 4 = 228). The warning sign of sharp curves would be 114 (57 x 2 = 114). Road studs of 6 m spacing for 150 m length would be 4,275 (25 x 3 lines x 57 locations = 4,275). Chevron boards on outer side curves of 5 installations each would be 285 (57 x 5 = 285). Guardrails should be installed along the hazardous locations, of which total length would be 1,710 m (150 x 2 x 57 = 1,710).



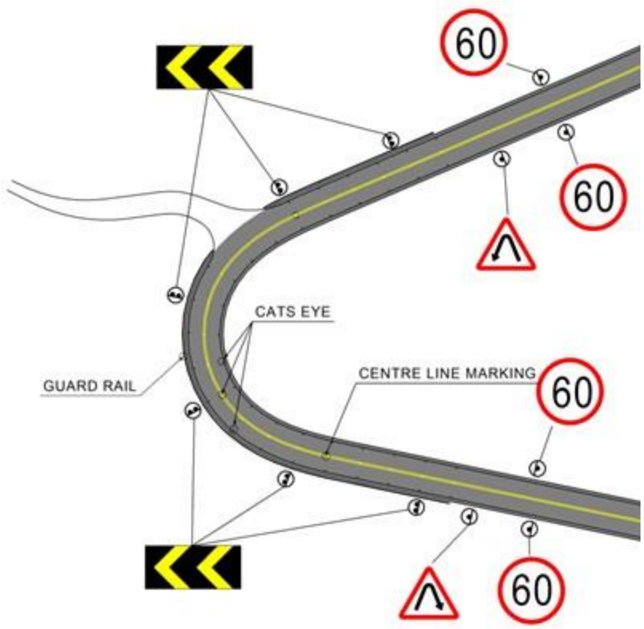
Source: JICA Study Team

Figure 5-89: Proposed Safety Measures at KP25.60 (R=50 m)



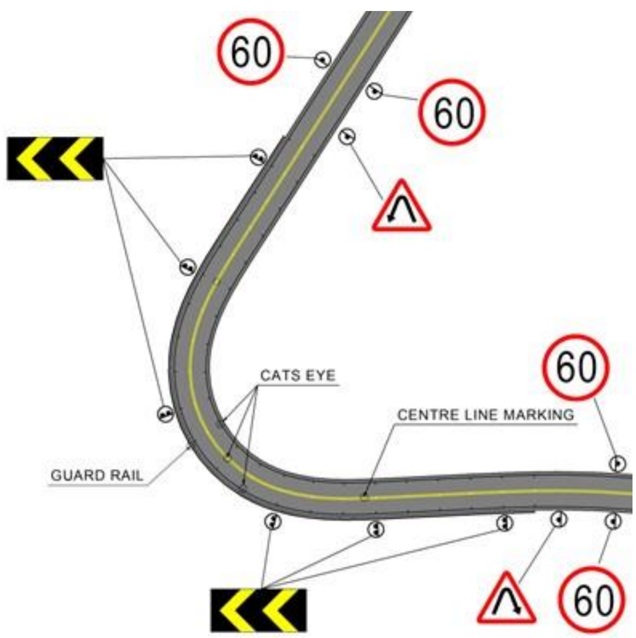
Source: JICA Study Team

Figure 5-90: Proposed Safety Measures at KP60.40 (R=51 m)



Source: JICA Study Team

Figure 5-91: Proposed Safety Measures at KP47.27 (R=90 m)



Source: JICA Study Team

Figure 5-92: Proposed Safety Measures at KP30.17 (R=80 m)

5.2.9 Road Appurtenances Plan

(1) Road Appurtenances Plan

Road appurtenances are miscellaneous facilities for road users to take a rest and obtain road-related information as well as for road administrators to maintain their roads efficiently. In this study, considering the road function of rural roads and usage of the target roads, facilities listed in Table 5-45 are discussed for NH40.

Table 5-45: Road Appurtenance Design Guidelines

	Type of Road Appurtenances	Remarks/related codes
1	Kilometer posts (stone)	IRC8-1980, IRC26-1967
2	Boundary stone	IRC25
3	Bus bay	IRC80-1981
4	Road amenity	Public toilet

Source: JICA Study Team

a) Kilometer Post

There are various locations of kilometer posts along NH 40. The photos shown are some of the kilometer posts seen during site visit.

Source: JICA Study Team

Figure 5-93: Kilometer Posts along NH40

b) Boundary stone

Boundary stones are not found along NH40.

c) Bus bay

There are very few (1 or 2 services a day) regular bus services on NH40 between Shillong - Pynursla. Residents of rural areas depend on small-size taxis as public transport. Taxis are cheap, convenient, and provide better service than a regular bus. The taxi business attracts more passengers and creates employment for drivers.

On the other hand, there are public bus services in the Shillong urban area using middle and small size buses. Regular bus routes offer bus services of more than ten a day.

Regular route bus in Shillong	Small size bus	Taxis in the station in Pynursla

Source: JICA Study Team

Figure 5-94: Bus Bay and Taxi Yard along NH40

There are no actual bus bays along NH40 from Shillong to Dawki. However, there are huts along NH40 built for waiting for buses or to provide shelter from strong rain, and some of them could be used as a bus stop. Well-designed bus bays will be indispensable for the safe and smooth flow of traffic when in the future, inter-city bus services frequently operate along NH40 that has been improved as a trunk highway.

Near Ritmawniew Village	Near Laitlingkot Village	Near Kongwang Village

Source: JICA Study Team

Figure 5-95: Bus Waiting Shelters along NH40

d) Road amenity

Public toilets are built near villages, bridges, parking spaces, etc., mainly for the convenience of villagers. There are very few toilets along the road, and tourists and passing drivers usually use toilets in restaurants. Clean and convenient toilets along the roadway should be designed and installed for the amenity of users of the road.

Near Mylliem Village	Near Siatbakon Village	Both ends of Dawki Bridge

Source: JICA Study Team

Figure 5-96: Public Toilets along NH40

(2) Tourist Facilities Plan

a) High Potential of Tourism with Picturesque Scenery

Shillong, a hill at an altitude of 1,400 m, is not just known as a summer resort place for people in India but full of nature with many picturesque spots such as Shillong Peak and Elephant Falls.

The road concerned passes through mountainous areas at an altitude over 1,800 m, and has quite a few spots that can command grandeur mountain scenery of Shillong District. Along the present road, there are some scenic view spots with lookout platforms, to which drivers make a short visit for a rest.

Source: JICA Study Team

Figure 5-97: A View of Shillong Peak

b) Viewpoint

Road alignment design is crucial to the aesthetic design of the road. Beautiful natural landscapes of mountains and rivers should be effectively incorporated into road landscaping. It is important to create comfortable landscapes which minimize damage to nature and the environment and also to create scenic harmony between the road and the surrounding terrain. Viewpoints should be planned for road users to enjoy panoramic views at locations such as immediately after crossing a mountain pass where grandeur scenery awaits, or, after turning a curve where there is a majestic mountain view.

Viewpoint 1	Viewpoint 2	Elephant Fall
		

Source: JICA Study Team

Figure 5-98: View Points along NH40

c) Mountain Scenery

NH40, starting at an altitude of 1,400m, includes many precipitous slopes and mountain scenery in the distance, which is pleasing for the driver. In particular, the sections along the ridge of the mountain command spectacular views of the mountainous areas, and many drivers pull off the road and enjoy taking photographs.

Source: JICA Study Team

Figure 5-99: Mountain Scenery at Altitude of Around 1,400 m

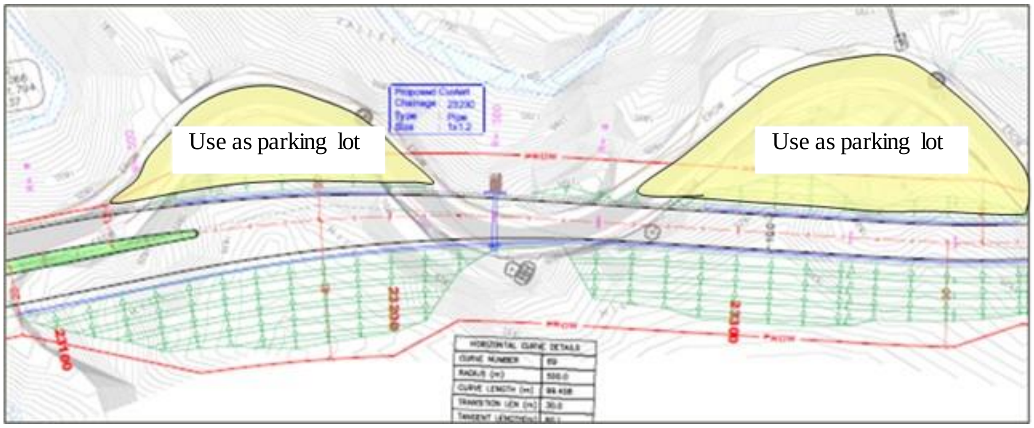
Source: JICA Study Team

Figure 5-100: Mountain Scenery at Altitude of Around 1,800 m

d) Securing Parking Lots

Parking lots are needed for drivers to enjoy scenery, but needs earth cutting and filling, which is not desirable for landscape conservation.

A possible idea is to take advantage of dead space created at the time when the present S-shaped curve is renovated into a straight line. This will utilize dead space rather than require the planning of new space for parking lots.



Source: JICA Study Team

Figure 5-101: A Usage of Parking Space

e) Handling of the Existing Scenic Spot

There is a rest area near Sta30+500, where people can eat and drink. The area was built also as a scenic spot, and should be utilized as a tourist resource for the road. However, it is located in a short bypass section, and thus is outside the planned road.

Source: JICA Study Team

Figure 5-102: Landscape from the Existing Scenic Spot

As shown in the figure below, the scenic spot will not be accessible from the starting point, where the present roadbed is planned to be cut down and lowered. However, it is possible to make the scenic spot accessible from the end point by creating an intersection. In this case, it is desirable to install guide signs around the junction to give information regarding the scenic spot to drivers.

TO Dawki

Source: J TO Shillong

Figure 5-103: Positional Relation between the Existi Plan to construct the cross road **and Bypass**

5.2.10 Preliminary Study of Bypass Routes

(1) Evaluation of DPR Designs

It was found after the review that there are 26 locations in the plan that does not satisfy the newly updated design standards of ruling or minimum requirements for the horizontal curvatures.

Table 5-46: Minimum Horizontal Curves (m)

Class	Features	Ruling	Minimum
Mountainous	25% - 60%	150 (80)	75 (50)
Steep	More than 60%	150 (50)	75 (30)

Source: IRC:SP:73-2015. The numbers in parentheses are taken from IRC52-2001.

Table 5-47: Locations with Sharp Horizontal Curvatures

Locations (Station)	Horizontal Alignment (radius)		Remarks		
	Less than 75 m	Less than 50 m	(vertical grade, crossfall)	Elevation (m)	Length (Less 100 m)
0+540	*60*		*G=5 - 6%, e=5%*	*1497*	*(54 m) By-pass #1*
1+840	*60*		*G=4%, e=5%*	*1567*	*By-pass #1*
2+570	*70*		*G=2.5%, e= 7%-*	*1597*	*By-pass #1*
18+810		30	G= 3.0 – 5.0%, e= 7%	1699	(L-26 m)
25+840		40	G= 4.3%, e.= 7%	1721	(45 m)
27+380	60		G= 4.0%, e= 7%	1669	(64 m)
33+070	75		G=+6%--2.5%, e=7%	1515	(58 m) crest
33+210	75		G=-2.5%, e=7%	1517	(49 m)
34+060	60		G=-0.5%, e.= 7%	1515	(57 m)
35+200	70		G= 5.5%, e= 7%	1528	(48 m)
43+690		35	G=- 2.0%, e= 7%	1272	(49 m)
48+420		40	G= 5.5%, e= 7%	1133	(48 m)
50+740	60		G=-8.0%, e=5%	1019	(23 m)
54+920	60		G= 6.5%, e= 5.0%	777	(44 m)
55+070	60		G= 6.5%, e= 5.0%	776	(21 m)
60+300	70		G= -3.0%, e= 7%	591	
60+620	50		G= -3.0%, e= 7%	999	(91 m) cut
67+500	*60*		*G= 4.0%, e= 7%*	*314*	*Bypass No. 6*
68+120		*35*	*G= 2.5%, Sl.= 7%*	*292*	*Bypass No. 6*
68+570	*70*		*G=-5.0%--3.0%, e=7.0%*	*271*	*(77 m) Bypass No. 6*
68+760		*40*	*G= 3.0%, Sl.= 7%*	*265*	*(65 m) Bypass No. 6*
69+130	*70*		*G= 6.0%, e.= 7%*	*244*	*(57 m) Bypass No. 6*
69+310	*70*		*G= 6.0%, e.= 7%*	*241*	*(78 m) Bypass No. 6*
69+830		*35*	*G= 2.5%, e.= 7%*	*201*	*(69 m) Bypass No. 6*
70+450		*35*	*G= 2.5%, Sl.= 7%*	*186*	*(72 m) Bypass No. 6*
72+820		*50*	*G=0.0%, e.= 5.0%*	*65*	*(29 m) Bypass No. 7*

Note G: Vertical Gradient, e: Super Elevation, Numbers in italics are within the bypass under investigation
Source: JICA Study Team

In addition, there are some sections of the planned edge of the roadway in DPR that are located outside of the existing edge, which would usually need to be widened on the valley side by an embankment or concrete or stone structures. Adjustment of minor design changes would be necessary after the detail topographic survey is finished, as aforementioned, widening on the valley side is almost impossible due to the valley being very steep and deep.

Attention is needed to ensure the safety of traffic at the spots where the combination of down grade and horizontal alignment is severe. If possible, it would be better to design more flat curves with combinations of transitions to allow drivers to easily prepare for difficult conditions. As explained in section 5.2.8 Traffic Safety Facilities Plan, the combinations of various safety measures should be installed, providing well-advanced information to the drivers.

Based on the suggestion by the Study Team due to safety concerns, DPR design has been modified to incorporate the new design standard as much as possible. Bypass #1, #6 and # 7 have been rerouted and redesigned. One of the reasons was the realignment of the Dawki Bridge. The whole design of new NH40 road has been improved by the review. However, there are some sections that need special attention to traffic safety. Table 5-48 indicates the sharp horizontal curve locations in relation to the standard value of 150 m (ruling) and 75 m (minimum).

Table 5-48: Locations with Sharp Horizontal Curves in Reviewed DPR Design

Locations (Station)	Horizontal Alignment (radius)		Remarks		
	Less than 150m	75m or less	(vertical grade, crossfall)	Elevation (m)	Length
0+550		***75***	G=5 - 6%, e=5%	1498	(L=80m) #1
0+720	***80***		G=6.0%, e=5%	1506	(L=29m) #1
1+850		***75***	G=4%, e=5%	1568	(L=89m) #1
2+590		***75***	G=4%, e= 7%-	1597	(L=89m) #1
2+800	***90***		G=4-5%, e=7%	1605	(L=108m) #1
3+150	***105***		G=5%, e=7%	1636	(L=144m) #1
3+610	***105***		G=7%, e=5%	1644	(L=145m) #1
14+710	***120***		G=7-2%, e=5%	1712	(L=95m)
15+850	***90***		G=2.2%, e=5%	1743	(L=63m)
16+130	***105***		G=2.2%, e=5%	1740	(L=64m)
16+340	***90***		G=2.2%, e=5%	1745	(L=87m)
16+520	***140***		G=3%, e=5%	1748	(L=70m)
16+690	***120***		G=3%, e=5%	1741	(L=55m)
16+940	***120***		G=3%, e=5%	1735	(L=82m)
17+350	***125***		G=5%, e=7%	1715	(L=95m)
17+630	***105***		G=5%, e=7%	1698	(L=139m)
18+090	***120***		G=2%, e=7%	1695	(L=71m)
25+210	***100***		G=3-4.3%, e=7%	1739	(L=58m)
25+470	***90***		G=4.3%, e=7%	1726	(L=54m)
25+600		***50***	G=4.3-3%, e=7%	1721	(L=71m)
26+130	***105***		G= 4%, e.= 7%	1721	(L=151m)
26+460	***90***		G= 0.5%, e.= 7%	1702	(L=69m)
27+120		***60***	G=4%, e=7%	1682	(L=231m)
27+700	***100***		G= 4.0%, e= 7%	1665	(L=67m)
29+990		***75***	G=3.5%, e=7%	1541	(L=81m)
30+170	***80***		G=6%, e=7%	1533	(L=85m)
30+530	***100***		G=6%, e=7%	1508	(L=81m)
31+870	***100***		G=2%, e=7%	1520	(L=80m)

32+830		***75***	G=+6%--2.5%, e=7%	1515	(L=58m)
32+970		***75***	G=-6%, e=7%	1517	(L=49m)
33+340	***120***		G=-2.8%, e=7%	1504	(L=47m)
33+470	***120***		G=-2.8%, e=7%	1502	(L=22m)
33+670	***105***		G=-2.8%--0.5%, e=7%	1497	(L=38m)
33+820		***60***	G=-0.5%, e.= 7%	1515	(L=66m)
33+970	***105***		G=-0.5%-+0.5%, e=6.8%	1496	(L=42m) sag
34+800	***90***		G=5.5%, e=7%	1526	(L=61m)
34+960		***70***	G= 5.5%, e= 7%	1528	(L=48m)
35+080	***100***		G=5.5%, e=7%	1546	(L=34m)
35+340	***120***		G=5.5%--1.0%, e=7%	1555	(L=75m)
36+410	***100***		G=-1.9%--1%, e=7%	1540	(L=39m)
42+260	***90***		G=-5.0%, e=7%	1336	(L=111m)
43+400		***50***	G=- 2.0%, e= 7%	1272	(L=87m)
44+910	***120***		G=- 1.5%--3.5%, e= 7%	1265	(L=148m)
45+700	***90***		G=- 3.7%--5.0%, e= 7%	1228	(L=145m)
46+560	***105***		G=-5.0%--3.5%, e=7%	1180	(L=75m)
47+270	***90***		G=-2.7%, e=7%	1185	(L=86m)
48+070		***50***	G= 5.5%, e= 7%	1133	(L=70m)
48+500	***105***		G=-5.5%--1.0%, e=7%	1107	(L=93m)
50+370		***60***	G=-7.0%, e=5%	1019	(L=23m)
50+480	***100***		G=-0.0%, e=5%	1015	(L=29m)
54+180	***105***		G=-6.5%, e=5%	801	(L=144m)
54+530		***60***	G= 6.5%, e= 5.0%	777	(L=44m)
54+690		***60***	G= 0%, e= 5.0%	776	(L=20m)
60+050	***85***		G= 6.0%, e= 5%	589	(L=188m)
60+400		***51***	G= 2.4%, e= 7%	586	(L=100m) cut
62+090	***90***		G=-6.0%--2.4%, e=7%	473	(L=84m)
62+340	***105***		G= -2.40%, e= 7%	471	(L=97m)
Total	***41***	***16***			

Source: JICA Study Team

(2) Alignment of Bypass #1

This section of the existing NH40 contains many sharp curves and zigzag alignments. The DPR plans for a bypass to have a smooth alignment traversing the wood land. Since this wood land is the property of the Ministry of Defense, the JICA Study Team is proposing to shift the alignment to follow the existing NH40 as much as possible to minimize building of the bypass into the property.

Source: JICA Study Team

Figure 5-104: Existing NH40 and Proposed Alignments of Bypass #1

(3) Alignment of Bypass #2

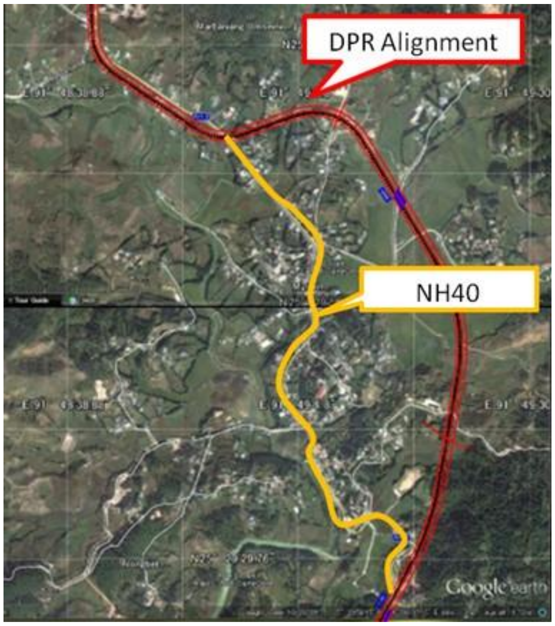
This section is from Sta. 7+600 to Sta. 10+600 (3.0 km), and is mainly composed of relatively gentle, rolling terrain. The natural horizontal alignment of most of the section is within the ruling minimum of R = 150 m. The vertical grade is also around 2% to 2.5% except one location at 10+500 has 4% to 4.5% grade with a horizontal alignment of R = 200 m.

Source: JICA Study Team

Figure 5-105: Existing NH40 and Proposed Alignment of Bypass #2

(4) Alignment of Bypass #3

This section is from Sta. 12+200 to 14+400 (2.2 km), and is mainly composed of relatively gentle terrain that is slightly steeper than Bypass #2. Its vertical grade is around 4% with a horizontal alignment of R = 150 m to 200 m.

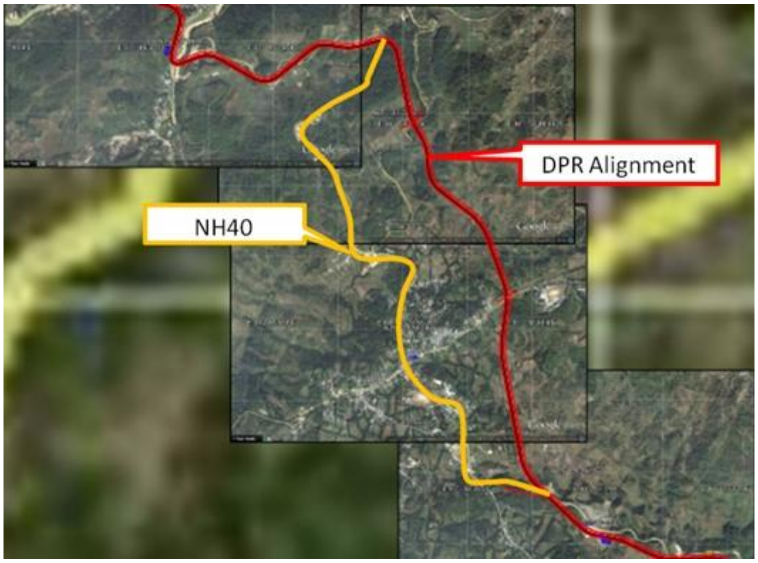


Source: JICA Study Team

Figure 5-106: Existing NH40 and Proposed Alignment of Bypass #3

(5) Alignment of Bypass #4

This section runs from Sta. 20+000 to Sta. 23+200 (3.2 km), which is a section characterized mainly by rolling and mountainous terrain. The vertical grade of the road is naturally slightly steeper than #2 and #3. It is around 4% to 5% with a horizontal alignment of more than R = 150 m except one location of R = 90 m, with vertical grade of 4% at Sta. 20+130.

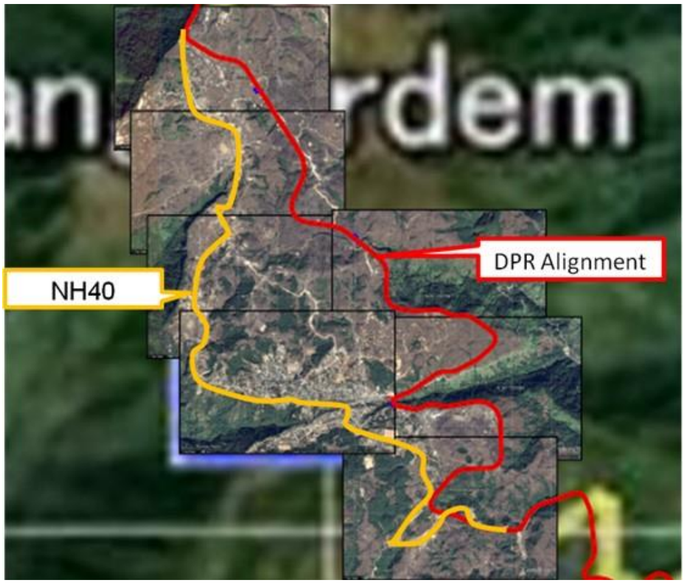


Source: JICA Study Team

Figure 5-107: Existing NH40 and Proposed Alignment of Bypass #4

(6) Alignment of Bypass #5

This section is in the mountainous terrain at an altitude between 1,500 m to 1,200 m. The bypass starts at Sta. 37+800 and ends at Sta. 46+100 (8.3 km). Because of the mountain terrain, the maximum vertical grade reaches around 5% with minimum radius of curvature around 90 m which is smaller than the new ruling standard of 150 m for the design speed of 60 km/h. However there is one location where the minimum radius of curvature is 50 m, which is smaller than the 75 m standard at the location of Sta. 43+400. Although the curve is very small, the vertical alignment remains relatively gentle at 2%.

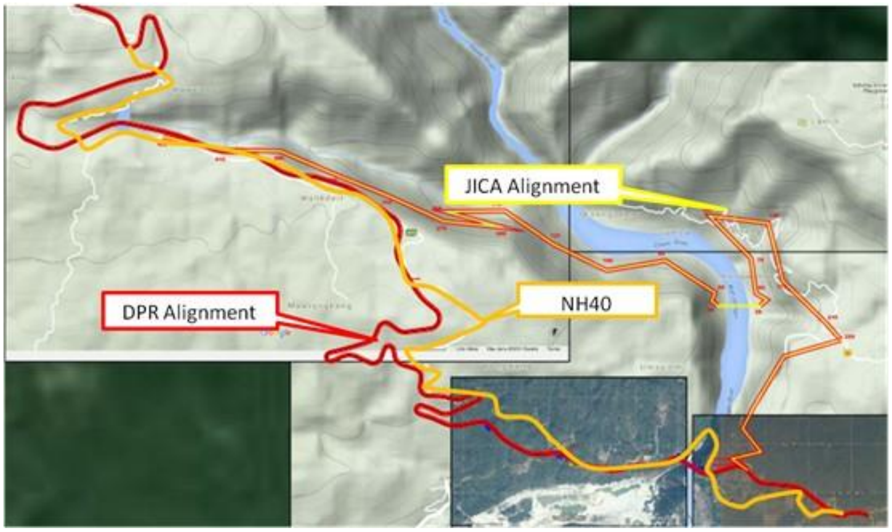


Source: JICA Study Team

Figure 5-108: Existing NH40 and Proposed Alignment of Bypass #5

(7) Alignment of Bypass #6 and #7

The difficulty with this section is selecting a crossing location of the Dawki River. The existing bridge is located about 200 m from the mouth of the river. DPR proposes an alignment near the mouth of the river. However, the border with Bangladesh is close to the mouth of the river, which means there would be some restrictions imposed on construction activities. The JICA Study Team is proposing an alignment to be away from the border line.

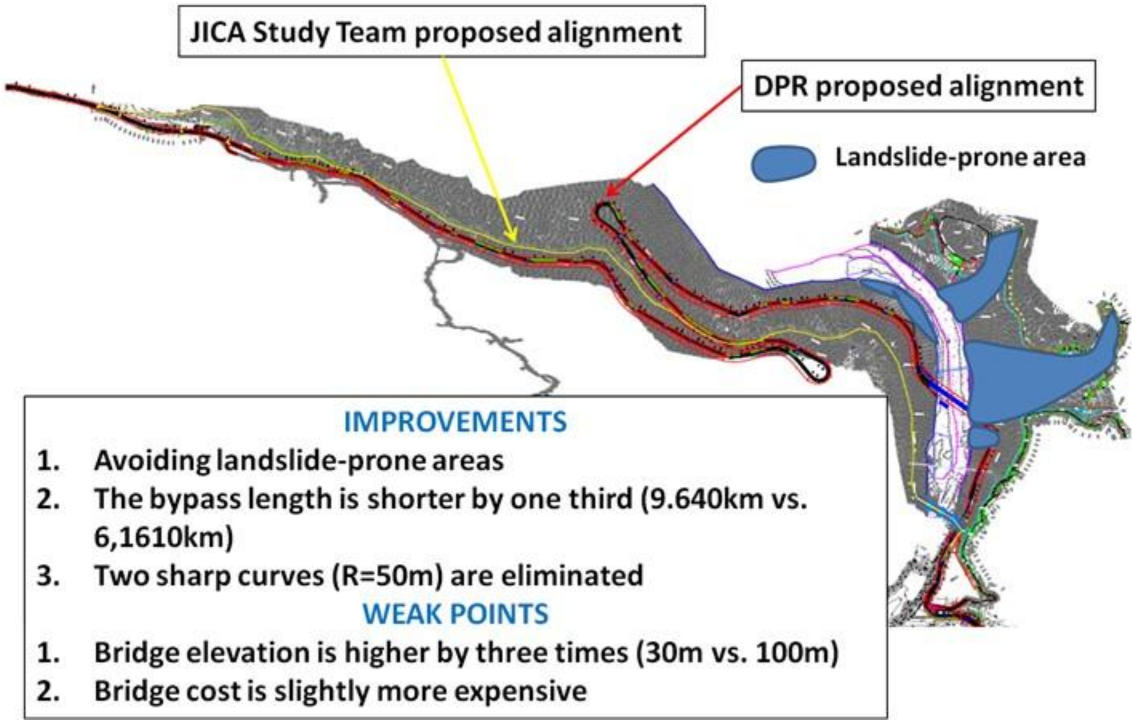


Source: JICA Study Team

Figure 5-109: Existing NH40 and Propose Alignment of Bypass #6 and #7

The alignments of bypass #6 and #7 were reexamined to addressthe above stated problem. The JICA Study Team decided to redesign the alignments along the route proposed by PWD and carried out topographic and geotechnical surveys. The topography is very steep and rugged and there are many boulders accumulated on the bottom of the Dawki River.Traces of a landslide were also observed. The design of the bridge required considering these topographic and geotechnical features.

The JICA Study Team designed the bypass alignment based on the results of the surveys. The DPR consultant also submitted their redesigned alignment and both proposals were reviewed. After the consultation with NHIDCL, the Meghalaya State PWD, and the DPR consultant, the alignment proposed by the JICA Study Team as shown below has been selected as the final alignment.



Source: JICA Study Team

Figure 5-110: Proposed Alignments for Bypass #6 and #7

5.2.11 Monolith

(1) Monolith

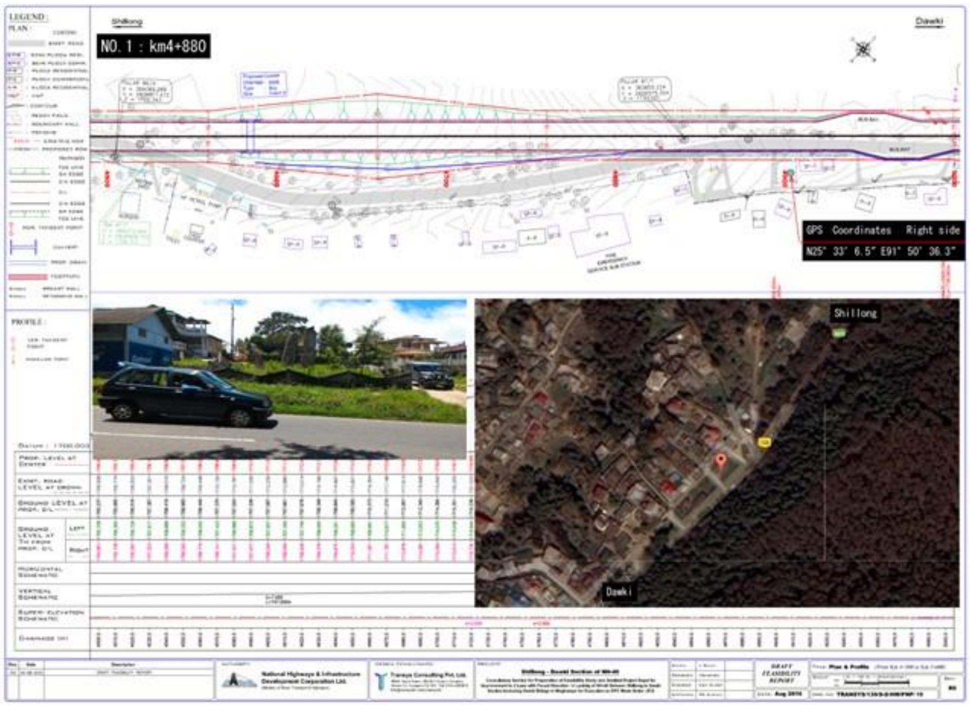
Monoliths are religious objects for local people, which are a combination of three or more stones standing upright. Village people believe that they must not be moved for the sake of roads or any other construction. This chapter outlines and clarifies the positional locations of these monoliths and the planned road to confirm the impact of monoliths on the planned road.

Source: JICA Study Team

Figure 5-111: Monoliths

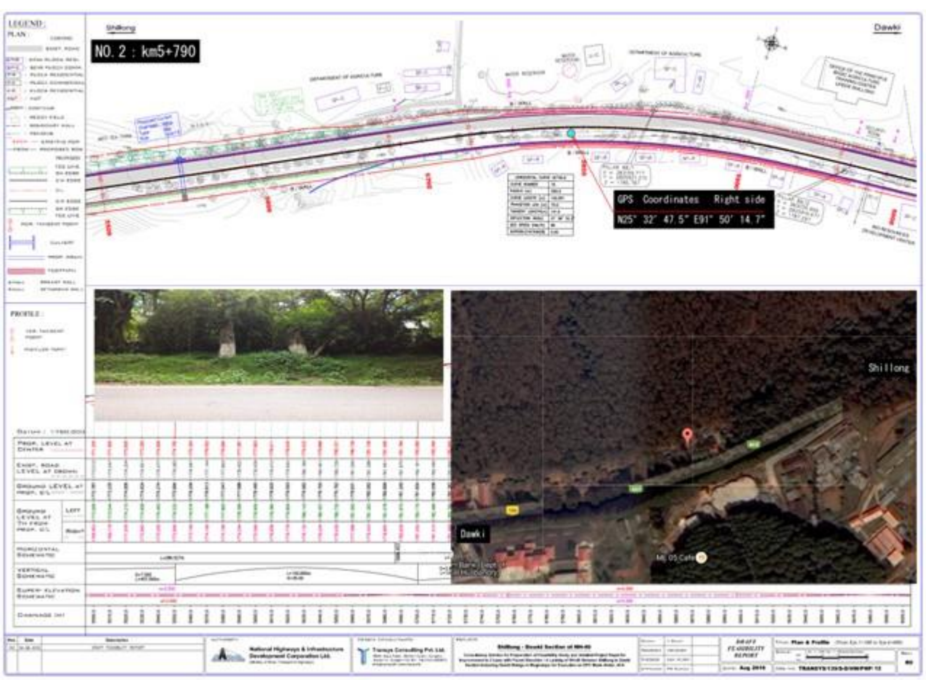
(2) Monoliths Having Impact on the Planned Road

The survey has confirmed seven monoliths that are adjacent to the planned road. Figures below outline the positional relation of these monoliths and the planned road.



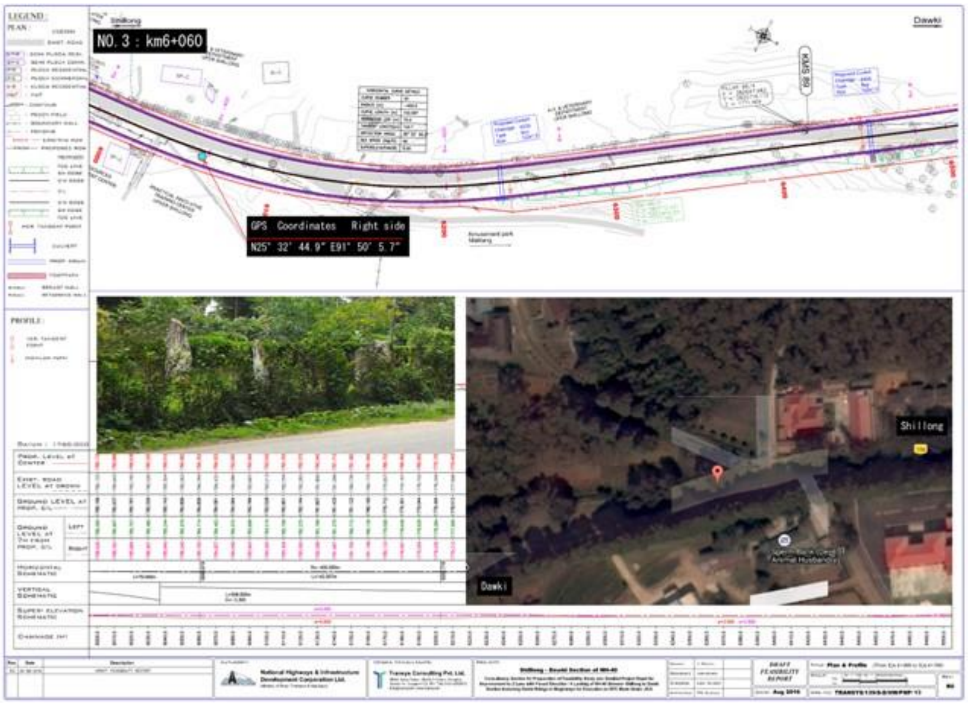
Source: JICA Study Team

Figure 5-112: Monolith #1 (KP4+880)



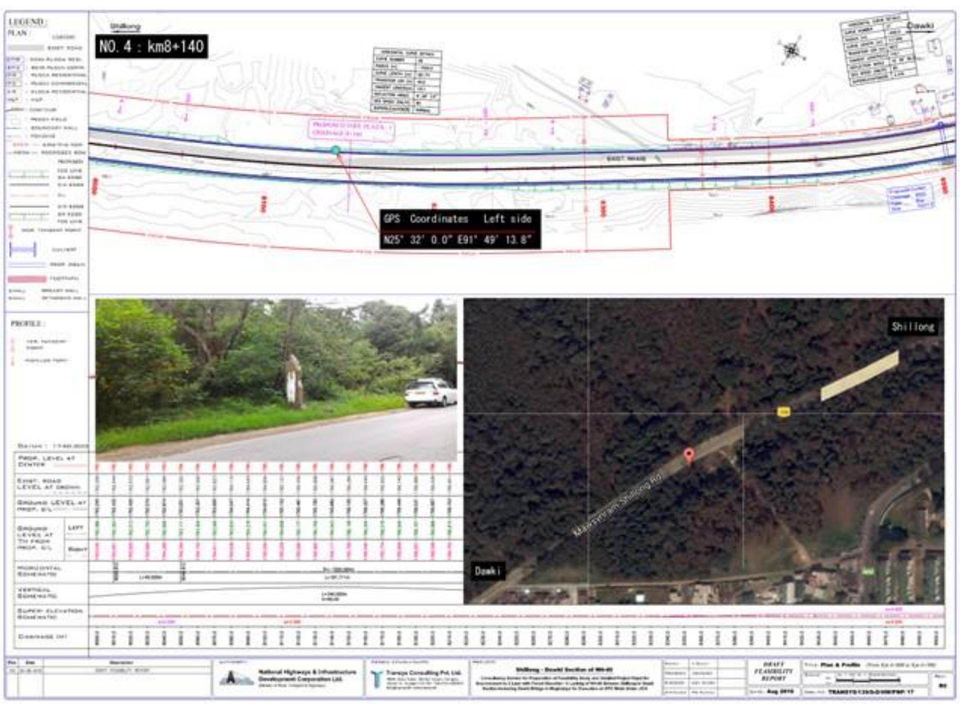
Source: JICA Study Team

Figure 5-113: Monolith #2 (KP5+790)



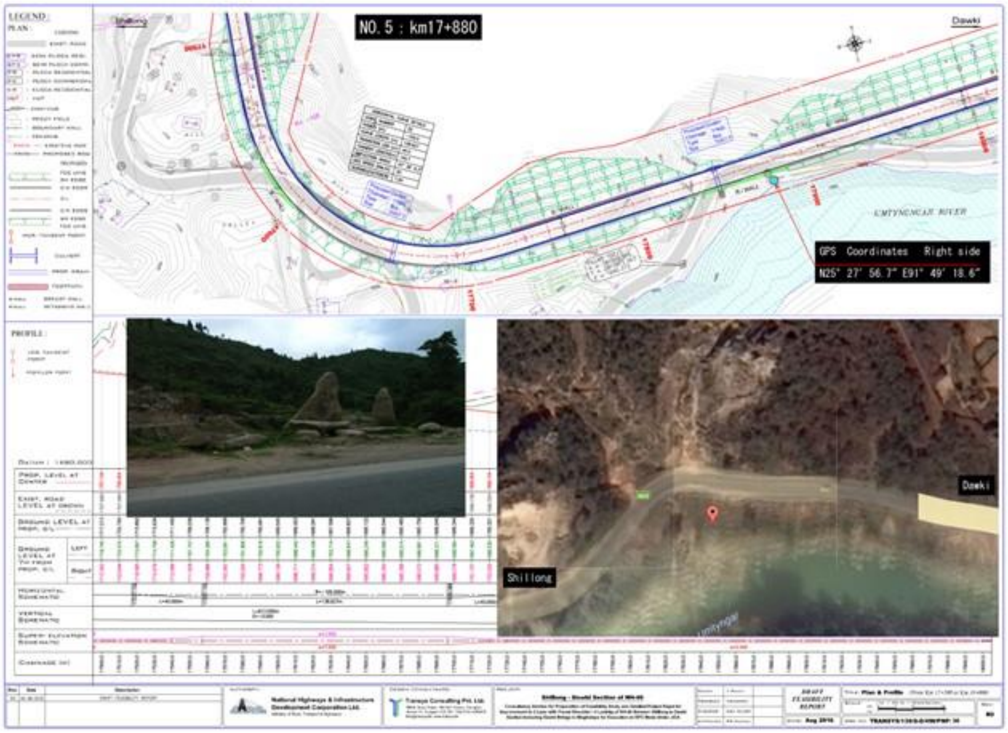
Source: JICA Study Team

Figure 5-114: Monolith #3 (KP6+060)



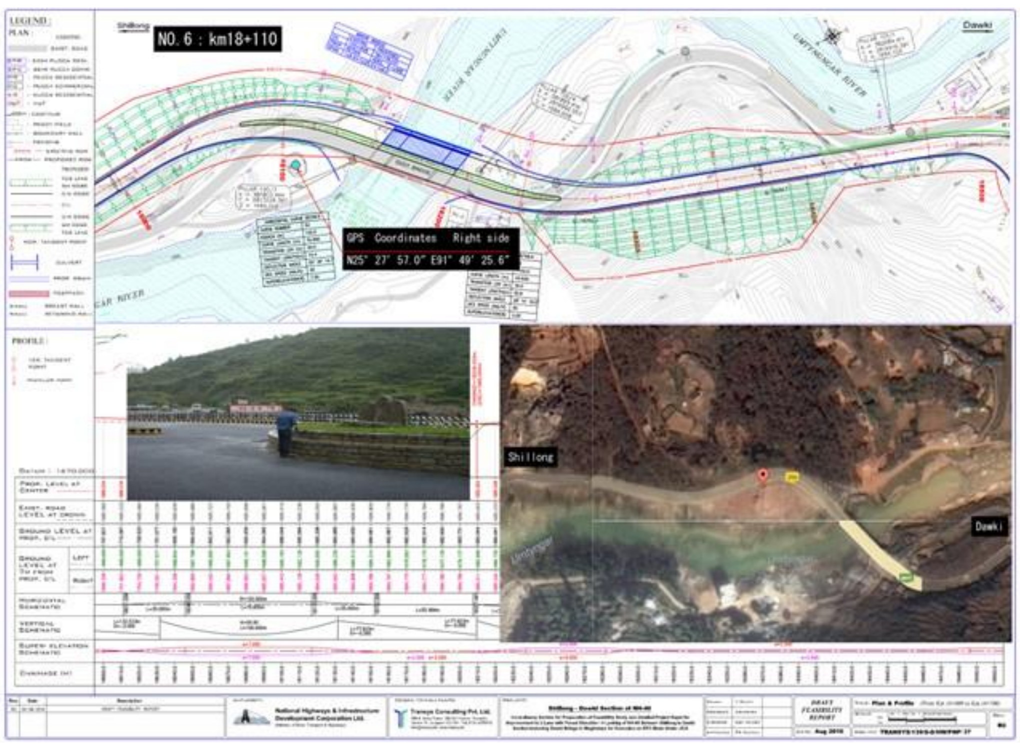
Source: JICA Study Team

Figure 5-115: Monolith #4 (KP8+140)



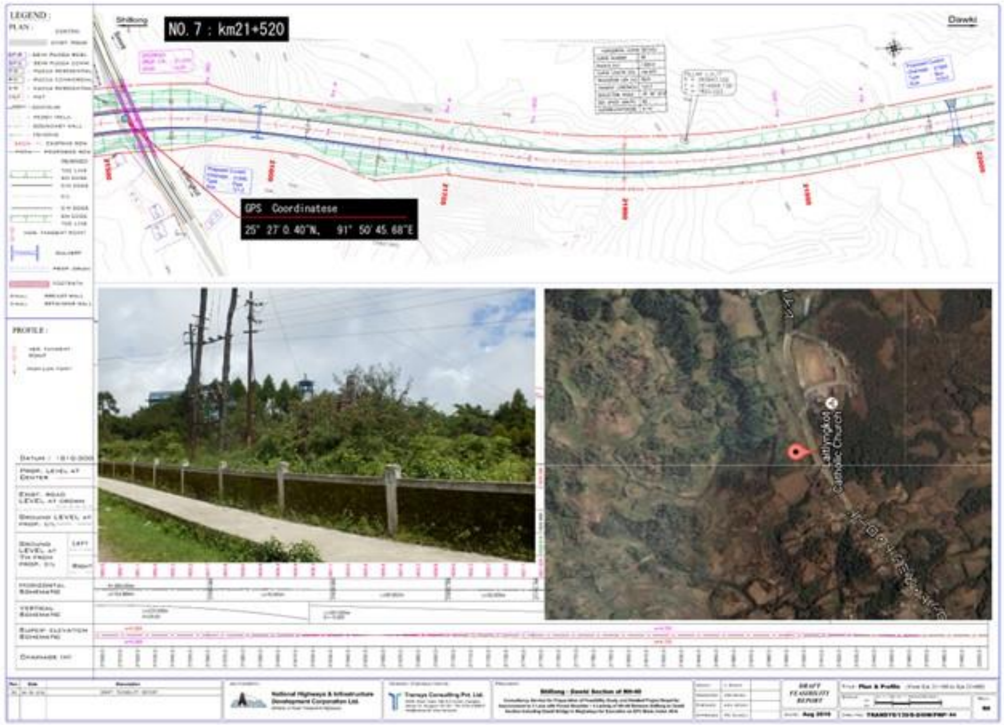
Source: JICA Study Team

Figure 5-116: Monolith #5 (KP17+880)



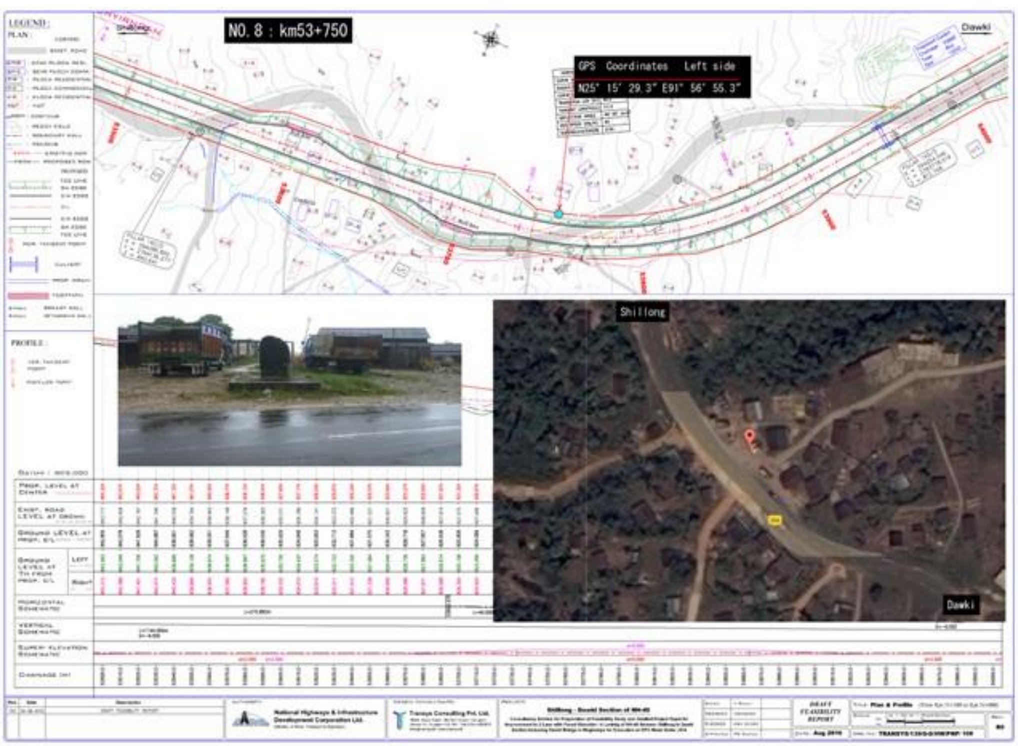
Source: JICA Study Team

Figure 5-117: Monolith #6 (KP18+110)



Source: JICA Study Team

Figure 5-118: Monolith #7 (KP21+520)



Source: JICA Study Team

Figure 5-119: Monolith #8 (KP53+750)

(3) Impact of Nearby Monoliths and Measures

The Survey Team has examined whether these nearby monoliths are within the width of the planned road, and considered possible measures for each.

Table 5-49: Positional Relations with Monoliths and Possible Measures

Monolith No.	Survey Point No.	Positional relation with the planned road			Possible measures		
		Outside the road	Within the road		(i) Relocation of monoliths	(ii) Monolith to be included as part of the road facilities	(iii) Change in the road shape to avoid monolith
No.1	Around 4,880	○	—		There is no particular problem.		
No.2	Around 5,790	—	○		○ It will be feasible if the consensus is gained from the local community.	○ The monolith will be placed on the central medians isolated from the roadway. This will reduce the impact of the monoliths, compared to Proposal (iii).	Δ Measures will be taken to shift residential houses in the south of the road to the south by 10m. The change in the road shape will have a substantial impact.
No.3	Around 6,060	—	○		○ It will be feasible if the consensus is gained from the local community.	○ The monolith will be placed on the central medians isolated from the roadway. This will reduce the impact of the monolith, compared to Proposal (iii).	Δ Measures will be taken to shift residential houses in the south of the road to the south by 10m. The change in the road shape will have a substantial impact.
No.4	Around 8,140	—	○		○ It will be feasible if the consensus is gained from the local community.	Δ The monolith is located just on the edge of the road shoulder, so it is difficult to include it in the road facilities.	○ The road itself will be shifted to the north by 5m.
No.5	Around 17,880	○	—		The monolith will remain in the premises but will not conflict with the planned road. Further confirmation is required.		
No.6	Around 18,110	○	—		There is no particular problem.		
No.7	Around 21,520	-	○		○ It will be	Δ No any	Δ Measures will

					feasible if the consensus is gained from the local community.	advantages. Because road level is lower than existing ground.	be taken to shift by 30m. The change in the road shape will have a substantial impact.
No.8	Around 53,750	—	○		○ It will be feasible if the consensus is gained from the local community. -> Result of hearing, relocation is available.	Δ The monolith is located just on the edge of the road shoulder, so this does not have many advantages.	○ Measures will be taken to shift residential houses in the west of the road to the west by 5m. The change in the road shape will have a substantial impact.

Source: JICA Study Team

(4) Issues to Be Solved for Detailed Design

The survey has roughly confirmed the locations of monoliths and the planned road, and examined possible measures. The following issues must be solved prior to the detailed design in the future.

- The locations and areas of monoliths will be actually measured to clarify the positional relations with and distance from the planned road.
- The local people have consented to the relocation of the monoliths. The exact relocation points shall be discussed further with the local people.

5.2.12 Spoil Plan

The volume of cut and fill along the proposed NH40 are estimated and spoil plan is studied as follows.

(1) Volume of Cut and Fill

In order to estimate the volume of cut and the necessary volume of fill material, the proposed NH40 is separated into 26 sections every 5km or by rock types as shown in Table 5-1. Basically, excavated material is used as material for fill in the same section.
The volume of "loosened excavated material" is obtained using the rate of change of excavate volume (L). The following values are adopted as value of L which varies by rock type.

Rate of change of excavated material (L)

Type A (hard rocks):	1.8
Type B (medium hard rocks) :	1.6
Type C (soft rocks) :	1.5

Volume of "compacted material" is obtained using the rate of change of compaction material (C). The following values are adopted as value of C which varies with rock type.

Rate of change of compaction material (C)

Type A (hard rocks):	1.4
Type B (medium hard rocks) :	1.3
Type C (soft rocks) :	1.2

The results of estimation is shown in the following table.
However, the volume of cut is more than the volume of fill in most of the sections; the excavated material for the fill volume is in short in Sections 2, 3, 4, 5, 6, 19 and 22.

Table 5-50: Volume of Cut and Fill

section	KP		Rock type	Volume of cut	Volume of loosened excavated material	Volume of fill	Necessary Volume of material for fill	Surplus volume of material	Shortage volume for fill
	from	to		A m3	A x L m3	B m3	B x C m3	A x L - B x C m3	(AxL-BxC)/C m3
1	0	3.3	C	500,671	751,006	128,339	154,006	597,000	-
2	3.3	5.0	A	44,901	80,821	75,113	105,158	(24,337)	(17,384)
3	5.0	5.2	A	545	982	15,790	22,107	(21,125)	(15,089)
4	5.2	9.5	C	43,040	64,561	124,401	149,281	(84,720)	(70,600)
5	9.5	10.0	A	946	1,704	66,259	92,762	(91,059)	(65,042)
6	10.0	11.2	A	8,015	14,427	43,272	60,581	(46,154)	(32,967)
7	11.2	15.0	B	184,227	294,763	186,879	242,943	51,820	-
8	15.0	20.0	B	429,512	687,219	103,500	134,550	552,669	-
9	20.0	21.3	B	137,989	220,783	86,652	112,648	108,135	-
10	21.3	21.7	C	112,566	168,850	14,004	16,805	152,045	-
11	21.7	25.0	A	477,734	859,920	121,828	170,560	689,361	-
12	25.0	29.1	A	739,024	1,330,243	132,483	185,476	1,144,766	-
13	29.1	29.4	C	14,176	21,264	9,863	11,836	9,428	-
14	29.4	30.0	A	143,540	258,372	6,370	8,919	249,453	-
15	30.0	35.0	A	1,062,540	1,912,572	207,073	289,903	1,622,669	-
16	35.0	40.0	C	626,127	939,190	117,330	140,796	798,393	-
17	40.0	45.0	C	709,361	1,064,041	131,888	158,265	905,776	-
18	45.0	50.0	C	643,682	965,524	150,614	180,736	784,787	-
19	50.0	55.0	C	30,342	45,513	142,209	170,651	(125,138)	(104,282)
20	55.0	60.0	C	240,946	361,419	172,486	206,984	154,435	-
21	60.0	63.8	C	430,946	646,420	144,927	173,912	472,507	-
22	63.8	65.0	A	21,146	38,062	57,437	80,411	(42,349)	(30,249)
23	65.0	70.0	A	837,401	1,507,321	150,834	211,168	1,296,153	-
24	70.0	71.2	A	254,878	458,780	19,374	27,124	431,656	-
25	71.2	75.0	C	1,051,114	1,576,671	45,179	54,215	1,522,456	-
26	75.0	75.12	C	6,296	9,444	368	442	9,002	
			Total	8,751,664	14,279,869	2,454,475	3,162,240	11,117,629	(335,614)

Source: JICA Study Team

(2) Supplement to Deficit in Fill

Excavated material is used in the same section from which it has been excavated, but the excavated material within TP 0 – 10km can be used in 10 km areas. The surplus material in section 1 is to be used for the total 267,395 m^3 of shortage for fill in section 2, 3, 4, 5 and 6 (KP 3.3 – 11.2 km). The necessary volume for fill in the sections is 320,874 m^3 (267,395 m^3 x 1.2). The surplus material in section 18 is to be used for the shortage of 104,282 m^3 of fill in section 19 (KP 50 – 55 km). The necessary volume for fill in the sections is 125,138 m^3 (104,282 m^3 x 1.2). The surplus material in section 21 is to be used for the shortage of 30,249 m^3 of fill in section 22 (KP 63.8 – 65.0 km). The necessary volume for fill in the sections is 36,299 m^3 (30,249 m^3 x 1.2).

(3) Usage of Quality Rock

Fresh rocks of Type A can be appropriate quality as aggregate / gravel, seeing that Type A rocks along NH40 are being excavated as aggregate / gravel by private companies. It is recommended that the fresh Type A rocks obtained by cutting in road construction should be used as aggregate / gravel.

In section 11, 12, 14, 15, 23 and 24, Type A rocks can be obtained as surplus material. Table 5-51 shows the estimation of the volume of good quality rocks in the sections. The estimation is based on Table 5-52 which shows rate of soil / rock for every type of rocks estimated by the JICA Study Team. The appropriate quality rocks of Type A are Rock A and Rock B in Table 5-52. As shown in Table 5-51, total 4,903,184 m3 of quality rocks may be obtained.

Table 5-51: Volume of Quality Rock in Type A

Section	KP		Rock Type	Volume of excavated material	Volume of quality Rock	Rate of Quality Rock
	from	to				
11	21.7	25.0	A	689,361	654,893	95 %
12	25.0	29.1	A	1,144,766	1,087,528	95 %
14	29.4	30.0	A	249,453	236,980	95 %
15	30.0	35.0	A	1,622,669	1,541,535	95 %
23	65.0	70.0	A	1,296,153	1,036,923	80 %
24	70.0	71.2	A	431,656	345,325	80 %
				Total	4,903,184	

Source: JICA Study Team

Table 5-52: Soil rock classification of proposed cutting volume

Classification of soil/ rock is according to "Schedule of Rate - PWD Assam"

KP		Rock Type	Soil A	Soil B	Rock A	Rock B	Rock C	Total
from	to		%	%	%	%	%	%
0	3.3	C (Cs)	50		50			100
3.3	5.2	A (Ss)	80		20			100
5.2	9.5	C (Cs)	80		20			100
9.5	11.2	A (Ss)	15		85			100
11.2	21.3	B (Mg)	50		50			100
21.3	22.0	C (Cs)	5		95			100
22.0	29.0	A (Ss)	5		85	10		100
29.0	29.4	C (Cs)	10		90			100
29.4	35.0	A (Ss)	5		70	25		100
35.0	63.8	C (Cs)	25		75			100
63.8	71.2	A (Ss)	20		75	5		100
71.2	end	C (Cs)	15		85			100

Source: JICA Study Team

* Soil / rock classification on "Schedule of Rate - PWD Assam"

Soil A Excavation in Hilly Area in Soil by Mechanical:
Excavation in soil in hilly area by mechanical means including cutting and trimming of side slopes and disposing of excavated earth with all lifts and lead upto 1000 metres.

Soil B Excavation in Hilly Area in Soil by Manual:
Excavation in soil in hilly area by manual means including cutting and trimming of

side slopes and disposing of excavated earth with all lifts and lead upto 1000 metres *Rock A Excavation in Hilly Area in Ordinary Rock by Mechanical:* *Excavation in hilly area in ordinary rock not requiring blasting by mechanical means including cutting and trimming of slopes and disposal of cut material with all lift and lead upto 1000 metres* *Rock B Excavation in Hilly Areas in Hard Rock Requiring Blasting:* *Excavation in hilly areas in hard rock requiring blasting, by mechanical means including trimming of slopes and disposal of cut material with all lifts and lead upto 1000 metres.* *Rock C Excavation in Hilly Areas in Hard Rock with controlled Blasting:* *Excavation in hilly areas in hard rock with controlled blasting, by drilling, blasting and breaking trimming of bottom and side slopes in accordance with requirement of lines, grades and crossection and disposal of cut road within all lifts and lead upto 1000 metres.*

(4) Volume of Spoil

The table shows the volume of spoil which is the material left over after subtracting the amounts of the material used for fill and the material used as quality rocks from the surplus material.
The total volume of spoil is 6,569,466 m^3.

Table 5-53: Volume of Spoil Per Sections

Sec-tion	KP		Rock Type	Surplus volume of material & necessary volume for fill	Volume of material used for fill in other section	Volume of quality rock utilized for aggregate	Volume of spoil
	from	to		m^3	m^3	m^3	m^3
1	0	3.3	C	597,000	(241,299)		355,701
2	3.3	5.0	A	(17,384)			-
3	5.0	5.2	A	(15,089)			-
4	5.2	9.5	C	(70,600)			-
5	9.5	10.0	A	(65,042)			-
6	10.0	11.2	A	(32,967)			-
7	11.2	15.0	B	51,820			51,820
8	15.0	20.0	B	552,669			552,669
9	20.0	21.3	B	108,135			108,135
10	21.3	21.7	C	152,045			152,045
11	21.7	25.0	A	689,361		(654,893)	34,468
12	25.0	29.1	A	1,144,766		(1,087,528)	57,238
13	29.1	29.4	C	9,428			9,428
14	29.4	30.0	A	249,453		(236,980)	12,473
15	30.0	35.0	A	1,622,669		(1,541,535)	81,133
16	35.0	40.0	C	798,393			798,393
17	40.0	45.0	C	905,776			905,776
18	45.0	50.0	C	784,787	(125,138)		909,925
19	50.0	55.0	C	(104,282)			-
20	55.0	60.0	C	154,435			154,435
21	60.0	63.8	C	472,507	(36,299)		508,806
22	63.8	65.0	A	(30,249)			-
23	65.0	70.0	A	1,296,153		(1,036,923)	259,231
24	70.0	71.2	A	431,656		(345,325)	86,331
25	71.2	75.0	C	1,522,456			1,522,456
26	75.0	75.12	C	9,002			9,002
					Total	4,903,184	6,569,466

Source: JICA Study Team

(5) Spoil Bank Location

The JICA Study Team selected locations for spoil banks along NH40 based on the following conditions as shown in Table 5-54.

- Locations should be close to NH40
- Topographically, small basins encircled by slopes or hills is recommended
- It should not be build-up areas nor in natural sanctuary areas.
- Formation of slopes formed by a spoil bank must be less than 30m in height, 1:2 (27 degree) in gradient with berm every 6 m in height

Table 5-54: Location and Capacity of Soil Bank Candidates

Section	KP		Volume of spoil	Location of candidate for spoil bank	Capacity of spoil bank
	from	to	m^3		m^3
1	0	3.3	355,701	2.3 km R500m	500,000
7	11.2	15.0	51,820	12.8 km R100m	80,000
8	15.0	20.0	552,669	15.87 -16.16 km L 12.5 km R120m 19.0 km R	180,000 100,000 350,000
9	20.0	21.3	108,135	20.72 km LR	300,000
10	21.3	21.7	152,045	20.88 km LR	
11	21.7	25.0	34,468	21.9 – 22.1 km L	100.000
12	25.0	29.1	57,238	28.2 km R	85,000
13	29.1	29.4	9,428		
14	29.4	30.0	12,473		
15	30.0	35.0	81,133	30.6 km L	100,000
16	35.0	40.0	798,393	27.85 km R 38.8 – 39.1km LR	100,000 700,000
17	40.0	45.0	905,776	44.76 km LR	1,100,000
18	45.0	50.0	909,925	45.7 km R	1200,000
20	55.0	60.0	154,435	56.85 km R	250,000
21	60.0	63.8	508,806	60.4 km LR	600,000
23	65.0	70.0	259,231	62.6 – 64.5 km L	315,000
24	70.0	71.2	86,331	70.7 km R100m end L350m	500,000 1,150,000
25	71.2	75.0	1,522,456		
26	75.0	75.125	9,002		

Source: JICA Study Team

5.3 Consideration of Climate Change Adaptation

5.3.1 India's Commitment to COP 21

India's statement made on COP 21, the so-called "Paris Agreement" on climate change has been ratified on 2nd October 2016. The GOI's statement on COP21 is summarized as follows:

a) Achieving an effective and equitable agreement on COP 21

The goal of limiting global warming to 2°C by 2050 in order to prevent catastrophic outcomes must be achieved by drastically cutting down Greenhouse Gas (GHG) emissions due to anthropogenic (human) activity. Thus, ensure a rapid reduction in carbon emissions to keep global warming below 2°C.

In case of developing countries like India, adaptation to climate change measures is extremely essential. Thus, the GOI seeks cooperation from the international community to provide sufficient support to the developing countries under this agreement, to increase their adaptive capacity.

b) Taking suitable initiatives at the National/Domestic level

The GOI commits to motivate its national and state governments to promote inclusive and sustainable development in India, by ensuring synergy between economic growth and environmentally sustainability.

The GOI also commits to working towards the establishment of suitable legislative, regulatory, policy and financial measures for ensuring large-scale use and dissemination of low carbon technologies and implementation of Intended Nationally Determined Contributions (INDCs).

c) Enhancing low carbon development at the local level

Given the immense influence legislators have at local level, the GOI commits that:

- Planning and development should take into consideration resilience to climate change and adaptive capacity;
- Demonstrate, implement and scale up low carbon development projects in constituencies and state in order to strengthen the overall development programs for the mitigation of drastic climate changes;
- Promote awareness and understanding about climate change and other environmental issues among the local population; and
- Promote uptake of sustainable consumption of energy, natural resource conservation and waste management practices by the citizens of the country.

5.3.2 Greenhouse Gas Emissions of Road Development Projects

Every single development interventions including road development projects causes significant amounts of GHG emissions. The World Bank has put out "Greenhouse Gas Emissions (GHG) Mitigation in Road Construction and Rehabilitation" in November 2010. It addresses the GHG emissions resulting from transport development and restoration activities.

Road construction projects contribute to the production and release of GHG emissions as a result of: 1) site clearing; 2) preparation of the sub-grade; 3) production of construction materials (i.e. granular sub-base, base course, surfacing) and their site delivery; 3) construction works with heavy construction plants; and 4) supervision and maintenance activities of the roads.

The aggregate GHG emissions for a road construction project can be calculated depending on the use of equipment, local geographic and biological conditions, as well as standard construction and maintenance practices of each project. As is indicated in the table below, the World Bank released a standardized GHG emission calculation for road construction projects. Within the framework of this project, overall GHG emission is calculated as follows:

794 (t CO2 eq./km) x 74.63 km = 59,256 t (CO2 eq.)

Table 5-55: Typical GHG Emissions of Road Construction Project

Parameter \ Category of Road	Express-way	National Rod	Provincial Road	Rural Road (Gravel)	Rural Road (Dirt)
Emissions (t CO2 eq./km)	3,234	794	207	90	103
Factor Equivalent to Expressway	100	25	6	3	3

Source: "Greenhouse Gas Emissions Mitigation in Road Construction and Rehabilitation" 2010, WB

5.3.3 Measures Adapted for GOI's Commitment for Climate Change

(1) Construction Industry and Practices

The construction industry related to road construction projects are generally dominated by local contractors using substandard plants and equipment. These construction machineries are usually lacking the capabilities to implement the latest construction methods and practices.

The involvement of foreign contractors, which could help promote technology transfer, has been limited to projects of a large scale. Quality control or so-called "Kaizen" approaches are not widespread and modernization of construction machineries is practically non-existent.

Procurement practices usually do not consider GHG emissions as a criterion for bids by looking into whether a contractor has the plants and equipment to minimize emissions. Environmental management policies, either governed by local regulations or by donor/MDBs guidelines, do not require GHG monitoring during construction, however it would increase in the near future because of the world commitment on COP 21. Thus the following is recommended:

a) Environmental Clearance of GOI should be developed so as to legitimize monitoring works of GHG emissions during the construction period;
b) The contract agreement should clearly state that the construction plants and machineries are routinely maintained in order to minimize GHG emissions; and
c) Environmental monitoring work of this project should include GHG emissions.

(2) Carbon Sequestration of Trees

Because 59,256 t (CO2 eq.) of GHG emission is expected to be generated by the implementation of the project, tree planting as one of the project components should be carried out as follows:

1 ton of carbon = 3.666 tons of CO_2

Where: Carbon dioxide (44) divided by the atomic mass of carbon (12).

125.5 metric tons of carbon per ha of forest x 3.666 tons of CO_2 = 460.2 metric tons of CO_2 per ha of forest. Thus:

It is estimated that 1 ha of trees contains 125.5 metric tons of carbon[22]. Thus:

[22] Sources of Carbon Sequestration Calculations as follows:
1) United States Department of Agriculture, Forest Service, Methods for Calculating Forest Ecosystem and Harvest Carbon with

59,356 t (CO2 eq.) / 460.2 metric tons of CO_2 per ha = 128.98 ha of forest development

Therefore 10 ha/year of forest area developed over 13 years should compensate the GHG emissions made by the implementation of the project.

(3) Compensatory Tree Planting for the Forest Areas Cleared for the Project

Within the framework of the global climate change measures, compensatory tree planting area should be developed. The area for tree planting should generally be the same area of forest that was cleared as a result of the bypasses inserted for the improvement of NH-40.

At present, approximately 231 ha of the total land area subject to acquisition, of which approximately 123 ha is forest. The rest are agricultural fields and residential areas. Thus, additional afforestation area of 123 ha for the compensation of the lost forest area should be allocated and carried out by Meghalaya State Environment and Forest Department in order to successfully complete the project. Afforestation area could be allocated in the grassland area where traditionally thrush-and-burn agriculture practice was carried out.

Standard Estimates for United States Forest Types, 2006, http://www.treesearch.fs.fed.us/pubs/22954.

2) US Department of Agriculture, Forest Service, Carbon Storage and Accumulation in United States Forest Ecosystems, 1992, http://www.nrs.fs.fed.us/pubs/gtr/gtr_wo059.pdf.

【Note】
The information related to bidding has been deleted.

CHAPTER 6 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

6.1 Introduction

6.1.1 Background of the Project

In India, road is one of most important modes of ground transportation as it constitutes 85% of passenger and 60% of freight transported in India. However, development of road network in mountainous regions of Northeastern Region of India has been much worse than the rest of India. This is due to financial and technical reasons. Thus Northeastern Region suffered greater economic disparity comparing to other areas of India.

While 63.4% of the road in India has been paved, only 28.5% of the road in Northeastern Region is paved out of which 53% of national highways are more than 2-lane road. This is because the Northeast Region is located far from major part of India. Further, the roads leading to neighboring countries have been underdeveloped due to security concerns.

Severe natural conditions of Northeastern Region featured by steep mountainous and prolonged monsoon season have been obstacles to appropriate endeavor of road network. Acceleration of economic growth in this part of the country has therefore been much delayed. The regional connectivity of the road network should promote cross-border trade and commerce and help safeguard India's international borders. This would lead to a formation of more integrated and economically consolidated South and Southeast Asia. In addition, there would be overall economic benefits for the local population and help integrate the peripheral areas.

Approximate aggregate length of 10,000 km over the Northeastern Region has been identified to begin with for development. The road network envisages creating customized and specialized skills in terms of addressing issues like complexities of geographical terrains and addressing extensive coordination with various central and state governments.

The Government of India (GOI) thus launched in recent years "Special Accelerated Road Development Program for Northeastern Region" for which improvement of the road network is of great importance. GOI committed in "Twelfth Five Years Plan (from April, 2012 to March, 2017)" that the improvement of national highways in Northeastern Region should interconnect major cities within the region. Thus GOI requested Government of Japan to provide assistance in developing 10 routes in Northeastern Region, where NH54, NH51 and then NH40 were prioritized considering consistency with the upper plan, project maturity, traffic demand, and EIRR as evaluation criteria.

6.1.2 Purpose and Objectives of the Study

As per India's MOEFCC EIA Notification dated 14.09.2006 (as amended in August 2013), any highway project falls under Category A is obliged to carry out EIA Study if the project entails:

1) New National Highways; and
2) Expansion of National Highways greater than 100 km involving additional right of way or land acquisition greater than 40m on the existing alignments and 60m on re-alignments and bypasses.

On the other hand, the proposed expansion & widening of NH-40 does not involve additional land acquisition beyond 30 m and its length of widening including inserting bypasses is less than 100 km i.e. the Project is not a Category A project as defined in the EIA Notification of 2013 of India.

While DPR consultants in India undertook a preliminary environmental assessment during the preparation of the DPR for NH-40, because of the project is funded by JICA, it has been classified as Category A as per JICA's Guidelines for the Environmental and Social Considerations i.e. the project requires a full EIA study including SIA and RAP survey.

It is therefore JICA Study Team's obligation to carry out EIA/SIA/RAP studies, which supplement the environmental studies carried out by DPR consultants of India. Thereby additional requirements short of JICA's guidelines are fulfilled.

The EIA/SIA/RAP studies carried out by JICA Study Team aimed to:

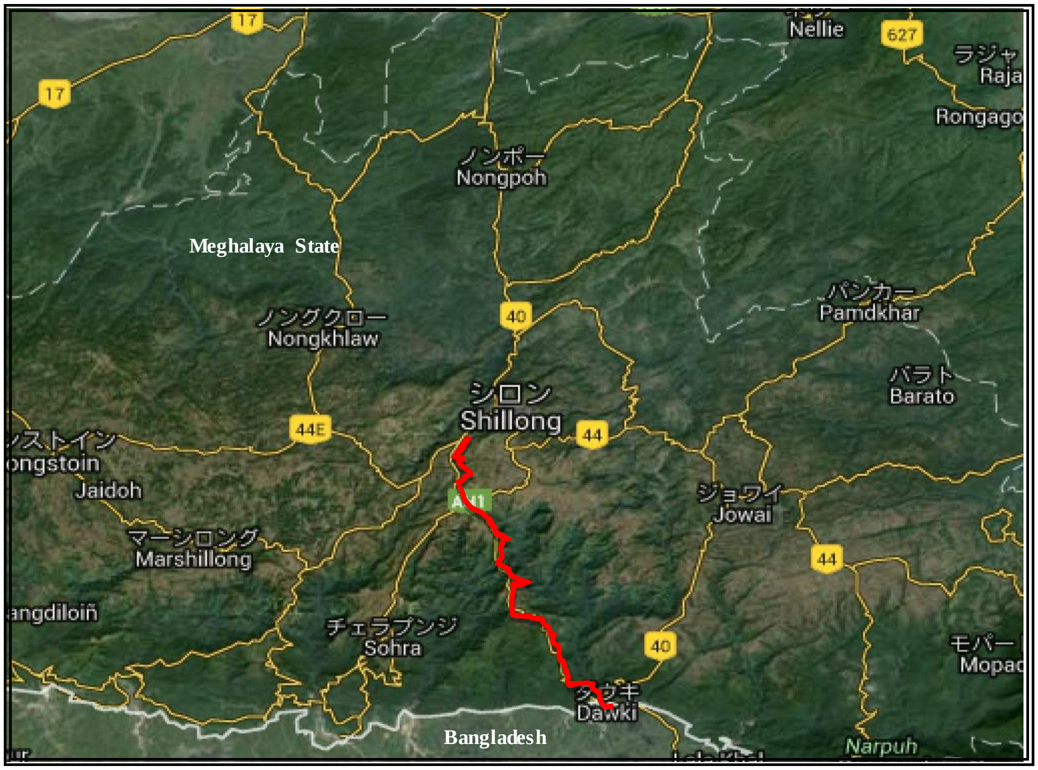
- Review the environmental assessment undertaken as part of the DPR study;
- Identify gaps between Indian laws and regulations relating to the EIA study and JICA Guidelines for Environmental and Social Considerations;
- Study the baseline of social and environmental conditions along the areas directly and indirectly affected during design, construction operation and maintenance of the NH-40 widening project;
- Carry out environmental impact analysis with respect to the proposed project;
- Identify environmental issues that require further studies;
- Carry out analysis of alternatives including comparison with a "no project' scenario;
- Develop cost effective measures for mitigating adverse environmental and social impacts and enhancing positive aspects;
- Develop an Environmental Management Plan (EMP) for the mitigation of environmental impacts and monitoring of the implementation of mitigation measures during the operation and maintenance period;

Consult and inform the project affected persons (PAPs) and other stakeholders concerned with the project to encourage their active participation.

6.1.3 Description of the Project

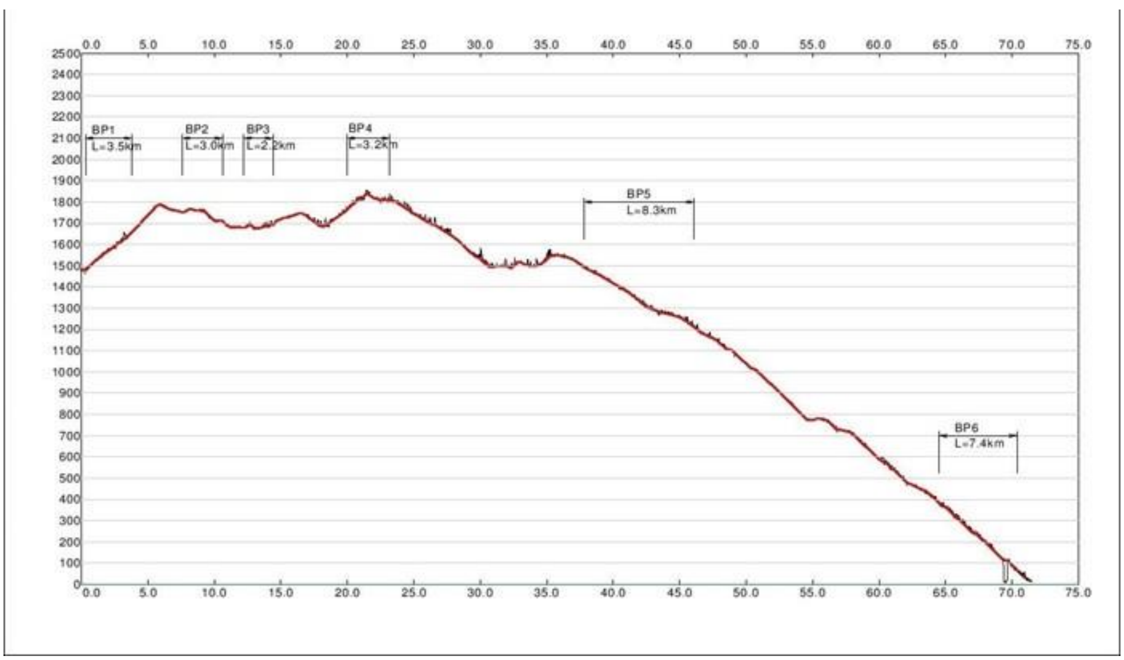
The Shillong-Dawki section of NH-40 stretches approximately over 71.5 km from the capital city of Shillong, Meghalaya State, to the border town of Dawki located on the border between India and Bangladesh. While Shillong is located on the plateau of 1,525 m above sea level, Dawki is on the plane of 35 m above sea level on the border area between India and Bangladesh. Thus NH-40 initially begins in the highland area of 1,525 m, passing through approximately 1,800 m asl highland area and gradually go down to 35 m asl as is shown in Figure 6-1 and Figure 7-2 エラー! 参照元が見つかりません。.

At present the road conditions of NH-40 is in good condition with footpath on both side of the road and drainage system in places up to the area of Eastern Air Force Headquarters. The length is approximately 8 km from the starting point while this section is climbing the mountain slope to 1,800 m asl thereafter the width of road, without road furniture, is maintained in general two lanes up to 61 km post climbing down East Khasi Hills. The last 6-7 km section of NH-40 is particularly narrow without appropriate road furniture causing traffic congestion going out to Bangladesh and coming into India. Thus improvement of NH-40 with wide and appropriate road furniture appears to be urgently needed.



Source: JICA Study Team

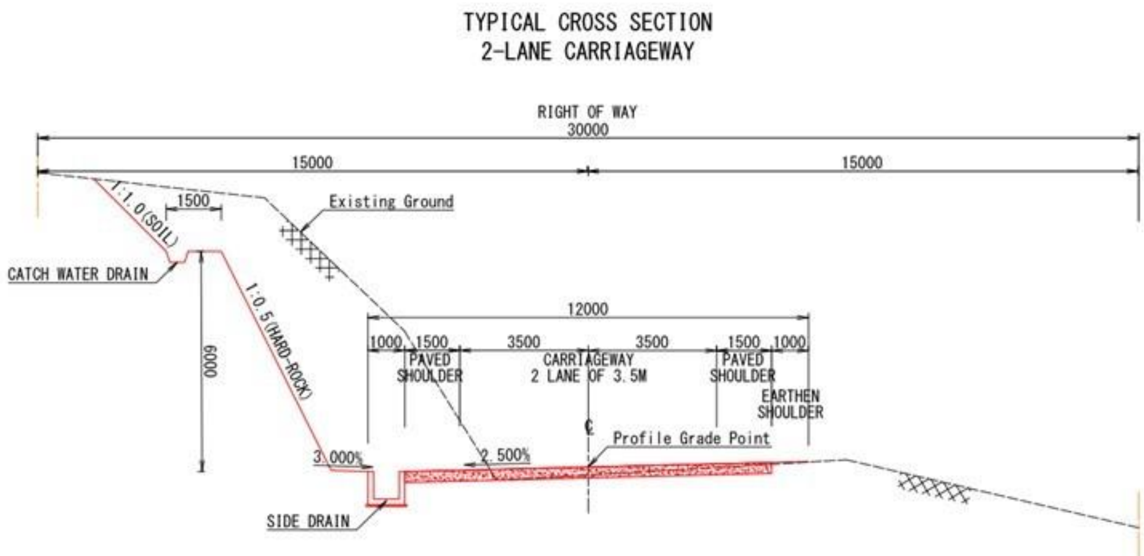
Figure 6-1: Location of the Project Area (NH40)



Source: JICA Study Team

Figure 6-2: Profile of the Project Area

As Figure 7-3 エラー! 参照元が見つかりません。 shows, the Right of Way (ROW) of the new NH-40 has to be 30 m wide in general throughout the project area. In some places, ROW of 30 m wide would not be able to maintain or not necessary to acquire additional land. Thus depending on the locations no land acquisition takes place. Within the framework of the Project, urban and rural built-up areas, mountain forest, grassland, limestone quarries are directly affected along the proposed bypasses & parallel alignment, local built-up areas would be involved in the resettlement of the local residents. To some extent, land acquisition for the bypasses would cause local farmers becoming landless depending on the area of farming areas subject to land acquisition for ROW.



Source: JICA Study Team

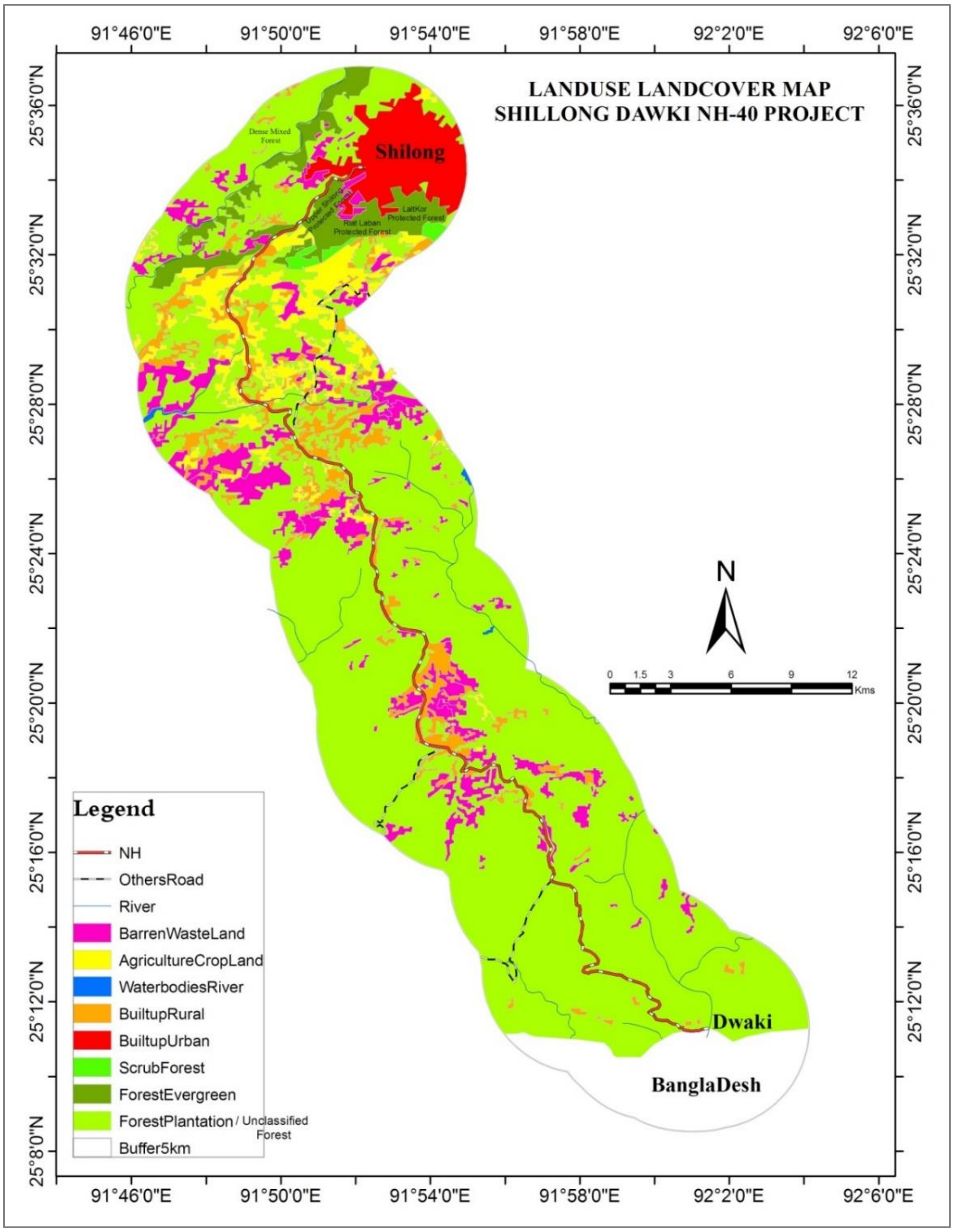
Figure 6-3: Typical Cross Section of the Hillside Road of NH-40

6.2 Scope of the Study

6.2.1 Geographical Extent of the Impacts

As Figure 6-1 and Figure 6-2 show, the length of the project area is 71.5 km. Because of the Wildlife Protection Law of India states, extent of impact area must be 5 km radius from the centerline of the road construction project as per Figure 6-4.

6.2.2 Study Components of Natural Environment and Socio-economic Environment



Source: SOI Toposheets, Resourcesat I – LISS-III Image

Figure 6-4 Geographical Extent of the Environmental Study

As is shown in Figure 6-4, the entire length of NH-40 is 71.5 km and it is the primary area of study including the area within 5 km radius, which is compulsory study area according to India's wildlife protection act, from the centerline of NH-40.

While this project is a road improvement project of the existing NH-40, it involves 6 locations of bypasses that are generally the new road construction works that a large area of forestland has to be cleared. Thus environmental components subject to study are meteorology, geography and geomorphology, geology, soil erosion, hydrology and groundwater, forest and plant biology, wildlife and wildlife conservation areas, aesthetic value of land scape and natural disaster prone areas. For the environmental pollution, air quality; water quality; soil; solid waste are all studied in terms of their effect on the environment in conjunction with the implementation of the Project.

While main aim of this project is to improve NH-40, there are six bypasses subject to new construction in the rural area including built-up area of human settlements, forested areas and agricultural fields. There are impacts induced by the road construction project on the air quality, water, soil, solid waste, traffic accidents, water rights, climate change, fauna and flora, public hygiene and safety, and involuntary resettlement that are taking place within the scheduled tribal area of Kashi living on the East Kashi Hill of Meghalaya State.

6.2.3 Legal Framework Related to the Project

Legal framework of the Government of India including those of Meghalaya State that depict impacts induced to the environment and socio-economic conditions by the Project is widely studied. There are JICA Guidelines as well as World Bank and ADB safeguard policies that have to be studied in relation to the laws and regulations of the Government of India including those of Meghalaya State that are dealing with scheduled tribe as minority of the country.

6.2.4 Resettlement

Because of the Project is taking place in its entirety within the territory of Khasi Tribe and a part in Jaintia Tribe's territory, who are two of the minority groups of India and that they are subject to resettlement, study on the involuntary resettlement is important in terms of the successful implementation of the Project. Thus, information dissemination on the Project's plan through stakeholder dialogues, where resettlement agreement has to reach among the project-affected households (PAHs).

Those who are subject to resettlement should be given ample supply of resettlement compensation, employment opportunities and enhancement of livelihood, be it traditional or modern. On the hand, there are a number of issues such as land and natural resource use of the tribal/clan areas, local tribal organizations including social and NGO organizations, gender relationships, women in development, child rights, cultural and traditional heritage, advantages and disadvantages on the interests of different local groups, HIV/AIDS, direct and indirect impacts induced by the project implementation, cumulative and intensifying impacts of the project otherwise improvement of economic conditions in the rural area as a whole. These issues are studied as a whole in relation to the project implementation of 2-lane improvement of NH-40.

Resettlement plan has to be drawn based on the laws and regulations of the Government of India. LARR 2013 is especially important act for drawing clear picture of resettlement action plan. However, JICA Guidelines including World Bank's Safeguard policy, such as OP4.12 Annex A and B should also be referred to. Regarding the scheduled tribe of Khasi and Jaintia, elements of Indigenous People's Plan (IPP) has to be examined in resettlement plan. This has to be examined against the laws and regulations of India in terms of its appropriateness comparing the safeguard policies of World Bank.

During the process of resettlement dialogue for agreement based on the World Bank's policy on the replacement basis for which lost asset has to be compensated, contents of further resettlement package of enhancing livelihood and increasing opportunities for employment and other benefit has to be generally agreed. PAHs will have to be supported in different way at the time of resettlement. In order to monitor the livelihood of PAHs after resettlement, 3-5 years of monitoring works should be included in the resettlement study for which every PAH is satisfied after the resettlement.

6.3 Baseline Data of the Natural and Socio-economic Environment

6.3.1 Natural Environment

(1) Climate

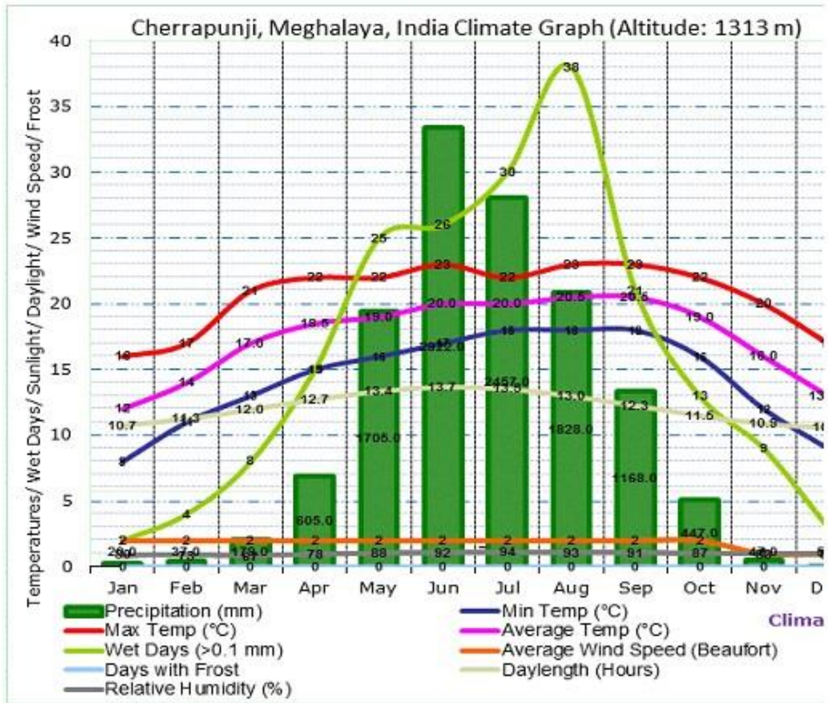
Meghalaya falls in the tropical monsoon climate zone, which varies from the western to eastern parts of the state. Table 6-1 and Figure 6-5 show climatic conditions of Meghalaya state. The indicated precipitation is the data recorded in Cherrapunji in Meghalaya, which is located approximately 10 km to the west of NH40 and is where the world's highest rainfall is recorded.

As is shown, almost all of the rainfall occurs in the period between April – October. It is also noteworthy that the average number of hours the sun shines is incredibly low, at 12 hours a month. Because the state is in a high altitude area, temperatures are cool compared to the flat areas of India. The data on the wind speed and direction have been collected for Shillong from Indian Metrological Department (IMD) during April to June, 2016.

Table 6-1: Precipitation in Meghalaya State

Parameters	January	February	March	April	May	June	July	August	September	October	November	December	Annual Average
Average High Temperatures (°C)	16	17	21	22	22	23	22	23	23	22	20	17	21
Average Low Temperatures (°C)	12	14	17	19	19	20	20	21	21	19	16	13	17
Average Precipitation (mm)	20	37	179	605	1705	2922	2457	1828	1168	447	47	5	11420
Average Sun Shine Hours	11h 44m	11h 15m	11h 57m	12h 43m	13h 21m	13h 40m	13h31m	12h 59m	12h 15m	11h 30m	10h52m	10h 34m	12h 00m

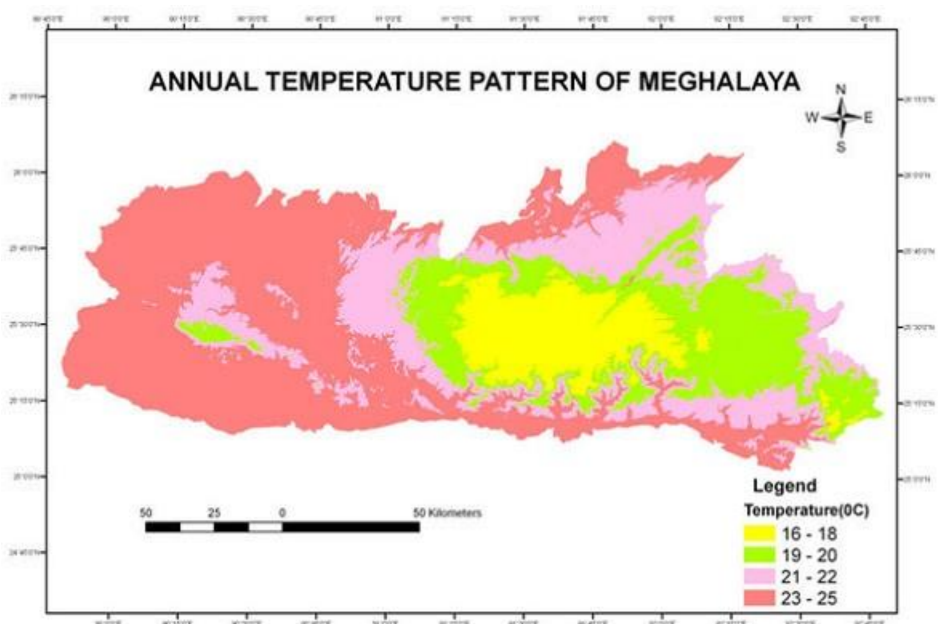
Source: http://www.meghalaya.climatemps.com/precipitation.php



Source: http://www.meghalaya.climatemps.com/precipitation.php

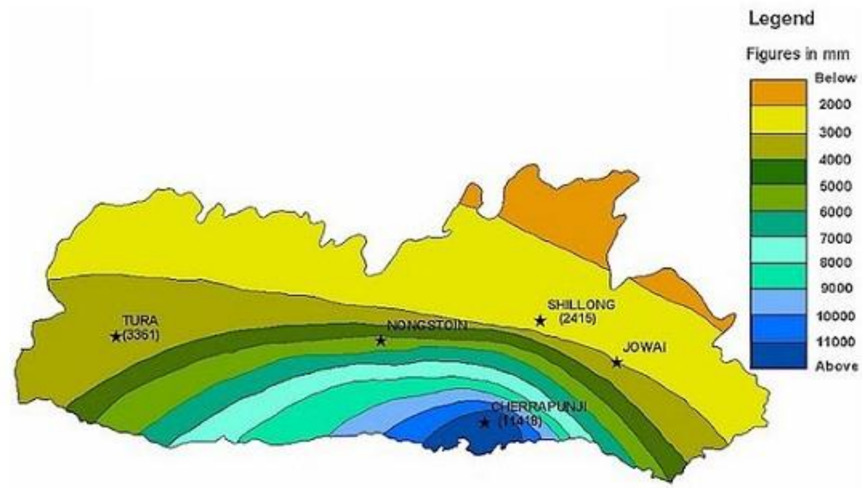
Figure 6-5: Precipitation and Temperatures of Meghalaya State

Figure 6-6 and Figure 6-7 show rainfall patters in Meghalaya. Because of the highland area in the eastern half of Meghalaya state and monsoonal rainfall generally comes from the Bay of Bengal in the south, the southern half of East Khasi Hill receives a significant amount of rainfall as shown above.



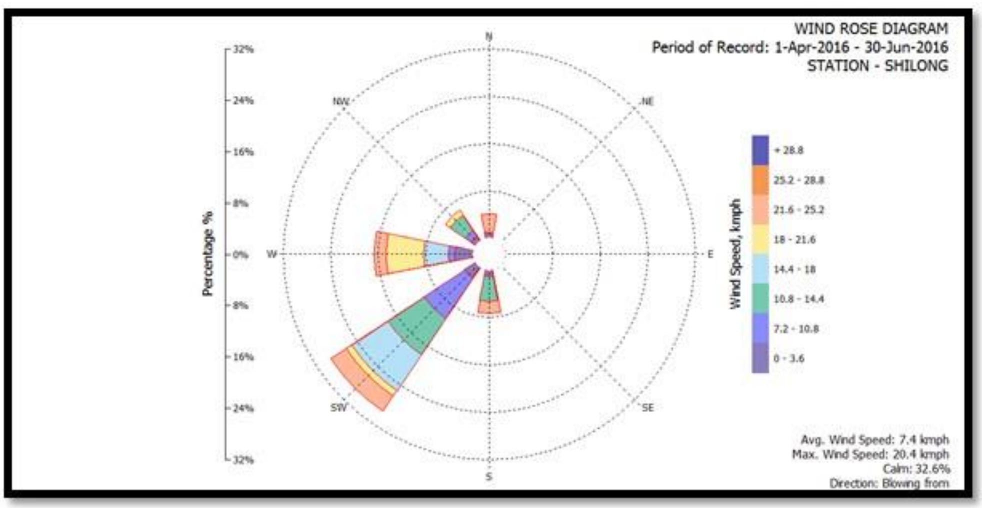
Source: http://www.meghalaya.climatemps.com/precipitation.php

Figure 6-6: Temperature Patterns of Meghalaya State



Source:http://www.meghalaya.climatemps.com/precipitation.php

Figure 6-7: Rainfall Patterns of Meghalaya State



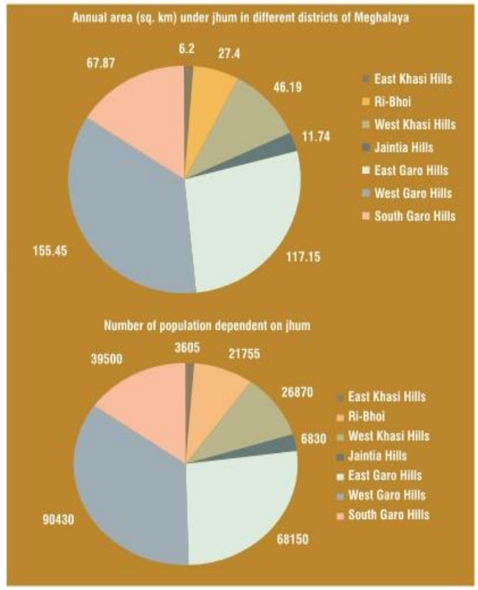
Source: IMD

Figure 6-8: Windrose Diagram

(2) Land Use

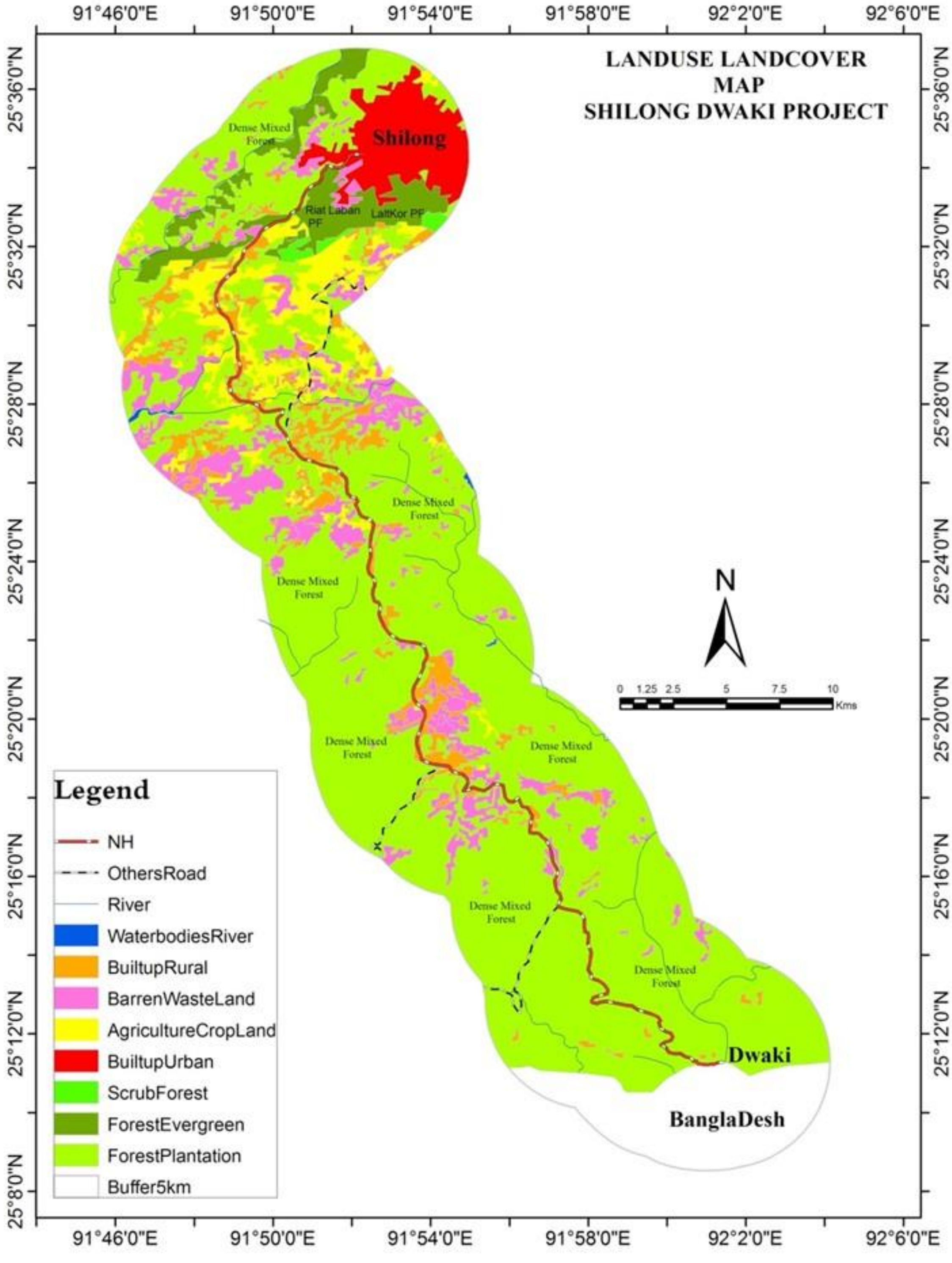
Figure 6-9, Figure 6-10 and Table 6-2 show land use patterns of Meghalaya state. While relatively cool temperatures are suitable for the dairy industry, there are no pastures and grazing areas in Meghalaya state. Modern agricultural areas in Meghalaya state are on the rise at the cost of thick forested areas while in the western half of Meghalaya state, slash and burn agriculture is still maintained as one of the major means of growing staple foods.

There is not much slash and burn agriculture in the area along NH40. The East Khasi Hill District, where most parts of NH40 goes through, accounts for 6.2 % of the slash and burn agricultural land of Meghalaya state while in the western half of the state, slash and burn agriculture is still prominent.



Source : State of Environment Report 2005, Meghalaya State Government

Figure 6-9: Area under Slash and Burn agriculture in Meghalaya



Source: JICA Study Team based on Meghalaya State Department of Agriculture

Figure 6-10: Agricultural Land Use of the Project Area

Table 6-2: Land Use in Meghalaya State

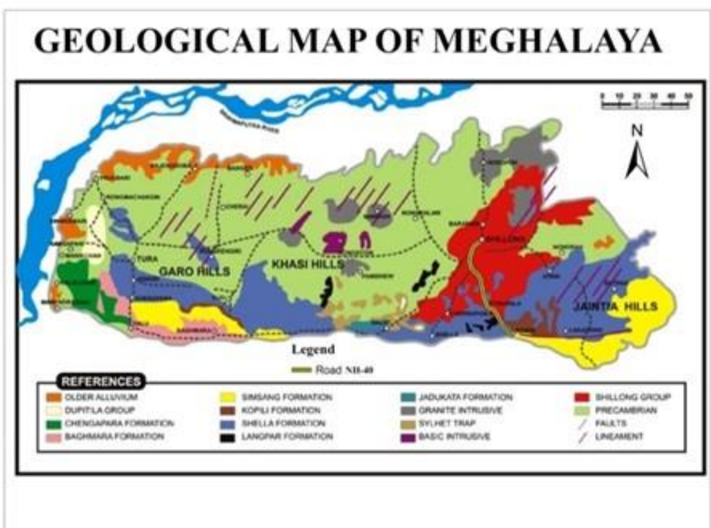
Land Use	Area in '000 ha	Percentage
Total geographical area	2,243	
Reporting area for land utilization	2,227	100.00
Forests	948	42.57
Not available for cultivation	226	10.15
Permanent pastures and other grazing lands	0	0.00
Land under misc. tree crops and groves	160	7.18
Culturable wasteland	393	17.65
Fallow lands other than current fallows	157	7.05
Current fallows	59	2.65
Net area sown	284	12.75

Source: Land Use Statistics, Ministry of Agriculture, GOI, 2008-09.

(3) Geography and Geology

The proposed alignment passes through the western area of East Khasi Hills and west to southern area of Jaintia Hills District of Mehgalaya state. Topography of the state is mostly hilly with deep gorges and ravines in the southern portion. The most important physiographic features of the area is the Shillong Plateau interspersed with river valleys, then the sharp fall in the southern portion forming deep gorges and ravines in Mawsynram and Shella-Bholaganj bordering Bangladesh.

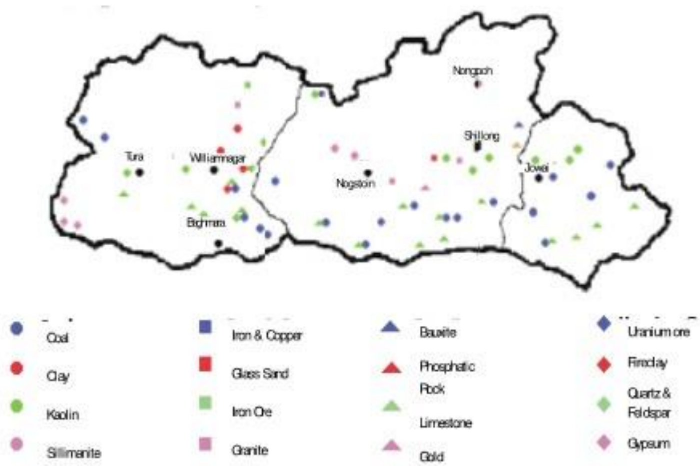
The geology of Meghalaya consists of older and stable rock types, which are resistant to weathering, mostly belonging to periods of Archean Genessic complex, Shillong Groups of rocks, Lower Gondwana rocks, Sylhet Traps, and Cretaceos-Tertiary sediments. The layers of land surface in the project area mainly comprises of Schist, Gneisses, Quartzite, sand stone, Shale, Lime, Stone, Granite, Granodiorite and Pegmatite. The geological map of the Meghalaya is shown in Figure 6-11.



Source: Department of Mining & Geology, Government of Meghalaya

Figure 6-11: Geological Map of Meghalaya State

In recent years, Meghalaya State Government began exploiting mineral resources. As is shown in Figure 6-12, the area to the south of Shillong is rich with limestone, coal and some uranium.



Source: State of Environment Report 2005, Meghalaya State Government

Figure 6-12: Mineral Resources in Meghalaya State

(4) Hydrogeology

According to the Central Ground Water Board, the district of East Khasi Hills is covered mainly by crystalline rocks with Tertiary sedimentary rocks. The secondary porosity in consolidated formation e.g. fractures, joints, etc., developed due to tectonic movements and was exposed to prolonged physicochemical weathering, then formed the conduits as well as ground water reservoirs.

The weathered mantle varies from 10 to 30 m bgl. Ground water is found under the water table in the top weathered quartzite and in semi-confined spaces in the fractured and jointed rocks. At locations that are hydro geologically feasible, a well drilled down to the depth of about 80 -150 m below ground level may yield a moderate discharge of 5-15 m 3 /hr in Archaean and Pre-Cambrian Group of rocks. The depth to water level is between 2 and 15 m bgl.

The valley areas are found to be favorable for the construction of dug wells and bore wells in other steep areas. The zones are not uniform in that the aquifer material, fracture density, and distribution and hydrogeological characteristics vary widely over short distances. Consequently, their water yielding capabilities vary considerably.

Ground water development in the district is mainly through dug / open well tapping of water in the weathered zone and bore wells are constructed to tap ground water from the fractures / joints in the hard rocks. In the shallow aquifer, the depth to water level ranges from less than 2 m bgl to 6 m bgl. Springs play a major role in meeting the water needs of the people throughout the year. Most of the springs are gravity springs. It is observed that discharge of most of the springs lie within the range of 5,000-25,000 lpd in pre and post monsoon periods.

6.3.2 Living Environment and Pollution Control Measures

Based on the above environmental standards set up by CPCB, Meghalaya State's SPCB carries out various environmental monitoring works periodically. The following is selected result of latest monitoring works of Meghalaya State.

(1) Water Quality

Based on the national standards set up by CPCB, Meghalaya State's SPCB carries out water quality monitoring works as per Table 6-3

Table 6-3: Water Quality Monitoring Works of Meghalaya State

Name of Stations	Location	Frequency	Parameters Analysed on a Regular basis	Parameters Analysed once a year
1 Surfce Water			i) Field Observation: Weather, Colour & intensity, Odour, Visible effluent discharge, human activities around station, ii) Physico-chemical & bacteriological parameters: Dissolved Oxygen, pH, Conductivity, Biological Oxygen Demand, Nitrate Nitrogen, Nitrite Nitrogen, Total and Fecal Coliform iii) Biomonitoring: Saprobity Index, Diversity Index	Turbidity, Alkalinity, Total Hardness, NH3-N, Kjeldahl-N, Calcium, Magnesium, Potassium, Sodium, Sulphates, Phosphates, COD, As, Zn, Cu, Cr, Cd, Pb, Fe, Ni, Flouride and Boron.
Umtrew River	Byrnihat	Quaterly		
Kyrhukhla river	Khliehriat	Quaterly		
Umiam Lake	Umiam	Quaterly		
Ward's Lake	Shillong	Quaterly		
Thadlaskein Lake	Thadlaskein	Quaterly		
Myntdu River	Jowai	Quaterly		
Ganol River	Tura	Quaterly		
Simsang River	Williamnagar	Quaterly		
2 Ground Water				
Police Bazaar Spring	Shillong	Half Yearly		
Mawpdang Spring	Shillong	Half Yearly		
Wah U Dkhar	Sohra	Half Yearly		
Umsahep Spring	Shangpung	Half Yearly		
Narbong Well	Byrnihat	Half Yearly		

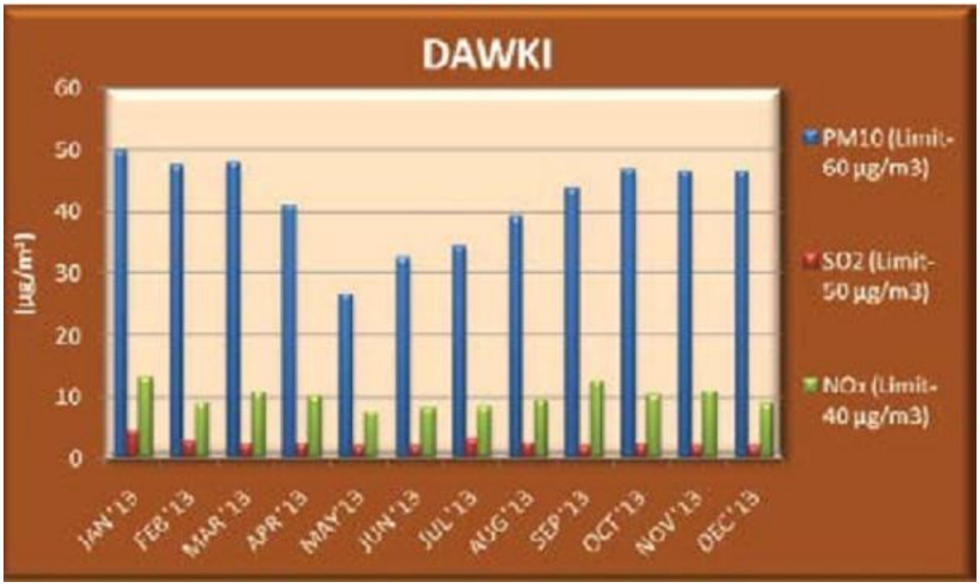
Source: MSPCB

(2) Air Quality Monitoring

Meghalaya State's SPCB carries out air monitoring works at 8 strategic point within the state. SO2, NOx and PM10 are monitoring periodically. As a sample, Figure 6-13 shows air quality monitoring works carried out in Shillong and Figure 6-14 in Dawki.

Source: Meghalaya Pollution Control Board

Figure 6-13: Air Monitoring Result in Shillong, Meghalaya



Source: Meghalaya Pollution Control Board

Figure 6-14: Air Monitoring Result in Dawki, Meghalaya

(3) Vehicular Emission

Meghalaya State's SPCB monitors vehicular emissions based on the standard set out by CPCB. One of the standards of vehicular emission, Table 6-4 shows the number/percentage of vehicles in the state that comply with the national standards for emission standards.

Table 6-4: Air Quality Monitoring Works of Meghalaya State

PERIOD	TYPE OF VEHICLES	TOTAL NO. OF VEHICLES TESTED	PERCENTAGE PF VEHICLES COMPLYING TO EMISSION STANDARDS	PERCENTAGE NOT COMPLYING TO EMISSION STANDARDS
01/04/2009 to 31/03/2010	Petrol Driven	1287	95%	4.10%
	Diesel Driven	22	100%	0%
01/04/2010 to 31/03/2011	Petrol Driven	1154	99.80%	0.20%
	Diesel Driven	9	100%	0%
01/04/2011 to 31/03/2012	Petrol Driven	2524	97.70%	2.30%
	Diesel Driven	722	96.20%	3.70%
01/04/2012 to 31/03/2013	Petrol Driven	2231	93.00%	6.90%
	Diesel Driven	1497	91.60%	8.40%
01/04/2013 to 31/03/2014	Petrol Driven	3725	95%	5%
	Diesel Driven	1473	92.90%	7%
01/04/2014 to 31/03/2015	Petrol Driven	3506	98.80%	1.20%
	Diesel Driven	1428	95.40%	4.60%
01/04/2015 to 31/03/2016	Petrol Driven	6524	99%	1.00%
	Diesel Driven	2399	93.20%	6.80%

Source: Meghalaya Pollution Control Board

(4) Noise Monitoring

Meghalaya State's SPCB monitors ambient noise within the city/built-up area before and during the holiday and political events as loud speakers are generally used for political slogans etc. During the national holiday of Deepawali Festival where a large number of fireworks are carried out, noise pollution is also a major concern of the general public. There is no evidence monitored by Meghalaya State's SPCB on the diesel generators, vehicles, etc.

(5) Soil Contamination

Meghalaya State's SPCB monitors heavy metals discharged into rivers within the state, which is discharged from the public solid waste dump. Table 6-5 shows the result of the analysis of soil components.

Table 6-5: Soil Contamination of Meghalaya State

No	Monitoring stations/sampling source	Purpose	Parameters Analysed
1	Mawiong Municipal dumping ground, Shillong	Quality of the Compost	Heavy Metals
2	National Water Monitoring Programme (NWMP)	Quality of the Sediment	Heavy Metals
	1) Umtrew River	Quality of the Sediment	Heavy Metals
	2) Kyrhukhla River	Quality of the Sediment	Heavy Metals
	3) Umiam Lake	Quality of the Sediment	Heavy Metals
	4) Ward's Lake	Quality of the Sediment	Heavy Metals
	5) Thadlaskein Lake	Quality of the Sediment	Heavy Metals
	6) Myntdu River	Quality of the Sediment	Heavy Metals
	7) Ganol River	Quality of the Sediment	Heavy Metals
	8) Simsang River	Quality of the Sediment	Heavy Metals

Source: Meghalaya Pollution Control Board

6.3.3 Socio-economic Environment

(1) Population, Language and Religion

1) Meghalaya

Prior to 1970, this state was an integral part of undivided Assam, and the capital city Shillong was the capital of Assam. On 2nd April 1970, Meghalaya was created as an autonomous state, and got the full-fledged state status on January 21st 1972. The state of Meghalaya is bound on the north by Goalpara, Kamrup, Nagoan and Karbi Anglong districts of Assam state, and on the east by the Districts of Cachar and North Cachar Hills, also of the state of Assam. On the south and west sides of the state is Bangladesh.

The total area of the state is 22,429 square kilometers. The state is now divided into eleven administrative districts. They are: (i) West Jaintia Hills District, (ii) East Jaintia Hills District, (iii) East Garo Hills District, (iv) West Garo Hills, (v) North Garo Hills District, (vi) South Garo Hills District, (vii) South West Garo Hills District, (viii) East Khasi Hills District, (ix) West Khasi Hills District, (x) South West Khasi Hills District, and (xi) RiBhoi District. They are predominantly inhabited by the Khasi, the Jaintia and the Garo people. Shillong is the state capital and also the district headquarters of East Khasi Hills district and is situated at an altitude of 1,496 meters above sea level. The demographic profile of Meghalaya is presented in Table 6-6.

Source: JICA Study Team

Figure 6-15: Map of Meghalaya State

Table 6-6: Demographic Profile of Meghalaya State

Description	Census 2011
Population	2,966,889
- Male	1,491,832
- Female	1,475,057
Population Growth (Decadal)	27.95%
Population density Persons/sq km	132
Sex Ratio	989
Percentage of total population of India	0.24%
Literacy	74.43 %
- Male literacy	75.95 %
- Female literacy	72.89 %

Source: Census 2011

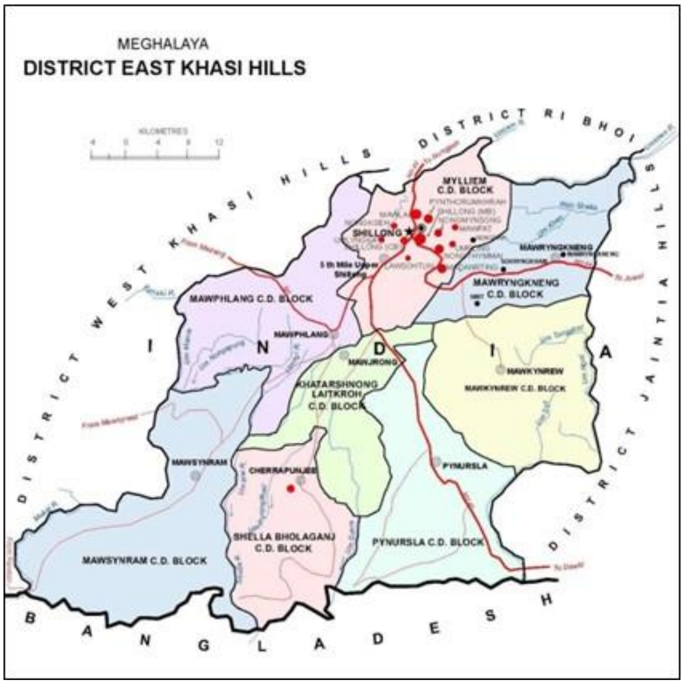
The Meghalaya Language Act states that the Khasi language may be used as the associate official language for all purposes in the district, sub-divisions and block level offices of the state government located in the districts of East Khasi Hills, West Khasi Hills, Jaintia Hills and Ri Bhoi, while English is the official language of the state. The Garo language may be used as the associate official language for all purposes in the districts, sub-divisions and block level offices of East Garo Hills, West Garo Hills and South Garo Hills.

2) East Khasi Hills District

East Khasi Hills District forms a central part of Meghalaya and covers a total geographical area of 2,748 sq. km. It lies approximately between 25°07” & 25°41” N Lat. and 91°21” & 92°09” E Long. The northern portion of the district is bounded by the plain of the Ri-Bhoi District, Jaintia Hills District to the east and the West Khasi Hills District to the west.

The East Khasi Hills District is mostly hilly with deep gorges and ravines on the southern portion. The most important physiographic features of the district is the Shillong Plateau combined with the river valley, and sharp falls in the southern portion forming deep gorges and ravine in Mawsynram and Shella-Bholaganj bordering Bangladesh.

The headquarters of the district, Shillong, is connected by NH44 to Guwahati which is 103 km away and to Silchar 240 km away. The nearest railhead and airport are situated at Guwahati. There is an airstrip suitable for small aircrafts at Umroi which is 35 km from Shillong. The agricultural products and others are transported by trucks, jeeps and tractors. Shillong is well-connected with other parts of the state by a motorable road. Similarly, all the block headquarters in the district are also connected by roads. However, the villages in the interior areas are poorly connected and transport services are inadequate. The demographic profile of East Khasi Hills is presented in Table 6-7 エラー! 参照元が見つかりません。.



Source: JICA Study Team

Figure 6-16: Map of East Khashi Hills District

Table 6-7: Demographic Profile of East Khasi Hills District

Description	2011 Census
Population	825,922
- Male	410,749
- Female	415,173
Households	163,397
Population Density	301
Literacy	84.15 %
- Male Literacy	84.51%
- Female Literacy	83. %
No of CD Blocks	8
No of Villages	975

Source: Census 2011

3) West Jaintia Hills District

West Jaintia Hills District is one of the eleven districts of the state of Meghalaya. With the bifurcation of the erstwhile Jaintia Hills District into East and West Jaintia Hills District, West Jaintia Hills District came into existence on 31st July 2012 with its headquarters at Jowai. Jowai is the host of all the heads of important governmental offices and establishments, educational institutions, hospitals, banking institutions, etc. The total area of the district is 1693 sq. km. The district comprises of one civil sub-division viz. Amlarem Civil Sub-Division and three community and rural development blocks viz. Amlarem C&RD Block, Laskein C&RD Block and Thadlaskein C&RD Block with boundaries with North Assam, South Bangladesh and East Jaintia Hills District, East Assam, and West – East Khasi Hills District. The district has a total population of 272,185, of which 135,052 are males and 137,133 are females. The density of the population is 160.69 per sq. km.

Source: JICA Study Team

Figure 6-17: Map of Jaintia Hills District (currently East/ West Jaintia Hills)

Table 6-8: Demographic Profile of West Jaintia Hills District

Description	2011 Census
Population	272,185
- Male	135,052
- Female	137,133
Households	45,272
Population Density	160
Literacy	63.12 %
- Male Literacy	58.51%
- Female Literacy	67.61. %
No of CD Blocks	3
No of Villages	331

Source: Census 2011
(Extracted data of CD Blocks currently belongs to West Jaintia Hills)

4) Project District population and percentage of SC and ST

The following Table 7-9 エラー! 参照元が見つかりません。 presents Scheduled Tribe (ST) and Scheduled Caste (SC) population in the districts in which the project runs through.

Table 7-9: District-wise population and percentage of SC and ST

State / district name	ST	SC	Others	Total	% ST	% SC	% others
Meghalaya	2,555,861	17,355	393,673	2,966,889	86.15	0.58	13.27
East Khasi Hills	661,158	5 ,642	159,122	825,922	80.05	0.68	19.27
West Jaintia Hills	257,941	844	13,400	272,185	94.77	0.31	4.92

Source: Census 2011
(Extracted data of CD Blocks currently belongs to West Jaintia Hills)

5) Scheduled Tribes in Project Districts

Of the population in East Khasi Hills, 80.05% are STs, of which 90.60% are Khasi or its ethno-historically related tribes. In Jaintia Hills, 95.97% of the population is STs, of which 89.18% are Khasi, Jaintia or its ethno-historically close tribes.

Table 6-10: District-wise Scheduled Tribes

State / District	All Scheduled Tribes	Garo	Hajong	Khasi, Jaintia, Synteng, Pnar, War, Bhoi, Lyngngam	Koch	Any Kuki Tribes	Mikir	Raba, Rava	Other ST
Meghalaya	2,555,861	821,026	38,576	1,411,775	22,716	14,275	19,289	32,662	195,542
East Khasi Hills	661,158	23,481	3,244	599,025	445	2,810	3,339	410	28,304
Jaintia Hills	376,099	488	20	335422	3	8807	1026	23	30,310

Source: Census 2011

Khasi / Jaintia Tribe

The term Khasi is applied to the group of matrilineal and Mon-Khmer speaking people who contemporarily inhabit the Khasi Hills and Jaintia Hills districts of Meghalaya state. It is generally considered by many Khasi sociologists that the Khasi Tribe consists of seven sub-tribes, hence the title '*Children of the Seven Huts*': Khynriam, Pnar, Bhoi, War, Maram, Lyngngam and Diko. The Khynriam (or Nongphlang) inhabit the uplands of the East Khasi Hills District; the Pnar or Syntengs live in the uplands of Jaintia Hills. The Bhoi live in the lower hills to the north and north-east of the Khasi Hills and Jaintia Hills towards the Brahmaputra valley. The War, usually divided into War-Jaintia in the south of the Jaintia Hills and War-Khasi in the south of the Khasi Hills, live on the steep southern slopes leading to Bangladesh. The Marams inhabit the uplands of the West Khasi Hills districts. The Lyngngam people who inhabit the western parts of the Khasi Hills bordering the Garo Hills display linguistic and cultural characteristics which show influences from both the Khasis to their east and the Garo people to the west. The Jaintia tribe is in fact a sub-tribe of the Khasis; with time, the Jaintias was befitted as a major tribe, because of their dominance in population and because of their inhabitance in a major part of the Khasi Hills and the whole of Jaintia hills area of the state. They are also known as “Pnar”, they speak the Jaintia language, which is different from the Khasi language.

The Khasi language is believed to be one of the very few surviving dialects of the Monkumer family of languages in India. The Khasi language was essentially oral until the arrival of Christian missionaries. Particularly significant in this regard was a Welsh evangelist, Thomas Jones, who transcribed the Khasi language into the Roman script. While the main language for communication is in Khasi, the sub-tribes have dialects of their own, and usually communicate in Khasi only when they are communicating with another sub-tribe and with the major tribe, referred to as the “khynriam”.

The Khasi people form the majority of the population of the eastern part of Meghalaya, and are the state's largest community. Though the majority of the 85.00 % Khasi populace have embraced Christianity, a substantial minority of the Khasi people still follow and practice their age old indigenous religion, which is known as "Ka Niam Khasi" and it is their belief that the rooster (U Syiar Khraw Jutang) is sacrificed as a substitute for man, it being thought that the rooster "bears the sins of men and by its sacrifice, man will obtain redemption.” A small number of Khasis, as a result of inter-community marriages, are also Muslims. There is also a very small number of Khasi Hindus inhabiting the Jaintia Hills of Meghalaya, a result of hundreds of years of exposure to the plains of Bengal and Assam.

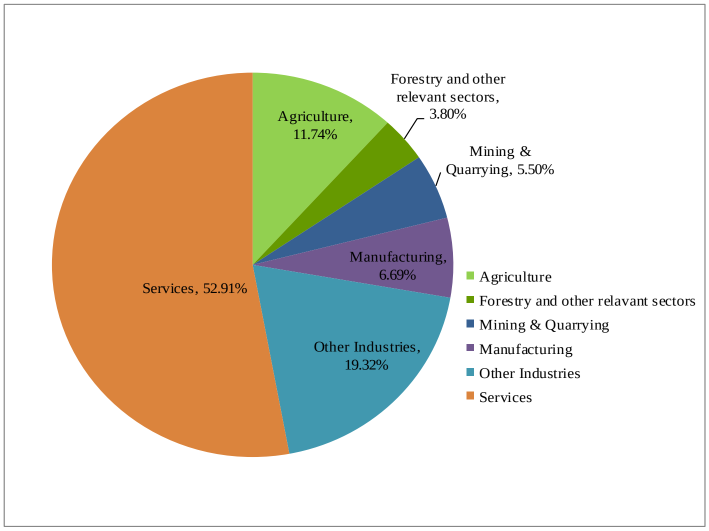
The Khasis follow the matrilineal system of society. Here, the lineage of the tribe is traced through the women. The children take the name of the mother and their children continue to do the same. Ancestral property is passed down to the youngest daughter (ka Khatduh). If the Khatduh dies or marries a non Khasi, or takes the name of her husband, these will be then passed to the daughter elder to the Khatduh. Although the women in this society is given the ancestral property, it is the man, usually the eldest brother, or the maternal uncle who decides on the management of the property. The husband is the bread earner and makes the final decisions in matters of his immediate family, and also in his mother's family as the maternal uncle. The Khasis follow the matrilocal type of residence, where the man stays in the woman's house after marriage.

Garo Tribe

In the RAP survey, it was observed that a few Garo people could be affected by the Project. The Garo, of Tibeto-Burman origin, address themselves as *A'chik* or *Mande*. The Garo have a matrilineal society, where the land can only be inherited through the women of the families. The traditional Garo religion includes the belief of supernatural spirits called *mite*. They believed that these spirits lived in the jungle and caused diseases. They also believed in important gods that overlooked the growth of the crops.

(2) Economy and Industrial Structure

Gross State Domestic Product (GSDP) of Meghalaya in 2013-2014 is Rs 210,450 million (Rs 134,650 at constant 2004-05 prices), of which agriculture and forestry is 15.54%.



Source: Planning Commission, Government of India

Figure 6-18: Share of GSDP by Industries

6.4 Legal Framework

6.4.1 Major Laws and Regulations Relevant to the Project

Within the framework of environmental laws of India, the Environmental Protection Act of 1986 and its enforcement rights has been given to Ministry of Environment, Forest & Climate Change (MOEFCC). It has overall authority for the administration and implementation of the EIA related policies, laws and regulations, sustainable development and pollution control in India. MOEFCC identifies the need to enact new laws and to issue amendment to the existing environmental legislations when required, in order to continue to conserve and protect the environment in India. Central Pollution Control Board (CPCB) and respective State Pollution Control Board (SPCB) implement the acts. At the state level, the Department of the Environment and the Department of Forest of Meghalaya State perform a similar role to MOEFCC.

(1) The Environment (Protection) Act, 1986

The Environment (Protection) Act, 1986 is the umbrella legislation providing for the protection of environment of India. Subject to the provisions of the Act, the Central Government has the power to take all measures as it deems necessary or expedient for the purpose of protecting and improving the quality of the environment and preventing, controlling and abating environmental pollution.

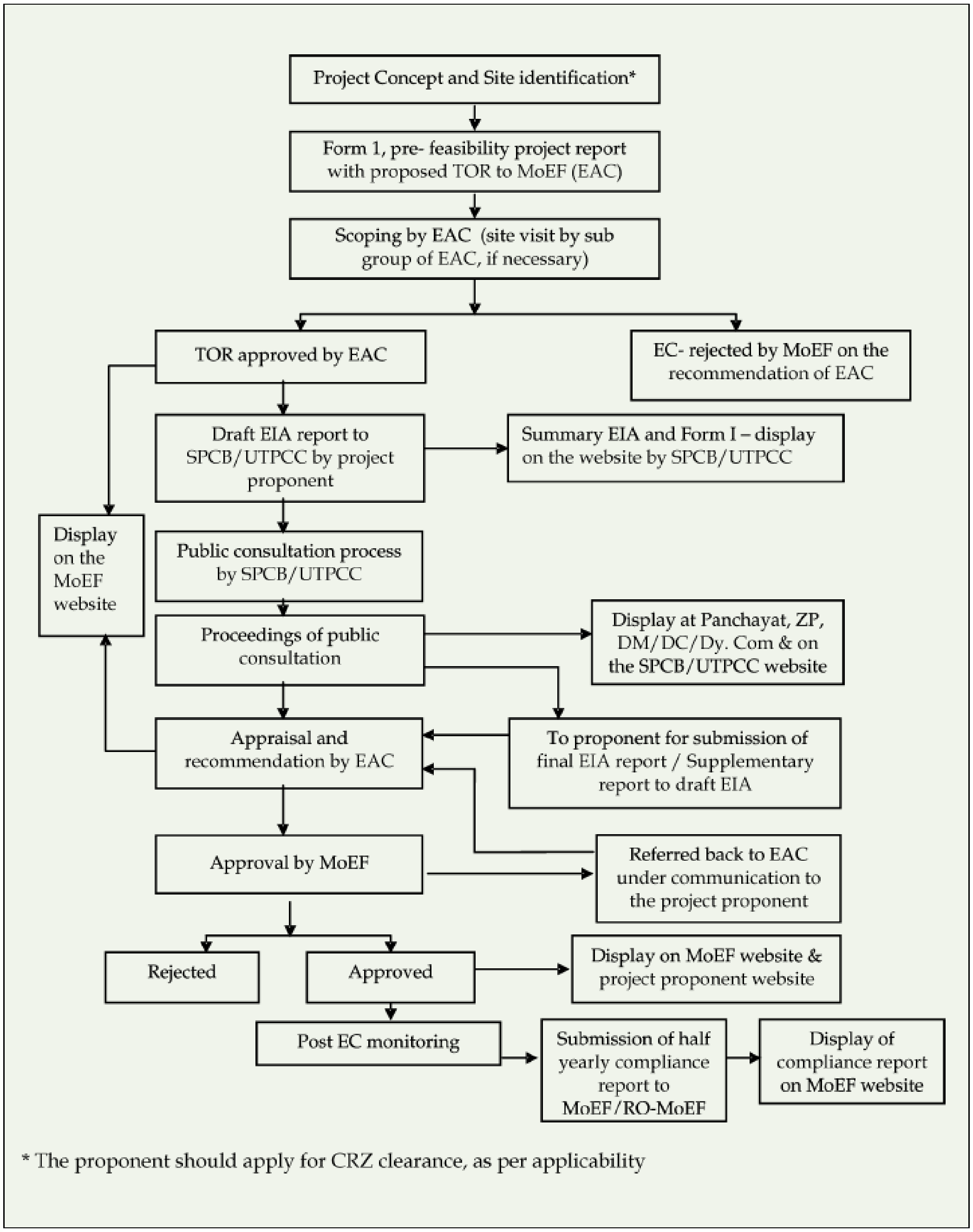
For the implementation of Environment (Protection) Rules, which has been formulated in 1986 provides for various standards for emission and discharge of environmental pollutants (Schedule I to IV).

The central government has delegated the power vested on it under the section 5 of the Act to the State Govt. of Meghalaya. This law is applicable to this project for environment protection in general.

(2) Notification on the Environmental Impact Assessment of Development Projects

Amendments have been made in 2006, 2009, 2012 and 2014. Expert Appraisal Committee or State Level Expert Appraisal Committee are requested to establish and are given power to make recommendations for decision making at central government level. Expert Appraisal Committee of the central government and the State Level Expert Appraisal Committee are to meet once every month for screening, scoping and appraisal of development projects.

Those projects intended to implement for national level of economic development as well as for the project of each industrial sector in India are obliged to follow the guidelines of studying environmental impacts. Elaborating environmental management and monitoring programs are also one of the obligations.



Source: Environmental Impact Assessment Guidance Manual for Highways, 2010

Figure 6-19: Environmental Clearance Process for Category A Projects

(3) Wildlife Protection Act 1972

Amendment was made in 1982, 1986, 1991, 1993, 2002, 2006 and 2013 in order to protect wildlife of India. Code of conduct in terms of wildlife protection, trade of wildlife products, punishment for illegal hunting etc. have been amended from time to time.

(4) The Forest (Conservation) Act, 1980 (amended in 1988)

The Forest (Conservation) Act, 1980 amended in 1988 pertains to the cases of diversion of the use of forest area and felling of roadside trees and those in the plantation areas. Depending on the size of the area subject to clearing, license for felling trees should be applied to which the level of governments empowered for issue of permission differs depending on the type of forest clearance:

- If the area of forests subject to clearing exceeds 20ha (or, 10ha in the hilly area) then prior permission of Central Government is required;
- If the area of forest clearance has a forest density of more than 40%, permission to undertake any work is needed from the Central Government, irrespective of the area to be cleared;
- If the area of forest subject to clearing is between 5 to 20ha, the Regional Office of Chief Conservator of Forests is empowered to approve; and
- If the area of forest subject to clearing is below or equal to 5ha, the State Government can issue permission.

(5) The Water (Prevention and Control of Pollution) Act, 1974

The Water (prevention and Control of Pollution) Act, 1974 resulted in the establishment of the central and state level Pollution Control Board (CPCB/SPCB). Their responsibilities include managing water quality and effluent standards as well as monitoring water quality, prosecuting offenders and issuing licenses for construction and operation of certain facilities.

(6) The Air (Prevention and Control of Pollution) Act, 1981

The CPCB and the SPCB are empowered to set air quality standards, monitor and prosecute offenders under this Act. Powers have also been conferred to give instructions for ensuring standards for emission from automobiles to concerned authority in charge of registration of motor vehicles under the Motor Vehicles Act, 1939 (Act 4 of 1939).

(7) The Motor Vehicles Act, 1988

The Indian Motor Vehicles Act empowers the State Transport Authority to enforce standards for the control of vehicular pollution and prevention of air pollution. The authority also checks emission standards of registered vehicles, collects road taxes, and issues vehicular licenses. In August 1997, the Pollution under Control Certificate (PUC) program was launched in order to control vehicular emissions in all states of India.

(8) The Land Acquisition, Rehabilitation and Resettlement Act, 2013

The new “Rights to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (LARR 2013)” has replaced the Land Acquisition Act of 1894. It has so far served as the basic policy document on which GOI passes resolution to acquire land for different projects while it traditionally not allowed compensation on the replacement basis. The LARR 2013 came into force on 1st January 2014 and Meghalaya States put the act into practice.

6.4.2 JICA’s Guidelines for Environment and Social Considerations

Application of JICA’s Guidelines for Environment and Social Considerations (ESCs) is required if a project is funded by JICA. If a significantly adverse impact on the environment or society has been identified during JICA-assisted project, the following has to be thoroughly considered and studied.

(1) ESCs are pre-requisite

a. JICA will take necessary measures to ensure that the appropriate ESC is given;

b. When JICA reviews a project proposal and finds that the project could cause negative impacts on the environment or society, JICA advises the project proponents to provide appropriate ESC;

c. If the negative impact of the project cannot be avoided or mitigated to an acceptable level, JICA will not support its implementation.

(2) Respect human rights

a. Development project should aim for fair distribution of its benefits and must not burden or exclude certain stakeholders for the sake of others;

b. The project proponents must respect the rights of all people concerned, and pay special attention to vulnerable social groups such as women, elderly, the poor, people with disabilities, indigenous peoples, ethnic minorities, and other minority groups to ensure that they are involved in decision-making processes and that they benefit from the project;

c. JICA's ESC Guidelines defines 'stakeholders' as local residents including non- titleholders who are affected by the project as well as local NGOs. By involving local stakeholders from the early stage of the project, the project proponents can receive their inputs and plan appropriate measures to address their concerns, avoid conflict, and achieve higher results with their support. For this reason, the project proponents should conduct a series of consultations with local stakeholders in an interactive and meaningful manner. During this process, appropriate consideration must be given to socially vulnerable or different people such as women, children, the elderly and ethnic minorities.

(3) Avoid adverse impacts

a. Priority should be given to the avoidance of adverse impacts on the environment or society when a project is planned;

b. Minimization or mitigation of impacts should be considered only if avoidance is not feasible and if the benefit of the project outweighs the cost of mitigation measures;

c. The project proponents must assess the environmental and social impacts at the earliest possible stage of planning, and implement ESC measures in accordance with the ESC Guidelines 9.

(4) Information on ESC must be disclosed to the public

a. Information disclosure is key in ESC. Project proponents must proactively release relevant information to the public;

b. Sharing information with a wide range of stakeholders from the early stage, the project proponents can utilize their feedback to improve the plan/project. In addition, the project proponents can ensure that unnecessary concerns and misunderstandings among the stakeholders are ameliorated.

(5) Host country's laws, standards, policies and plans

a. JICA-funded project must comply with the laws, standards, policies, and plans of the host country;

b. If the standard set by the host country differs from the international standard, the project proponents are advised to adopt international standard that better serves the purpose of attaining a higher level of ESC.

(6) The World Bank's Safeguard Policies

ESC in a JICA project must be in line with the World Bank's Safeguard Policies including:

a) Operational Policy on Environmental Assessment (OP 4.01);

b) Natural Habitats (OP 4.04);

c) Involuntary Resettlement (OP 4.12);

d) Indigenous Peoples (OP 4.10), and other relevant policies.

6.4.3 World Bank's Environmental Safeguard Policy

In respect of the Safe Guard Policies as listed above, the World Bank Performance Standards is imposed on the borrowers in terms of the requirement on the environmental impact assessment and resettlement action plan as guidelines for environmental study. It is compulsory requirement for financing economic development projects that developing countries borrow fund from the World Bank. Major points of concern of its Performance Standards are summarized as follows:

a. PS 1: Assessment and Management of Environmental and Social Risks and Impacts

   Performance Standard 1 underscores the importance of managing environmental and social performance throughout the life of the project.

b. PS 2: Labor and Working Conditions

   The requirements labor and working conditions set out in part guided by a number of international conventions and instruments, including those of the International Labor Organization (ILO) and the United Nations (UN).

c. PS 3: Resource Efficiency and Pollution Prevention

   This Performance Standard outlines a project-level approach to resource efficiency and pollution prevention and control in line with internationally disseminated technologies and practices. The Performance Standard promotes the ability of private companies to adopt such technologies and practices as far as their use is feasible in the context of a project that relies on commercially available skills and resources.

d. PS 4: Community Health, Safety, and Security

Performance Standard 4 recognizes that project activities, equipment, and infrastructure can increase community exposure to risks and impacts. In addition, communities that are already subjected to impacts from climate change may also experience an acceleration and/or intensification of impacts due to project activities. While acknowledging the public authorities' role in promoting the health, safety, and security of the public, this Performance Standard addresses the client's responsibility to avoid or minimize the risks and impacts to community health, safety, and security that may arise from project related-activities, with particular attention to vulnerable groups.

e. PS 5: Land Acquisition and Involuntary Resettlement

Involuntary resettlement refers both to physical displacement (relocation or loss of shelter) and to economic displacement as a result of project-related land acquisition and/or restrictions on land use. However, where involuntary resettlement is unavoidable, it should be minimized and appropriate measures to mitigate adverse impacts on displaced persons and host communities should be carefully planned and implemented.

f. PS 6: Biodiversity Conservation and Sustainable Management of Natural Resources

This Performance Standard recognizes that protecting and conserving biodiversity, maintaining ecosystem services, and sustainably management of the living natural resources are fundamental to sustainable development. The requirements set out in this Performance Standard have been guided by the Convention on Biological Diversity. This Performance Standard addresses how clients can sustainably manage and mitigate impacts on biodiversity and ecosystem services throughout the project's lifecycle.

g. PS 7: Indigenous Peoples

Performance Standard 7 recognizes that Indigenous Peoples, as social groups with identities that are distinct from mainstream groups in national societies.

h. PS 8: Cultural Heritage

Consistent with the Convention Concerning the Protection of the World Cultural and Natural Heritage, this Performance Standard aims to ensure that clients protect cultural heritage in the course of their project activities.

6.4.4 Safeguard Policy of Asian Development Bank

(1) Latest Development of ADB Operations

The ADB's Environment Policy mandates the consideration of environment in all aspects of ADB's operations. "Environment Policy and Operations Manual (OM) 20: Environmental Considerations in ADB Operations" outline ADB's environmental assessment procedures and requirements. In 2003, ADB up-dated the old guidelines of 1993 and that the contents are summarized as follows:

a. Introduced check-list system of Rapid Environmental Assessment (REA) for determining the environment category;
b. Introduction of Country Environmental Analysis (CEA) as a requirement in preparation of the Country Strategy and Program (CSP);
c. Introduction of Strategic Environmental Assessment (SEA) as an optional tool for environmental assessment for program loans, sector development program loans, and sector loans;
d. Establishing a new category FI for lending activities to financial intermediaries and other intermediaries and outlining environmental assessment requirements to apply to this category;
e. Strengthening the requirements of Environmental Management Plans (EMP);
f. Recommending environmentally responsible procurement; and

g. Strengthening public consultation as in integral part of environmental assessment and management.

(2) General Contents of EIA Study

a. Coordinate with government concerned and environment agencies;
b. Prepare a project description, define the study area, collect environmental baseline data, prepare site maps, and other relevant maps for the study area;
c. Identify potential environmental impacts based on the information obtained on the proposed project and the baseline environmental conditions of the study area;
d. Identify alternatives and analyze the environmental impacts of each alternative and propose measure to avoid or prevent impacts;
e. Estimate the magnitudes of environmental impacts and assess the significance of the impacts;
f. Recommend environmental mitigation measures and estimate the mitigation costs;
g. Prepare an EMP to be implemented by the executing agency during project implementation, operation and abandonment;
h. Prepare the EIA and SEIA reports;
i. Conduct public consultation and ensure information disclosure; and develop plans for public consultation and information disclosure during project implementation;
j. Assess the executing agency's capacity to undertake an environmental review of the environmental assessment report and EMP recommendations, and recommend measures for capacity building, if necessary; and
k. Ensure that the proposed project, with EIA and EMP implementation, conforms to the Government and ADB environmental assessment requirements, policies and regulations.
l. Economic assessment should be carried out that includes i) costs and benefits of environmental impacts; ii) costs, benefits, and cost effectiveness of mitigation measures; and iii) for environmental impacts that have not been expressed in monetary values, a discussion of such impacts, if possible in quantitative terms.

6.4.5 Comparison of JICA/WB/ADB Guidelines and EIA Regulations of India

JICA guidelines, World Bank and ADB Operational Manual and Environmental Safeguard policies, procedures & practices described in the Section 9.3.7 to 9.3.9 are compared to the following Government of India's guidelines in order to find the differences and elaborate a way to fill in the gaps if any.

- "Environmental Guidelines for Selected Infrastructure Projects";
- "Project Terms of Reference (TOR)";
- "Environmental guidelines for Road/Rail/Highway Projects", Government of India, 1989
- "Handbook of environmental procedures and guidelines", 1994, Government of India
- "Guidelines for Environmental Impact Assessment of Highway Projects" (IRC: 104-1988); and
- The Environmental (Protection) Act, 1986 and a series of its amendments as follows:

S.O.695, [4/04/2011] - Amendment to EIA Notification, 2006,
S.O.156, [25/01/2012] - Amendment to EIA Notification, 2006,
S.O.945, [11/06/2007] - Environmental Impact Assessment Notification-2007,
S.O.948, [12/06/2007] - Environmental Impact Assessment Notification-2007,
S.O.1105, [4/07/2007] - Environmental Impact Assessment Notification-2007,
S.O.1134, [12/07/2007] - Environmental Impact Assessment Notification-2007,

S.O.1203, [23/07/2007] - Environmental Impact Assessment Notification-2007,
S.O.1735, [11/10/2007] - Environmental Impact Assessment Notification-2007,
S.O.1736, [11/10/2007] - Environmental Impact Assessment Notification-2007,
S.O.1737, [11/10/2007] - Environmental Impact Assessment Notification-2007,
S.O.2674, [17/11/2008] - Environmental Impact Assessment Notification-2008,
S.O.2244, [22/11/2008] - Environmental Impact Assessment Notification-2008,
S.O.195, [19/01/2009] - Environmental Impact Assessment Notification-2009,
S.O.3067, [01/12/2009] - Environmental Impact Assessment Notification-2009
S.O.1850, [14/08/2012] - Environmental Impact Assessement Notification, 2012

Based on the above, a study on the India's laws and regulations comparing to JICA/WB/ADB Guidelines is carried out in following stages:

- The baseline environmental information in the study area viz., climate, physiographic features, drainage, geology, flora, fauna, ambient air, water and noise and socio-economic conditions.
- Reviews of literature, laws and guidelines and discussions with concerned agencies and organizations, National / State Authorities and on-site;
- Reconnaissance survey along with public consultation was during May 2016 to August 2016 and processes of public consultation continued till the completion of study) to inform the people about the project and collect the information / suggestions on environmental issues.
- The monitoring network with regard to air, water, soil and noise pollution.
- Assessment of the potential significant impacts and identification of the mitigative measures to address impacts adequately.
- Field observations including public consultation.
- Screening, testing and monitoring of environmental factors like air, water, soil and the noise level.
- Collection of secondary data from various departments.
- Compilation, analysis and presentation of the report.

Table 6-11: Comparison between JICA Guideline and Laws in India regarding EIA

No.	Items	JICA Guideline	Laws in India	Principle for this Project
1	Requirement of EIA	Environmental and social surveys at the EIA level (Category A projects) Proposed projects likely to have significant adverse impacts on the environment and society. Category A includes projects in sensitive sectors (ex. Roads, railways, and bridges), projects that have characteristics that are liable to cause adverse environmental impacts (ex. Large-scale involuntary resettlement), and projects located in or near sensitive	Projects requiring EIA (Category A projects) i) New National Highways ii) Expansion of National Highways greater than 100 km involving additional right of way or land acquisition greater than 40m on the existing alignments and 60m on re-alignments and bypasses. Projects whose requirement of EIA are judged by State level Environment Impact Assessment Authority (Category B projects) i) State Highway	EIA will be prepared as category A in accordance with JICA Guideline though not required by Laws in India

No.	Items	JICA Guideline	Laws in India	Principle for this Project
		areas. IEE level (Category B projects) Projects whose potential adverse impacts on the environment and society are less adverse than those of Category A projects.	ii) State highway Expansion projects in hilly terrain (above 1,000 m AMSL) and or ecologically sensitive areas	
2	Scope of Impacts to Be Assessed	In addition to the direct and immediate impacts of projects, their derivative, secondary, and cumulative impacts as well as the impacts of projects that are indivisible from the project are also to be examined and assessed to a reasonable extent.	Factors which could lead to environmental effects or the potential for cumulative impacts shall be identified. Indirect impacts on the avifauna of the area shall be examined.	Derivative, secondary, and cumulative impacts as well as the impacts of projects that are indivisible from the project are also to be examined
3	Stakeholder meetings/ Public consultation	Stakeholder meetings shall be held at the stages of scoping draft and report draft.	Public consultation shall be conducted after submission of draft report.	To hold Stakeholder meetings at the stages of scoping draft and report draft.
4	Disclosure of EIA	EIA reports are required to be made available to the local residents of the country in which the project is to be implemented. The EIA reports are required to be available at all times for perusal by project stakeholders such as local residents and copying must be permitted.	MOEFCC shall display the Summary of the draft EIA report on its website, and also make the full draft EIA available for reference at a notified place during normal office hours in the Ministry at Delhi.	To disclose EIA in accordance with JICA Guideline.
5	Certificate regarding the environment and society	If the project requires a certificate regarding the environment and society other than an EIA, indicate the title of said certificate and confirm the approval.	Forest Clearance will be required. The Contractor has to obtain permits from MSPCB for setting up hot-mix plants, batching plants, etc., under the Air and the Water Acts, whose results shall be reported to the Project proponents.	To confirm requirement of permits in accordance with laws in India.
6	Monitoring	After projects begin, project proponents etc. monitor whether any unforeseeable situations occur and whether the performance and effectiveness of mitigation measures are consistent with the assessment's prediction. They then take appropriate measures based on the results of such monitoring.	Project proponents are required to submit environmental management plan & monitoring programme. It shall be mandatory for the project management to submit half-yearly compliance reports in respect of the stipulated prior environmental clearance terms and conditions	To implement environmental monitoring in accordance with laws in India.

No.	Items	JICA Guideline	Laws in India	Principle for this Project
		In cases where sufficient monitoring is deemed essential, project proponents etc. must ensure that project plans include feasible monitoring plans. Project proponents etc. should make efforts to make the results of the monitoring process available to local project stakeholders.		

Source: JICA Study Team

6.4.6 Central Level Institutions of India

(1) National Highway Authority of India

Widening of NH-40 has been initiated and is being carried out by National Highways and Infrastructure Development Corporation Limited (NHIDCL), under the auspice of Ministry of Road Transport & Highways (MORTH). Though the primary responsibility of the Project rests with the NHIDCL, there are various institutions involved in the Project and their level of responsibilities in the project implementation are different as follow:

National Highway Authority of India (NHAI) and Regional Offices (RO) under the Ministry of Road Transport and Highway (MORTH) have promoted national highway development project and the Border Roads Organization (BRO) under Border Roads Development Board (BRDB). National Highways and Infrastructure Development Corporation (NHIDCL) was established for promoting development of National Highways in North East and border areas of India, and started operation from 1st January 2015.

The National Highways Authority of India Act of 1988 established NHAI. It is the main nodal agency for developing, managing and maintaining India’s network of national highways. It became an autonomous body in 1995. NHAI maintains 70,934 Km of national highways and expressways across India.

NHIDCL started operation from 1st January 2015. Development of widening NH-40 has been promoted by NHIDCL that it is a fully owned company of the Ministry of Road Transport & Highways of the Government of India. Function of NHIDCL is to promote survey, design, build, operate, maintain and upgrade of national highways and strategic road development including interconnecting roads in various parts of the country including the area of international boundaries with the neighboring countries.

The company also proposes to improve road connectivity and efficiency of the international trade corridors by expanding about 500 km of roads in the North Bengal and Northeastern Region of India.

(2) Ministry of Environment, Forests and Climate Change (MOEFCC)

The primary responsibility for administration and implementation of the Government of India’s (GOI) policy with respect to environmental management, conservation, ecologically sustainable development and pollution control rests with the Ministry of Environment Forests and Climate Change (MOEFCC). Established in 1985, the MOEFCC is the agency primarily responsible for the review and approval of EIAs pursuant to GOI legislation.

(3) Central Pollution Control Board (CPCB)

Statutory authority attached to MOEFCC, the main responsibilities of CPCB include the following:

a. Planning and implementing water and air pollution control programs;
b. Advising the central government on water and air pollution control programs;
c. Setting air and water standards; and
d. Coordinating the various State Pollution Control Boards.

The role of the CPCB for this Project will only be in an advisory capacity while the Project shall adhere to the norms and standards set up by the Meghalaya State Pollution Control Board (MSPCB).

6.4.7 State Level Institutions of Meghalaya State

(1) Public Works Department

Public Works Department (PWD) of the State of Meghalaya is the premier agency of the state government of Meghalaya engaged in planning, designing, construction and maintenance of the government assets in the field of infrastructure development. Assets in infrastructure development include roads, bridges, urban centers, footpaths, new capital complex, and airport. Assets in built environment include hospitals, schools, colleges, technical institutes, police buildings, prisons, courts among others are also part of PWD’s jurisdiction. PWD Meghalaya also sustains and preserves these assets through a system of maintenance, which includes amongst others specialized services like rehabilitation works, roads signage and aesthetic treatments like interiors, landscaping etc.

(2) MOEFCC Regional Offices

MOEFCC has set up regional offices that cover Northeastern Region including Meghalaya. It is located at Shillong, Meghalaya. This office is responsible for collecting and furnishing information relating to EIA of various projects in respect of pollution control measures, methodology and status, legal and enforcement measures and environmental protection in special conservation areas such as wetlands, mangroves and biological reserves.

(3) Meghalaya State Pollution Control Board (MSPCB)

MSPCB has the mandate for environmental management at the state level, with emphasis on air and water quality. It is responsible for planning and executing state-level air and water initiatives, advising state government on air, water and industry issues, establishing standards based on National Minimum Standards, enforcing and monitoring of all activities within the state under the Air Act, the Water Act and other relevant acts pertaining to pollution control.

MSPCB also conducts and organizes public hearings for projects as defined by the various Acts and as stipulated by the amendment related to the EIA Act. It also Issues No-objection Certificates (NOC) on the application of environment clearance for industrial development defined in such a way as to include road projects’ quarrying etc., which usually related to water and soil contamination.

(4) Meghalaya State Forest Department

The Meghalaya State Forest Department is responsible for the protection and managing the forest areas in the state that are designated for protection, conservation and production purposes. The Forest Department works out according to the Forest Working Plans for the various forest divisions to manage and protect the forest resources. These plans form the basis for managing the forest resources. It is responsible for granting licenses for clearances of the forest areas that need to be cleared for various projects, according to the provisions of the Forest (Conservation) Act, 1980.

They perform the functions similar to the MOEFCC at the state level but more specific to the forestry activities including social forestry and production forestry development and licensing.

6.4.8 Requirements of Environmental/Forest Clearance

Environmental Clearance is not required for this project as per MoEFCC notification, 2013 however forest clearance may be applicable as alignment is passing through forest area and forest land diversion may be required. The permit for forest clearance is the most important clearance permit for the implementation of the Project.

The application has to be processed by State Government as well as Central Government as follows:

1) Part 1 of the application is filled in by NHIDCL, the project proponent;
2) Part 2 will be cleared by the Forest Division of the East Khasi District of Meghalaya State;
3) Part 3 will have to be cleared by the State Environment and Forest Department;
4) Part 4 have to be cleared by the Nodal Officer under Forest Conservation Act; and
5) Part 5 will be the responsibility of the Secretary of Department of Environment and Forest, Government of Meghalaya before forwarding the forest clearance application to the MoEFCC for appraisal for issuing of the Forest Clearance Permit.
sal for issuing of the Forest Clearance Permit.

6.4.9 Other Environmental Clearance

General environmental clearances are subject to issue to the Contractor before the commencement of the construction works as follows:

1) The Contractor has to obtain permits from MSPCB for setting up hot-mix plants, batching plants, etc., under the Air and the Water Acts;
2) Clearance from the State Department of Mining is required for establishing quarries;
3) Clearance from the Water resource department/Authorities is required for establishment of new tube-wells/bore-holes in case they are required during construction work;
4) The provisions as laid down in the Factories Act, 1948, Labor Act, 1988 and the Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 with respect to hygiene and health during the construction stage would apply for the project's implementation works; and
5) The provisions of the Hazardous Wastes (Management and Handling) Rules, 1989 and the Chemical Accidents (Emergency Planning, Preparedness, and Response) Rules, 1996 may also be applied during the construction and the operation period.

Table 6-12 shows a list of environmental clearance necessary to obtain for the project implementation.

Table 6-12: Applicable Environmental Clearance

No.	Activity	Statute	Requirement	Competent Authority	Responsible Agency for Obtaining Clearance	Time Required
Pre-Construction Stage (Responsibility: MORTH)						
1	Road-side tree cutting and clearing forest	Forest Conservation Act1980 & MOEF Letter Dt.18.02.1998	Permission for Road-side tree cutting	State and Central Government	MORTH	2-3 months
2	Filling of Roadside water bodies (ponds and borrow pits)	State Fisheries Policy Draft Wetlands (Conservation & Management) Rules, 2008	Permission for filling of water bodies	State Irrigation Department State Fisheries Department State Wetlands Conservation Committee	MORT&H	2-3 months
Construction Stage (Responsibility: Contractor)						
1	Establishing stone crusher, hot mix plant, wet mix plant and Diesel Generator Sets	Water Act of 1974, Air Act of 1981, Noise Rules of 2000 and Environmental Protection Action of 1986 and as Amended	Consent-forest abolishment	States Pollution Control Boards for respective section	The Contractor	4-6 months
2	Operating stone crusher, hot mix plant, wet mix plant and Diesel Generator Sets	Water Act of 1974, Air Act of 1981, Noise Rules of 2000 and Environmental Protection Action of 1986 and as Amended	Consent-for operation	States Pollution Control Boards for respective section	The Contractor	4-6 months
3	Use and storage of explosive for quarry blasting work	India Explosive Act 1984	Explosive licence for use and storage	Chief Controller of Explosives	The Contractor	2-3 months
4	Storage of fueloil, lubricants, diesel etc. at construction camp	Manufacture storage and Import of Hazardous Chemical Rules 1989	Permission for storage of hazardous chemical	States Pollution Control Boards for respective section and or Local Authority (DC)	The Contractor	4-6 months
5	Quarry Operation	State Minor Mineral Concession Rules, The Mines Act of1952, Indian Explosive Act of1984, Air Act of1981 and WaterAct of 1974	Quarry Lease Deed and Quarry License	State Department of Mines and Geology	The Contractor	4-6 months
6	Extraction of ground water	Ground Water Rules of 2002	Permission for extraction of ground water foruse in road construction activities	State Ground Water Board	The Contractor	4-6 months
7	Engagement of labor	Labor Act	Labor license	Labor Commissioner	The Contractor	2-3 months

Source: JICA Study Team

6.4.10 Environmental, Emissions and Other Standards of India

Based on the Acts and Rules as above, NPCB set up various environmental standards as follows:

1) National Ambient Air Quality Standards
2) Water Quality Criteria
3) Vehicular Exhaust
4) Auto Fuel Quality
5) Noise and Emission Limits for Diesel Engines for Generators
6) Noise Standards

Other than the above, there are a large number of environmental standards set up for each sector of manufacturing industries. Since the Project is a road construction project widening the existing road as well as a number of bypasses inserted in the built-up areas along NH-40. Thus during the construction period, construction debris, soil contamination, pollution to air and water, noise and vibration are subject to monitoring in order to maintain emissions and discharges within the standards set up by NPCB. During the operation and maintenance period, increasing traffic could cause noise and vibration. However, the standards on the disposal of construction debris, soil contamination and vibration that could have been caused by the Project are not clearly defined. Following is a set of environmental standards the Government of India has imposed to date.

Table 6-13: Standards for Air Quality

S. No.	Pollutant	Time Weighted Average	Concentration in Ambient Air		
			Industrial, Residential, Rural and Other Area	Ecologically Sensitive Area (notified by Central Government)	Methods of Measurement
(1)	(2)	(3)	(4)	(5)	(6)
1	Sulphur Dioxide (SO_2), µg/m³	Annual* 24 hours**	50 80	20 80	- Improved West and Gaeke -Ultraviolet fluorescence
2	Nitrogen Dioxide (NO_2), µg/m³	Annual* 24 hours**	40 80	30 80	- Modified Jacob & Hochheiser (Na-Arsenite) - Chemiluminescence
3	Particulate Matter (size less than 10µm) or PM_{10} µg/m³	Annual* 24 hours**	60 100	60 100	- Gravimetric - TOEM - Beta attenuation
4	Particulate Matter (size less than 2.5µm) or $PM_{2.5}$ µg/m³	Annual* 24 hours**	40 60	40 60	- Gravimetric - TOEM - Beta attenuation
5	Ozone (O_3) µg/m³	8 hours** 1 hour**	100 180	100 180	- UV photometric - Chemilminescence - Chemical Method
6	Lead (Pb) µg/m³	Annual* 24 hours**	0.50 1.0	0.50 1.0	- AAS /ICP method after sampling on EPM 2000 or equivalent filter paper - ED-XRF using Teflon filter
7	Carbon Monoxide (CO) mg/m³	8 hours** 1 hour**	02 04	02 04	- Non Dispersive Infra Red (NDIR) spectroscopy
8	Ammonia (NH_3) µg/m³	Annual* 24 hours**	100 400	100 400	-Chemiluminescence -Indophenol blue method

Source: Central Pollution Control Board, India

Table 6-14: Vehicle Emission Standard 1991 to Date

Norms	Passenger Car	Heavy Diesel Vehicles			
	CO (g/km)	CO (g/km)	HC (g.km.hr)	NOx (g.km.hr)	PM (g.km.hr)
1991Norms	14.3-27.1	14	3.5	18.0	-
1996 Norms	8.68-12.40	11.2	2.4	14.4	-
1998Norms	4.34-6.20	-	-	-	-
India stage 2000 norms	2.72	4.5	1.1	8.0	0.4
Bharat stage-II	2.2	4.0	1.1	7.0	0.2
Bharat Stage-III	2.3	2.1	1.6	5.0	0.1
Bharat Stage-IV	1.0	1.5	1.0	3.5	0.0

Source: Central Pollution Control Board, India
Note: Bharat indicates Indian nomenclature of vehicular emission which is the same as Euro Stage.

Table 6-15: Water Quality

Designated best use	Class	Criteria
Drinking water source without conventional treatment but after disinfections	A	Total coliform organisms MPN/100ml shall be 50 or less
		pH between 6.5 and 8.5
		Dissolved oxygen 6 mg/l or more
		Biochemical oxygen demand 2 mg/l or Less
Outdoor bathing (organised)	B	Total coliform organisms MPN/100ml shall be 500 or less
		pH between 6.5 and 8.5 *Dissolved oxygen 5 mg/l or more
		Biochemical oxygen demand 3 mg/l or Less
Drinking water source with con- ventional treatment followed by disinfection	C	Total coliform organisms MPN/ 100ml shall be 5000 or less
		pH between 6 and 9
		Dissolved oxygen 4 mg/l or more
		Biochemical oxygen demand 3 mg/l or less
Propagation of wild life, fisheries	D	pH between 6.5 and 8.5
		Dissolved oxygen 4 mg/l or more *Free ammonia (as N) 1.2 mg/l or less
Irrigation, industrial cooling, con- trolled waste disposal	E	pH between 6.0 and 8.5
		Electrical conductivity less than 2250 micro mhos/cm
		Sodium absorption ratio less than 26
		Boron less than 2mg/l

Source: Central Pollution Control Board, India

Table 6-16: Fuel Quality

Diesel Specification

Contents	1996	2000	2005	2010
Cetane No, Min	45	48	48	51
Sulphur % W/w, Max	0.5	0.25 0.25(metro)	0.05	0.035
Distillation T95	-	370	370	360
Polyaromatic	-	-	-	11

Gasoline Specification

Contents	1996	2000	2005	2010
RVP at 38 Deg.c,kpa	35-70	-	35-60	60
Benzine % by Vol.,Max	5	5.0 3.0(metro)	3.0 (all) 1.0 (metro)	1
Lead G/m3, Max	0.15% (low Pb) 0.013% (unleaded)	0.013	0.013	0.005
Sulphur % by mass, Max	0.10 (low Pb) 0.20 (unleaded)	0.1	0.05	0.015
Aromatics % v/v., Max	-	-	45	42
Oxygen %by Vol., Max	-	-	2	2.7

Source: Central Pollution Control Board, India

Table 6-17: Noise Standards for Diesel Generators

No.	Descriptio
1	The maximum permissible sound pressure level for new diesel generator (DG) sets with rated capacity upto 1000 KVA, manufactured on or after the 1st January, 2005 shall be 75 dB(A) at 1 metre from the enclosure surface.
2	Noise limits for diesel generator sets not covered by 1, shall be as follows:-
	2.1 Noise from DG set shall be controlled by providing an acoustic enclosure or by treating the room acoustically, at the users end.
	2.2 The acoustic enclosure or acoustic treatment of the room shall be designed for minimum 25 dB (A) insertion loss or for meeting the ambient noise standards, whichever is on the higher side (if the actual ambient noise is on the higher side, it may not be possible to check the performance of the acoustic enclosure/acoustic treatment. Under such circumstances the performance may be checked for noise reduction upto actualambient noise level, preferably, in the night time). The measurement for Insertion Loss may be done at different points at 0.5 m from the acoustic enclosure/ room, then averaged.
	2.3 The DG set shall be provided with proper exhaust muffler with insertion loss of minimum 25 dB (A).
	2.4 Guidelines for the manufacturers/ users of Diesel Generator sets shall be as under:-
	2.4 (1) The manufacturer shall offer to the user a standard acoustic enclosure of 25 dB (A) insertion loss and also a suitable exhaust muffler with insertion loss of 25 dB(A).
	2.4 (2) The user shall make efforts to bring down the noise levels due to the DG set, outside his premises, within the ambient noise requirements by proper citing and control measures.
	2.4 (3) Installation of DG set must be strictly in compliance with the recommendations of the DG set manufacturer.
	2.4 (4) A proper routine and preventive maintenance procedure for the DG set should be set and followed in consultation with the DG set manufacturer which would help prevent noise levels of the DG set from deteriorating with use.

Source: Central Pollution Control Board, India

Table 6-18: Ambient Noise Standards

S. No.	Type of vehicle	Noise Limits from 1st January, 2003, dB(A)
1.0	**Two wheeler**	
1.1	Displacement upto 80 cc	75
1.2	Displacement more than 80 cc but upto 175 cc	77
1.3	Displacement more than 175 cc	80
2.0	**Three wheeler**	
2.1	Displacement upto 175 cc	77
2.2	Displacement more than 175 cc	80
3.0	**Vehicles used for carriage of passengers and capable of having not more than nine seats, including the driver's seat**	74
4.0	**Vehicles used for carriage of passengers having more than nine seats, including the driver's seat, and a maximum gross Vehicle Weight(GVW) of more than 3.5 tonnes**	
4.1	With an engine power less than150 KW	78
4.2	With an engine power of 150 KW or above	80
5.0	**Vehicles used for carriage of passengers having more than nine seats, including the driver's seat: Vehicles used for carriage goods.**	
5.1	With maximum GVW not exceeding 2 tonnes	76
5.2	With maximum GVW greater than 3 tonnes but not exceeding 3.5 tonnes	77
6.0	**Vehicles used for transport of goods with a maximum GVW exceeding 3.5 tonnes.**	
6.1	With an engine power less than 75 KW	77
6.2	With an engine power of 75 KW or above but less than 150 KW	78
6.3	With an engine power of 150 KW or above,	80"

Source: Central Pollution Control Board, India

6.5 Analysis of Alternatives

6.5.1 Alternatives Subject to Analysis

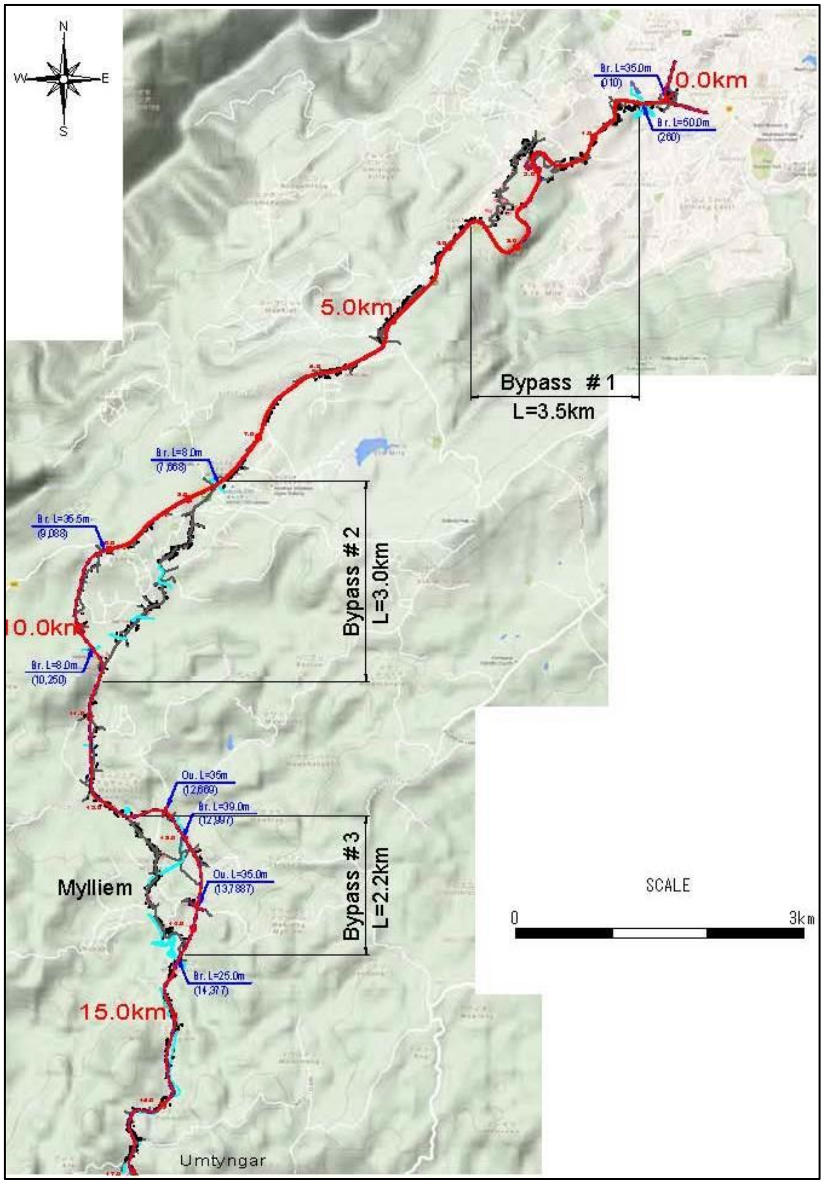
There are four options that must be considered in terms of impact mitigation measures as follows:

a. No-project Implemented Option
   No project intervention is implemented, i.e. the present road continues to be used.

b. Widening Option:
   The existing road is widened on both sides of the road. Where appropriate, mountain-side is widened as geographical conditions makes it impossible to widen on the steep valley side.

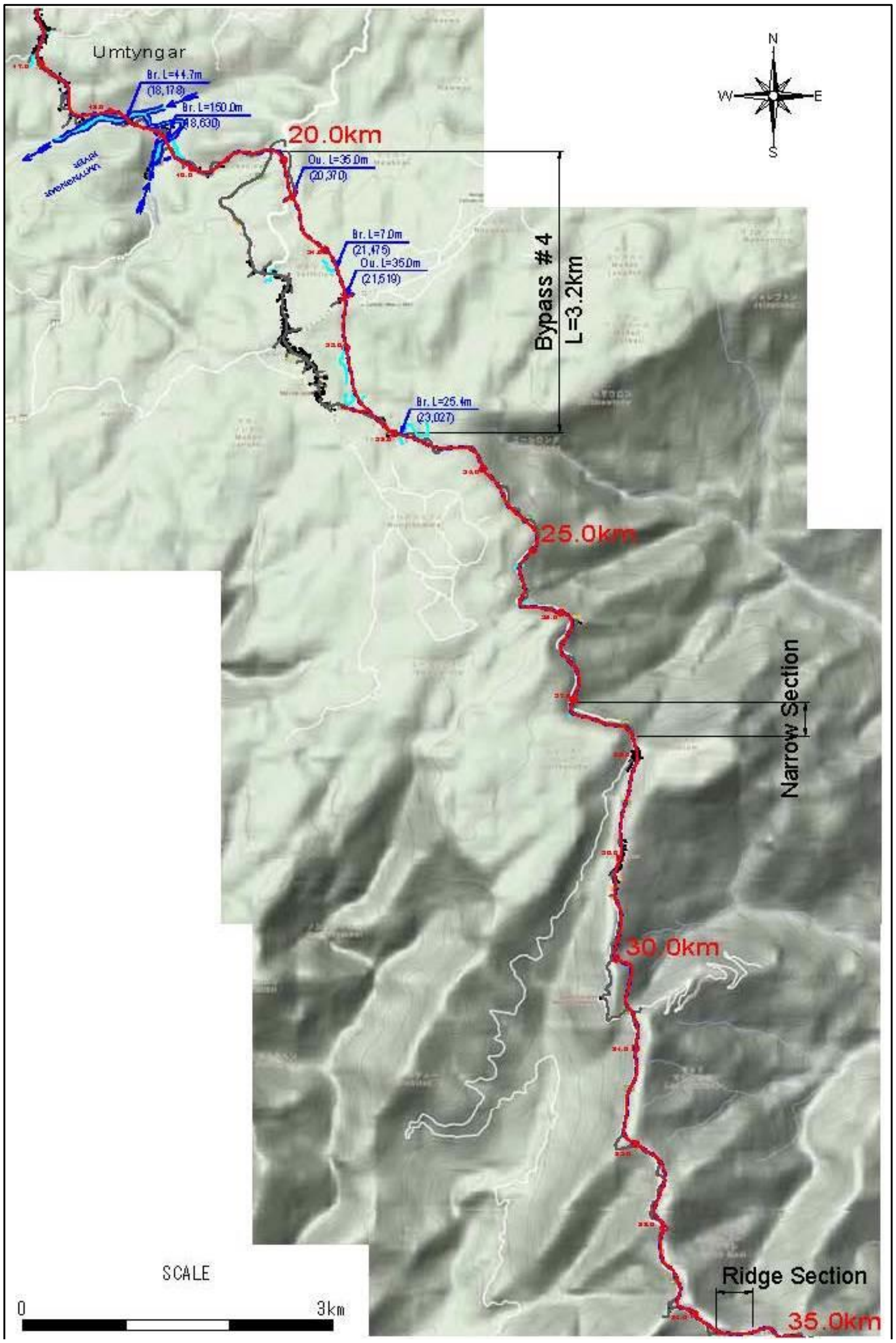
c. Bypass Inserting Option – DPR Design:
   A number of bypasses are inserted where built up areas have to be avoided to reduce the number of PAPs based on the DPR design showing the original bypasses of the DPR design in blue dashed line.

d. Bypass Inserting Option – JICA Study Team's Design:
The JICA Study Team reviewed the DPR design and concluded that the alignment of bypass #1, #6 and #7 are in need of re-designing. Basic concept behind the design of bypass #2 to #5 is that they are designed to avoid built-up areas in order to reduce the number of PAPs. Thus, bypass #2 to #5 remain the same as the DPR design. Bypass No.6 and 7 have been put together in order to improve geometric configuration as is shown in red line as per Figure 6-20 to Figure 6-23.



Dashed Blue Line : DPR Design、**Solid Red Line** : JICA Study Team's Design
Source: JICA Study Team

Figure 6-20: Bypass No.1-3 – DPR Design/ JICA Study Team Design

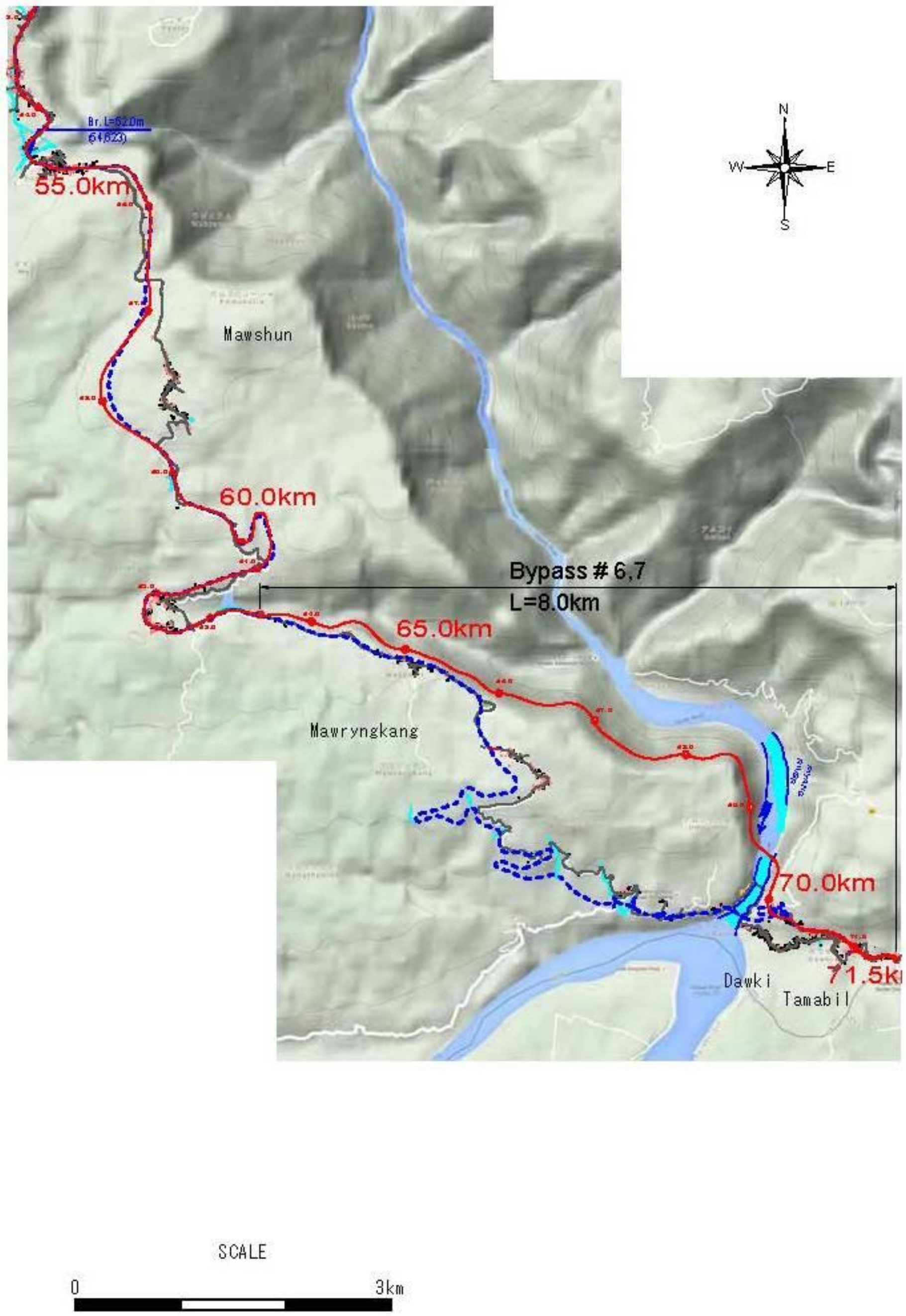


Dashed Blue Line : DPR Design、**Solid Red Line** : JICA Study Team's Design
Source: JICA Study Team

Figure 6-21: Bypass No.4 – DPR Design/ JICA Study Team Design

Dashed Blue Line : DPR Design、**Solid Red Line** : JICA Study Team's Design
Source: JICA Study Team

Figure 6-22: Bypass No.5 – DPR Design/ JICA Study Team Design



Dashed Blue Line : DPR Design、**Solid Red Line** : JICA Study Team's Design
Source: JICA Study Team

Figure 6-23: Bypass No.6-7 – DPR Design/ JICA Study Team Design

6.5.2 Criteria for Analysis of the Alternatives

Criteria to analyze the four scenarios are shown in エラー! 参照元が見つかりません。. These criteria as per Table 6-19 are based on the most important factors for the road improvement project running through Khasi Hills of Meghalaya State.

Table 6-19: Criteria for the Evaluation of the Alternatives

No.	Alternative Models	Criteria for Evaluation
1	No-project Implemented Option	Environmental Pollution - CO2 emissions increase/decrease - Noise and vibration increase/decrease - Health conditions improve/worsen Socio-economic Conditions - Road accidents increase/decrease - Living standards improve/worsen - Impacts of resettlement - Impacts of land acquisition Natural Environment - Mountain slopes are stabilized/destabilized - Effects on ecological conditions Road Conditions - Improvement of infrastructure for communication - Improvement of transportation of goods - Contribution to economic development of local/state economy Others - Technical viability of the road construction - Expected benefits of the project in terms of socio-economic conditions and natural environment (Is it worth implementing the project despite effects on the natural/social/economic conditions)
2	Road Widening Option (Entire section of NH40 is subject to road widening)	
3	Bypass Insertion Option – DPR Design (Seven bypasses are inserted while widening of no bypass sections are implemented)	
4	Modified Bypass Insertion Option – JICA Study Team's Design (Bypass #6 has been modified)	

Source: JICA Study Team

6.5.3 Result of the Analysis of Alternatives

(1) No-project Implemented Option

No-project Implemented Option is the scenario in which there is no project intervention on the existing NH40. This option is assessed as follows:

a. Positive Impacts

- There will be no involuntary resettlements.
- No forest and agricultural areas will be lost to the road construction works.
- No construction works will cause significant traffic jams, dust emanation during the dry season and muddy roads during rainy season.
- No significant impact will be caused to the near-by "Important Bird Area".

b. Negative Impacts

- Transportation capacity is already saturated at the starting and ending points of the existing road. The local businesses involved in the transportation of goods such as limestone exportation to Bangladesh will not be able to expand if no NH40 widening project is implemented.
- Meghalaya State Government is trying to exploit local mineral resources including uranium. If no project is carried out, the transportation of these mineral resources could not be effectively done.
- Current traffic conditions around the villages along NH40 cause traffic jams and the function of NH40 as one of the important trunk roads in Meghalaya State is lowered.
- Road accidents may increase as the number of vehicles increase without the road getting widened.
- There will not be any improvements to the function of NH40 as one of the important trunk roads in India for a long time.

(2) Widening of the Existing Road

The road widening option of NH40 is to widen the existing road and upgrade it as a two-lane road with appropriate drainage, footpath and other ancillary road furniture. This option is assessed as follows:

a. Positive Impacts

- Transportation capacity that is already saturated could be eased.
- Local businesses involved in limestone exportation to Bangladesh and transportation of agricultural products to Shillong will be able to expand if NH40 widening project is implemented.
- Meghalaya State Government is trying to exploit local mineral resources including uranium and the transportation of these mineral resources could be more efficient if NH40 widening project is implemented.
- Current traffic conditions around the villages along NH40 causing traffic jams will be improved.

b. Negative Impacts

- There will be involuntary resettlement of approximately 850 local households.
- Forest area of approximately 140 ha will be lost to road construction.
- Construction works will cause significant traffic jams throughout the construction period, dust during the dry season and muddy roads during the rainy season.
- Increase of traffic volume including heavy-load vehicles will increase the noise and vibration levels along the built-up areas over time.
- Significant impact could be caused to the near-by “Important Bird Area”.

(3) Bypass Insertion Option – DPR Design

The bypass insertion option of NH40 is to widen the existing road and upgrade it to a two-lane road with appropriate drainage, footpath and other ancillary road furniture. Where a concentration of population along the road might be adversely affected, bypasses are inserted in order to reduce the number of involuntary resettlements. This option is assessed as follows:

a. Positive Impacts

- It is positive for the local residents that traffic will be bypassing the built-up areas.
- Transportation capacity that is already saturated could be improved; i.e. local businesses such as limestone exportation to Bangladesh will be able to expand if NH40 widening project is implemented.

- Meghalaya State Government is trying to exploit local mineral resources including uranium and the transportation of these mineral resources could be more efficient if NH40 widening project is implemented.

b. Negative Impacts

- Involuntary resettlement of the local residents will be reduced to approximately 350 households compared to 850 households in the case of the road widening option. However, this is still not considered a positive impact of the project as a whole.
- Forest area of approximately 190 ha will be lost for bypasses and road construction.
- Construction works will cause significant traffic jams throughout the construction period, dust during the dry season and muddy roads during the rainy season.
- Increase of traffic volume including heavy-load vehicles will cause noise and vibration along the road while some traffic is diverted to bypasses.
- Current traffic congestion along the built-up areas of NH40 might not be reduced or increased in the long term.
- Significant impact could be caused to the near-by "Important Bird Area".

(4) Bypass Insertion Option – JICA Study Team's Design

The bypass insertion option of NH40 based on the DPR design was reviewed in terms of the configuration of bypasses at the end of the road approaching the border between India and Bangladesh. This option involves widening of the existing road and upgrading it as a two-lane road with appropriate drainage, footpath and other ancillary road furniture. Where a concentration of population along the road might be adversely affected, bypasses are inserted the same as those of the DPR design in order to reduce the number of involuntary resettlements. This option is assessed as follows:

a. Positive Impacts

- It is positive for the local residents that traffic will be bypassing the local built-up areas.
- Transportation capacity that is already saturated could be improved, i.e. the local businesses such as limestone exportation to Bangladesh will be able to expand if NH40 widening project is implemented.
- Meghalaya State Government is trying to exploit local mineral resources including uranium and the transportation of these mineral resources could be efficient if the NH40 widening project is implemented.

b. Negative Impacts

- Involuntary resettlement of the local residents will be reduced to approximately 300 households compared to 850 households in the case of the road widening option. However, this is still not considered a positive impact of the project as a whole.
- Forest area of approximately 190 ha will be lost including areas around bypass #6-7 where there is dense forest, and the road construction area.
- Construction works will cause significant traffic jams throughout the construction period, dust during the dry season and muddy roads during the rainy season.
- Increase of traffic volume including heavy-load vehicles will cause noise and vibration along the road while some traffic is diverted to bypasses.
- Current traffic congestion along the built-up areas of NH40 might not be reduced or increased in the long term.
- The existing road section near the border which is narrow and has a deteriorated surface will be left out of the project while the local population demands it to be renewed and up-graded.
- Significant impact could be caused to the near-by "Important Bird Area".

6.5.4 Weighted Average Analysis of the Alternatives

Based on the above four alternatives, each alternative is evaluated using a weighted average analysis as per Table 6-20. The evaluation parameters are items shaded in purple, i.e. each item is negatively or positively affected as a result of the implementation of the project. The larger the value, the larger the negative impacts on the socio-economic and natural environment.

On the other hand, the items that are shaded light-green are the factors that could improve in terms of the local economy and society. For these items, the higher the value, the more meaningful benefits there are of each alternative.

Table 6-20: Weighted Average Analysis of the Alternatives

Evaluation Criteria \ Options	Zero Option				Road Widening Option				Bypass Insertion Option – DPR Design				Modified Bypass Insertion Option - JICA Study Team Design			
	FI	QL	QT	Total	FI	QL	QT	Total	FI	QL	QT	Total	FI	QL	QT	Total
1 Environmental Pollution																
1) CO2 Emission	5	1	1	10	5	2	2	20	5	2	2	20	5	2	2	20
2) Noise and Vibration	5	2	2	20	5	2	2	20	5	2	2	20	5	2	2	20
3) Effect on the Health Conditions	5	1	1	10	5	2	2	20	5	2	2	20	5	2	2	20
Total for Impacts on Environmental Pollution	-	-	-	40	-	-	-	60	-	-	-	60	-	-	-	60
2 Socio-economic Conditions																
1) Road Accidents	5	3	3	30	5	3	3	30	5	3	3	30	5	3	3	30
2) Living Standards	7	5	0	35	7	5	0	35	7	5	0	35	7	5	0	35
3) Resettlement	10	1	1	20	10	10	10	200	10	8	5	130	10	8	5	130
4) Land Acquisition and/or Effect of Bypasses																
a. Commercial & Industrial Area	2	1	1	4	2	10	10	40	2	5	5	20	2	5	5	20
b. Agricultural Area	4	1	1	8	4	3	3	24	4	3	3	24	4	3	3	24
c. Residential Area	7	1	1	14	7	10	10	140	7	5	5	70	7	5	5	70
Total for Impacts on Socio-economics	-	-	-	111	-	-	-	469	-	-	-	309	-	-	-	309
3 Natural Environment																
1) Slope Stabilization	5	1	1	10	5	5	5	50	5	8	8	80	5	5	5	50
2) Ecological Changes																
a. Forest	10	1	0	10	10	3	5	80	10	5	10	150	10	5	10	150
b. Wildlife	4	1	0	4	4	3	0	12	4	5	0	20	4	5	0	20
c. Avifauna	3	1	0	3	3	3	0	9	3	5	0	15	3	5	0	15
d. National Parks	3	1	0	3	3	1	0	3	3	1	0	3	3	1	0	3
Total for Impacts on the Natural Environment	-	-	-	30	-	-	-	154	-	-	-	268	-	-	-	238
Total for Impacts (showing Negativity)	-	-	-	181	-	-	-	683	-	-	-	637	-	-	-	607
4 Road Conditions																
1) Road as communication infrastructure	10	3	3	60	10	10	10	200	10	10	10	200	10	10	10	200
2) Road for transportation of goods	7	3	3	42	7	5	5	70	7	5	5	70	7	5	5	70
3) Contribution to economic development	5	4	4	40	5	5	5	50	5	5	5	50	5	5	5	50
Total for Importance of Road Conditions	-	-	-	142	-	-	-	320	-	-	-	320	-	-	-	320
5 Others																
1) Technical Viability of the Road	5	4	0	20	5	3	3	30	5	5	5	50	5	5	5	50
2) Worth to Implement the Project	8	4	0	32	8	3	3	48	8	5	5	80	8	8	8	128
Total for Importance of Others	-	-	-	52	-	-	-	78	-	-	-	130	-	-	-	178
Total for Importance (showing positivity)	-	-	-	194	-	-	-	398	-	-	-	450	-	-	-	498

Note: QL - Qualitative assessment of importance/impact 1 (lowest) to 10 (highest) in terms of Impact/Importance
QT - Quantitative assessment of importance/impact 1 (lowest) to 10 (highest) in terms of Impact/Importance
FI - Factor of Importance from 1 to 10
0 - Quantitative or Quantitative assessment is not appropriate to carry out
"1-3 (Shaded in Magenta)" are assessed in terms of impacts with 1 (low impact) to 10 (high impact)
"4 Road Conditions" and "5 Others (Shaded in Light Green)" are assessed in terms of importance i.e. 1 (lowest) to 10 (highest)

Source: JICA Study Team

As shown above, the two “bypass insertion” options show a high value in the area shaded purple compared to the “No-project Implemented Option” alternative. This means that the impacts on the natural and socio-economic conditions are comparatively large for the bypass options. On the other hand, comparing the values in the sections shaded green show that the “No-project Implemented Option” has a lower value while the “bypass insertion” options show higher values. This indicates that there are more socio-economic benefits that can be expected from the “bypass insertion” options. The findings from this analysis suggests that JICA Study Team’s “modified bypass insertion option” is considered better in terms of this weighted average analysis, and is presented in the following section.

6.5.5 Selection of the Alternatives

Based on the result of analysis as above, four alternatives have been assessed in terms of their advents and disadvantages as per Table 6-21. As a result, “Bypass Insertion Option – JICA Review’s Design” was relatievy advantageous as follows:

a. Entire length of the project area has been shortened as Bypass No. 6-7 is inserted;
b. Because of the short length of Bypass No.6-7, forest clearing is reduced;
c. Because of the insertion of Bypass No. 6-7, no resettlement is induced to this section; and
d. Because of the large scale bridge is constructed, esthetics of original landscape is lost while new bridge could become one of the tourism sources of Dawki.

Table 6-21: Weighted Average Analysis of the Alternatives

Alternatives	Zero-Option	Widening the Existing Road	Bypass Insertion By DPR	Bypass Insertion by JICA Study Team’s Review
Outline of the Alternatives	No project implementation and the existing road is continued to use	Based on IRC, 2-lane widening for the entire length is implemented	A number of bypasses are inserted in order to avoid built-up areas	Generally the same as DPR while Bypass No.6 -7 are significantly improved
Scale of Involuntary Resettlement	◎ No involuntary resettlement is involved i.e. the largest advantage among others	× Largest involuntary resettlement of approximately 850 households is involved.	○ Involuntary resettlement is reduced to approximately 400 households.	○ Involuntary resettlement is reduced to 314 households
Impacts on the Natural Environment	◎ There is no significant impacts caused to the natural environment	○ There is a limited amount of impacts induced by the Project to the natural environment	× Bypasses will cause significant impacts on the forested area including wildlife and biological diversity as well as the agricultural areas.	× Bypasses will cause significant impacts on the forested area including wildlife and biological diversity as well as the agricultural areas.
Pollution to Air Quality, Water Quality and Soil	△ No short-term impact. However, present deterioration of the road conditions will lead to significant traffic congestions, air pollution and other side effects caused by the increase of traffic.	○ GHG as emission could increase as traffic volume increased all along the present road	◎ No air quality deterioration in the built-up areas while GHG emission could increase as a whole	◎ No air quality deterioration in the built-up areas while GHG emission could increase as a whole

Alternatives	Zero-Option	Widening the Existing Road	Bypass Insertion By DPR	Bypass Insertion by JICA Study Team's Review
Traffic Safety	× Traffic safety could increase as no project intervention is carried out	○ Widened road could allow speeding vehicles i.e. noise and vibration could increase. Traffic jam could increase at the built-up area.	◎ Bypasses could avoid built-up areas for any contact with human, bicycles and other vehicles.	◎ Bypasses could avoid built-up areas for any contact with human, bicycles and other vehicles.
Impacts on the Socio-economic Conditions	△ Natural disaster from significant rainfall could cause shut-down of the road net work that will cause disruption of the economic activities.	○ Increase of road width leads to increase of traffic and increase of economic activities. Traffic jam should increase at the built-up areas.	◎ Traffic flow avoiding built-up area should cause to enhance general economic activities.	◎ Traffic flow avoiding built-up area should cause to enhance general economic activities.
Cost of the Project	N/A	△ Land acquisition and involuntary resettlement is the largest financial and economic loss as well as the social up- heaval. Cost of construction works could be small while narrow road area would cause additional construction arrange-ment for traffic safety.	○ Cost of involuntary resettlement is small. Shortening of the entire length of the project could reduce cost of construction.	○ Cost of involuntary resettlement is smallest. Shortening of the entire length of the project could reduce cost of construction.
Land Acquisition	N/A	△ Land acquisition and involuntary resettlement is the largest financial and economic loss as well as the social up- heaval. Border Area's land acquisition is not possible.	× Land acquisition is a part in the area of the Min. of Defense i.e. negotiation for land acquisition takes time.	◎ Land acquisition is a part in the area of the Min. of Defense i.e. negotiation for land acquisition takes time.
Ranking	**4**	**3**	**2**	**1**
	Taking into the current road conditions, NH-40's role on the state economy, this option is not recommended.	Large-scale involuntary resettlement should be avoided. Cost of the project is largest among the alternatives.	Scale of involuntary resettlement is halved. Land acquisition for the agricultural areas and forest areas is the largest among other options. This option causes a largest economic impact as the same as that of JICA Study Team's Review Option.	Scale of involuntary resettlement is further reduced than DPR Option. Land acquisition for the agricultural areas and forest areas is slightly smaller than DPR Option. This option causes a largest economic impact as the same as that of DPR Option.

Legend: ◎-Highest ○-Good but other alternatives are available △-Other alternatives are better ×-Should be avoided N/A-Not applicable

Source : JICA Study Team

6.6 Scoping Analysis and TOR

6.6.1 Procedures of Scoping Analysis

Depending on the scale and nature of works during the various stages of the project, there are positive and negative impacts to the natural and social environment. These impacts are different in the intensity, in the spatial reach, and in whether it is irrevocable or temporary.

The scoping matrix as per エラー! 参照元が見つかりません。to Table 6-22 highlights anticipated impacts that occur on various environmental and social components during the scoping stage of the project. It is a generic scoping matrix that is applicable to development projects in general and has been prepared based on the initial environmental assessment.

In terms of the impacts caused by the project to the natural environment, mountain slopes are cut at a number of places while filling should also take place, therefore, soil erosion and changes to natural drainage systems during the construction period will take place. At places where bypasses are created and roadside widening takes place, significant amounts of forest areas are cleared. Agricultural fields are also permanently put under the ROW of the project area.

The majority of population in Meghalaya is from the major tribes of the Khasis, the Jaintias and the Garos. Besides the Khasis, Jaintia and Garos, the state has a host of other tribes that have resided in the state for years and have ownership of land and legal residency. Such groups are the Mizo, Hmar, (Mikir, Rabha,), Paitei, Meitei, etc. All these groups are groups from neighbouring states who migrated to Meghalaya and have settled there for countless years. These groups continue to follow their own customs and traditions. Agriculture is the mainstay of the people in the project region, which comprises almost 75% of the work force. Apart from agriculture, other activities in the region are dairy, goat rearing, and piggery operations. The project area represents mostly rural and some urban areas.

6.6.2 Scoping Matrix: Preliminary Analysis of Environmental Impacts

Depending on the scale and nature of works during the various stages of the project, there are positive and negative impacts of the project in relation to the natural and social environment. These impacts are different in intensity, continuity, cumulative nature, spatial reach, and whether it is permanent or temporary.

The scoping matrices of four options as per エラー! 参照元が見つかりません。 Table 6-22 and recommended option as per Table 6-23 highlight the anticipated impacts that may occur on various environmental and social sectors during the scoping stage of the project. It is a generic scoping matrix that is applicable to development projects in general and has been prepared based on the initial environmental assessment.

Within each table, the abbreviations are as follows.

"A" denotes that severe/irrevocable impact is expected (+: Positive impact, -: Negative impact)

"B" denotes that significant impact is expected (+: Positive impact, -: Negative impact)

"C" denotes that the impact is unknown

"D" denotes that impact with little significance occurs (+: Positive impact, -: Negative impact)

Table 6-22: Scoping Matrix of 4 Options

Item	Scoping Analysis of the Anticipated Environmental Impacts											
	No-project			Two-lane Widening			Bypass Inserting Option – DPR Design			Bypass Inserting Option – JICA Study Team's Design		
	Pre-construction	Construction Stage	Operation Stage	Pre-construction	Construction Stage	Operation Stage	Pre-construction	Construction Stage	Operation Stage	Pre-construction	Construction Stage	Operation Stage
Natural Environment												
Climate/ Meteorological Phenomena	D	D	D	D	D	D	D	D	D	D	D	D
Topography	D	D	D	D	B-	D	D	B-	D	D	B-	D
Geology	D	D	D	D	D	D	D	D	D	D	D	D
Soil Erosion	D	D	D	D	B-	B-/B+	D	B-	B-/B+	D	B-	B-/B+
Hydrology	D	D	D	D	C	C	D	C	C	D	C	C
Groundwater	D	D	D	D	D	D	D	D	D	D	D	D
Forest/Flora	D	D	D	D	A-	C	D	A-	C	D	A-	B-
Eco-system/Bio-diversity	D	D	D	D	A-	B-	D	A-	A-	D	A-	A-
Wildlife Reserve	D	D	D	D	D	D	D	D	D	D	D	D
Coastal Zone	D	D	D	D	D	D	D	D	D	D	D	D
Landscape	D	D	D	D	C	C	D	C	C	D	C	C
Natural Disasters	D	D	D	D	B-	B+	D	B-	B+	D	B-	B+
Living Environment/Pollution Control Measures												
Air Pollution	D	D	D	D	B-	B-	D	B-	C	D	B-	B-
Offensive Odor	D	D	D	D	D	D	D	D	D	D	D	D
Water Pollution	D	D	D	D	B-	C	D	B-	C	D	B-	B-
Bottom Sediment Contamination	D	D	D	D	C	D	D	D	D	D	D	D
Soil Contamination	D	D	D	D	C	D	D	C	D	D	C	D
Ground Subsidence	D	D	D	D	D	D	D	D	D	D	D	D
Noise and Vibration	D	D	D	D	A-	B-	D	A-	C	D	A-	C
Sunshine Obstruction	D	D	D	D	D	D	D	D	D	D	D	D
Wastes / Hazardous Materials	D	D	D	D	B-	C	D	B-	C	D	B-	B-
Social Environment												
Involuntary Resettlement	D	D	D	A-	D	D	A-	D	D	A-	D	D
Land Use	D	D	D	B-	B-	B-	A-	A-	A-	A-	A-	A-
Utilization of Local Resources	D	D	D	D	A-	D	D	A-	D	D	A-	D
General, Regional / City Plans	D	D	B-	D	D	B+	D	D	B+	D	D	B+
Social Institutions and Local Decision-making Institutions	D	D	D	B-	B-	B-	B-	B-	B-	B-	B-	B-
Social Infrastructure and Services	D	D	B-	B-	B-	B+	B-	B-	B+	B-	B-	B+
Local Economy and Livelihood	D	D	D	A-	A-/ B+	B+	A-	A-/ B+	B+/B-	A-	A-/ B+	B+/B-
Unequal Distribution of Benefit and	D	D	B-	A-	A-/ B+	B-/ B+	A-	A-/ B+	B-/ B+	A-	A-/ B+	B-/ B+

Damage												
Local Conflicts of Interest	D	D	B-	C	C	C	C	C	C	C	C	C
Water Use, Water Rights and Communal Rights	D	D	D	D	D	D	D	D	D	D	D	D
Cultural and Historical Heritage	D	D	D	D	D	D	D	D	D	D	D	D
Religious Facilities	D	D	D	B-	A-	B-	B-	A-	B-	B-	A-	B-
Sensitive Facilities (e.g. hospital, school, precision machine factory)	D	D	D	A-	A-	D	D	A-	D	D	A-	D
Poor People	D	D	B-	A-	A-/ B+	B+	A-	A-/ B+	B+	A-	A-/ B+	B+
Ethnic Minorities/ Indigenous People	D	D	B-	A-	A-	D	A-	A-	D	A-	A-	D
Gender	D	D	D	C	C	C	C	C	C	C	C	C
Children's Rights	D	D	D	C	D	C	C	D	C	C	D	C
Public Health (sanitation and infectious diseases)	D	D	B-	D	B-	B-	D	B-	B-	D	B-	B-
Occupational Health and Safety (OHS)	D	D	D	D	B-	B-	D	B-	B-	D	B-	B-
Others												
Accidents	D	D	D	D	B-	B+/ B-	D	B-	B+/ B-	D	B-	B+/ B-
Climate Change	D	D	D	D	B-	B+/ B-	D	B-	B+/ B-	D	B-	B+/ B-

Source: JICA Study Team

Table 6-23: Scoping Matrix for the Two-lane Widening of NH40 (Bypass Inserting Option – JICA Study Team's Design)

Item		Scoping Analysis of the Anticipated Environmental Impacts			
		Pre-construction	Construction Stage	Operation Stage	Rationale of the Impact Assessment
Natural Environment					
1.1	Climate/ Meteorological Phenomena	D	D	D	P: No impact is expected. C: Impacts on microclimate should occur but of negligible scale. O: Impacts on microclimate should occur but of negligible scale.
1.2	Topography	D	B-	D	P: No impact is expected. C: Changes in topographic conditions over the project area takes place due to the need for cutting and filling work. O: Topographic conditions should become stable after the completion of construction works, which include slope protection and stabilization.
1.3	Geology	D	D	D	P: No impact is expected. C: No impact is expected. O: No impact is expected.
1.4	Soil Erosion	D	B-	B-	P: No impact is expected. C: Soil erosion occurs particularly during the construction period with monsoon rains.

					O: The project is expected to improve the conditions and thus reduce risk over time as geo-technical measures of slope protection and stabilization should prevent soil erosion. However, periodical monitoring has to be carried out during and after the rainfalls.
1.5	Hydrology	D	C-	C-	P: No impact is expected. C: Construction work may cause minor and temporary impacts on hydrology because of cutting and filling, or the local use of water. O: Cutting and / or filling should result in permanent changes of local hydrology.
1.6	Groundwater	D	D	D	P: No impact is expected. C: The project does not envision the use of groundwater. There is no tunneling works. O: No impact is expected during the operation and maintenance stage.
1.7	Forest/Flora	D	A-	C-	P: No impact is expected. C: During the construction period, ecosystem in the mountain including local flora and fauna as well as forest/wooded areas of approximately 170 ha are cleared. O: Compensatory afforestation should be carried out in order to recover the forest areas lost to the project.
-	Eco-system/Bio-diversity/ Wildlife	D	A-	A-	P: No impact is expected. C: During the construction period, ecosystem in the mountain including local flora and fauna as well as forest/wooded areas are damaged to some extent. Birdlife International calls for Important Bird Area as per Figure 7-31. However, significant area of forest areas must be cleared for the project and wildlife habitat including that of bird species is lost. O: Increase of traffic volume will cause negative impacts on the ecosystem including fauna and flora along the road. Birdlife International calls for Important Bird Area as per Figure 7-31. It is in the area within 5 km of the project area. Because of the forest clearing at Bypass No.6, thick riparian forest is lost permanently causing negative impacts to the habitat for wildlife including bird species. Increase in emissions due to growing traffic volume will negatively affect the existing forest and surrounding ecosystem as access to the forest area becomes easy through the improved road.
1.8	Wildlife Reserve	D	D	D	P: There is no wildlife reserve within 5km radius of the project area. C: There is no wildlife reserve within 5km radius of the project area. O: There is no wildlife reserve within 5km radius of the project area.
1.9	Coastal Zone	D	D	D	P/C/O: There is no coastal zone subject to project intervention.
1.10	Landscape	D	C	C	P: No impact is expected. C: Changes in landscape during the construction work should cause significant landscape changes while it would be temporary during the construction period. O: The project should explore possibilities to develop scenic view areas along the road.
1.11	Natural	D	B-	B+	P: No impact is expected.

	Disasters				C: Many areas of the project area are prone to landslides during the construction period. O: Slope protection / stabilization measures and drainage are expected to significantly reduce the risk of natural disasters.
Pollution					
2.1	Air Pollution	D	B-	B-	P: No impact is expected. C: Some negative impacts are expected due to the operation of construction equipment and vehicles. One example is dust incidental to earthwork especially during the dry season. O: Air pollution is expected to increase due to increased traffic volume on the road.
2.2	Offensive Odor	D	D	D	P/C/O: No impact is expected.
2.3	Water Pollution	D	B-	B-	P: No impact is expected. C: Turbid water due to the earthworks, bridge pier construction work and wastewater effluents from construction workers' camps / yards are expected to pollute the surrounding rivers / canals to some extent. O: Some impacts on water quality in surrounding water bodies are expected due to water discharge from road users and wastewater from maintenance activities.
2.4	Bottom Sediment Contaminatio n	D	D	D	P: No impact is expected. C: There is a possibility that rainwater will wash out construction materials such as cement, sand and other debris into the natural drainage. Contractors are instructed to provide silt trap at places where natural drainage is likely to be affected. O: Some wastewater will be generated from maintenance activities along the road while the impacts on bottom sediment from the wastewater will be negligible.
2.5	Soil Contaminatio n	D	C	D	P: No impact is expected. C: Impacts on soil from deposition of pollutants from construction materials in the construction site are expected to be small. Since there is no major industrial activity along the road, it is unlikely that soil along the road is already polluted. O: No impact is expected.
2.6	Ground Subsidence	D	D	D	P: No impact is expected. C: No impact is expected. O: No impact is expected.
2.7	Noise and Vibration	D	A-	B-	P: No impact is expected. C: Noise and vibration generated by the operation of construction equipment and vehicles, although they are temporary. Construction schedule should take into account the location of schools, hospitals and religious facilities that require silence during parts of the day. O: Noise and vibration level are likely to increase due to greater traffic volume along the road. Specific measures may be required to minimize impacts on schools, hospitals and religious facilities.
2.8	Sunshine Obstruction	D	D	D	P: No impact is expected. C: No impact is expected. O: No impact is expected.
2.9	Wastes / Hazardous Materials	D	B-	B-	P: No impact is expected. C: Waste will be generated from construction workers' camps. Waste generated from construction and demolition work may

					include hazardous materials that must be treated before final disposal.
					O: Waste will be generated from road users and workers of maintenance works.
Social Environment					
3.1	Involuntary Resettlement	A-	D	D	P: Though bypasses are planned to avoid densely-populated areas, expansion of the existing road will result in involuntary resettlement of 30 households at maximum per village. The number of household to be resettled is estimated to be approximately 400.
					C: Resettlement will be completed before construction begins and thus no resettlement is expected during operation.
					O: No impact is expected, as relocation will be completed before construction begins.
3.2	Land Use	A-	A-	A-	P: Land acquisition and involuntary resettlement are likely to cause changes in the existing land use patterns.
					C: Land usage, including cultivation, shifting cultivation, quarry, and agro-forestry, might be significantly affected at bypass sections. Land clearance for construction yards and workers' camps is temporary.
					O: Land usage will be permanently changed especially at bypass sections.
3.3	Utilization of Local Resources	D	A-	D	P: No impact is expected.
					C: Mass-scale use of local resources such as sand and quarrying for the construction activities may make the materials scarce for their needs that exist locally.
					O: No impact is expected as use of local resources is not expected during operation.
3.4	General, Regional / City Plans	D	D	B+	P/C: No impact is expected.
					O: Better infrastructure network may trigger an influx of outsiders and economic development in the region.
3.5	Social Institutions and Local Decision-making Institutions	B-	B-	B-	P/C/O: Land acquisition and involuntary resettlement are likely to affect social institutions such as social capital and local decision-making institutions.
3.6	Social Infrastructure and Services	B-	B-	B+	P: Communal facilities such as public hall may be affected by the project. Access to social infrastructure and services may be temporarily affected due to resettlement and land acquisition.
					C: Access to social infrastructure and services may be temporarily affected due to construction of construction yard and accommodation for workers as well as traffic jams due to the operation of construction vehicles.
					O: In the long term, the project is expected to improve access to social infrastructure and services by providing a better road network.
3.7	Local Economy and Livelihood	A-	A-	B+	P: Loss of income source and livelihood due to involuntary resettlement and change in land usage are expected to negatively affect the local economy and livelihood. Realignment of the bridge section can negatively affect rental boats, tea stalls and open stalls nearby the boat slip, though the affect will be relatively minor.
					C: Loss of income source and livelihood due to involuntary

					resettlement and change in land usage are expected to negatively affect the local economy and livelihood, especially cultivation, quarry and agro-forestry. On the other hand, construction work will have a positive impact on the local economy by creating employment and business opportunities in the project area.
					O: The project will have a positive impact on the local economy as an improved road network ensures a more stable supply of essential goods and transport of cash crops. However, bypasses may negatively affect the business of shops and tea stalls in detoured villages, and business of rental boats, tea stalls and open stalls nearby the boat slip of the detoured bridge section. In the long-term, this will lead to regional economic development with more job and business opportunities. Meanwhile, it is suggested that a proposal be made to village/district council to ensure that the improved infrastructure network will not lead to uncontrolled development and deforestation.
3.8	Unequal Distribution of Benefit and Damage	A-	A-	B-	P: Land acquisition and involuntary resettlement will lead to unequal distribution of benefits and damage between those who are directly affected by the project and those who are not.
					C: While resettling households and households whose livelihood depends on affected lands will bear much of the damage, others may even enjoy benefits from new business opportunities created by construction work, resulting in the unequal distribution of benefits and damage.
					O: People residing along the road may accrue greater benefits compared to others, potentially increasing the rich-poor gap within the community. Over the long term, the project is expected to have a positive impact on the local economy through an improved road network.
3.9	Local Conflicts of Interest	C	C	C	P: Expectation for unequal distribution of benefits and damage may trigger and / or intensify local conflicts of interest in the community.
					C/O: Unequal distribution of benefits and damage may trigger and / or intensify local conflicts of interest in the community though the impact is relatively minor.
3.10	Water Usage, Water Rights and Communal Rights	D	D	D	P/C: Water usage of the affected households may be curtailed due to resettlement. However, rainwater is commonly used for both household and agricultural use in the region and thus, the impact will be minor, if any.
					O: No impact is expected.
3.11	Cultural and Historical Heritage	D	D	D	P/C/O: The targeted roads do not traverse or run near major cultural or historical heritage sites.
3.12	Religious Facilities	B-	A-	B-	P: A number of churches, several memorial stones and graves are located along the road. Several memorial stones are directly affected. Graves can be affected in private yards. The targeted roads do not traverse sacred groves of traditional religious beliefs.
					C: Roadside religious facilities may be affected by noise and vibration during construction and operation due to construction work and greater traffic volume.
					O: Several memorial stones are directly affected, which requires appropriate protection or realignment of the route.

3.13	Sensitive Facilities (e.g. hospital, school, precision machine factory)	D	A-	D	P: No impact is expected C: Noise and vibration during construction work may affect schools, public health centers and other medical facilities. O: No impact is expected as sufficient noise control measures will be implemented.
3.14	Poor People	A-	A-	B+	P: Given the limited coping capacity of the poor, it is necessary to assess their vulnerability and develop appropriate mitigation measures. C: The poor may bear a disproportionally higher burden due to their limited capacity to cope, although they can benefit from employment opportunities during construction work. P: In the long-term, economic development in the region is likely to benefit the poor, however, the poor may fail to benefit from the project due to the lack of skills and coping capacity.
3.15	Ethnic Minorities/ Indigenous People	A-	A-	D	P/C: East Khasi Hills and Jaintia Hills of Meghlaya State are home to tribal groups (Scheduled Tribe) with distinct languages and cultures. Preparation of RAP and livelihood restoration plan, therefore, must take this into account. O: Resettlement will be completed before construction. Negative impacts shall be minimized by considering relocation places and livelihood restoration plans.
3.16	Gender	C	C	C	P: Resettlement may affect gender-related work division such as cultivation, harvest and processing of crops. C: Equal opportunity should be sought for employment during construction work. Prevailing social and cultural norms must be carefully studied to avoid gender-related conflicts. Project may affect gender-related work division such as cultivation, harvest and processing of crops. O: Project may affect gender-related work division such as cultivation, harvest and processing of crops.
3.17	Children's Rights	C	D	C	P: Though child labor is unlawful according to Article 24 of the Indian Constitution, the project may affect children who help their families with work at roadside shops and tea stalls. C: Child labor is unlawful according to Article 24 of the Indian Constitution. Only adults are eligible for potential employment opportunities created by the project. O: Though child labor is unlawful according to Article 24 of the Indian Constitution, the project may affect children who help their families with work at roadside shops and tea stalls.
3.18	Public Health (sanitation and infectious diseases)	D	B-	B-	P: No impact is expected. C: Influx of construction workers is likely to increase health risks, particularly that of STD / STI and HIV / AIDS. The risk of malaria should be properly managed in construction work in areas where malaria is prevalent. O: An increase in traffic volume and road users may have negative impacts on public health.
3.19	Occupational Health and Safety (OHS)	D	B-	B-	P: No impact is expected. C: Occupational health and safety of construction work should be properly managed through adequate EMP. O: Maintenance and repair work should take into account the occupational health and safety of the workers.
Others					

4.1	Accidents	D	B-	B+/ B-	P: No impact is expected.
					C: Increased risk of accidents associated with construction activities is expected due to the operation of heavy equipment and vehicles. Special attention is required for construction in the foggy area.
					O: Risks of accidents is expected to increase due to greater traffic volume and speed. Speed limits and use of headlight / hazard lights shall be required especially in the foggy area. Putting in place accident-prevention measures (such as mirrors at curves) will reduce the risk of accidents.
4.2	Climate Change	B-	B-	B+/ B-	P: No impact is expected.
					C: The use of construction machines and operation of vehicles will result in an increase in GHG emissions, though the impact is small and short-term.
					O: GHG emissions will increase due to an increase in traffic volume. The project is expected to improve the resilience of the road against climate change by factoring long-term climate change (changes / increase in precipitation etc.) into the road design.

Source: JICA Study Team

Note:
P: Pre-Construction; C: Construction; and O: Operation Period
A: Severe/irrevocable impact is expected (+: Positive impact, -: Negative impact)
B: Significant impact is expected (+: Positive impact, -: Negative impact)
C: Further study is required as impact is unknown
D: Impact with little significance occurs

TOR of the Natural Environment and Socio-economic Survey is shown in Table 6-24.

Table 6-24: TOR of Natural and Socio-economic Environment Survey

Scoping No.	Survey	Locations	Methods and Duration	Items Subject to Investigation	Method of Assessment and Estimation of Impacts
Natural Environment					
1.2	Geography/ Geomorphoogy	Entire Project Area	• Field survey, interview survey and map location study for the disaster-prone areas Present conditions examined in may – July 2016	• Areas subject to cut and fill slope createon	Assessment of the Impact: Based on the secondary data and field survey, impact areas are assessed. Estimation of the Impact: Qualitative analysis on the assessed impacts.
1.4	Soil Erosion	Entire Project Area	• Field survey, interview survey and map location study for the disaster-prone areas Present conditions examined in may – July 2016	• Areas subject to cut and fill slope createon	Assessment of the Impact: Based on the secondary data and field survey, impact areas are assessed. Estimation of the Impact: Qualitative analysis on the assessed impacts.
1.5	Hydrogegrahhy	Entire Project Area	• Field survey, interview survey and map location study for the disaster-prone areas Present conditions examined in may – July 2016	• Existing waterways such as rivers, streams and agricultural canals as well as sewerage channel	Assessment of the Impact: Based on the secondary data and field survey, impact areas are assessed. Estimation of the Impact: Qualitative analysis on the assessed impacts.
1.7	Ecosystem/Biological Diversity	NH-40: 4 locations (approximately every 20km)	• Field Survey • Document survey • Hearing Survey on manger of parks and experts. • Bird survey (hearing survey on NGO/ Experts, Field Survey) Present conditions examined	• Rare species, breeding colony, wetland, parks, pictures Area of investing within the 5km of radious from the center of the alignment of NH-40.	Assessment of the Impact: Based on the field observation and secondary data, baseline data are determined. Estimation of the Impact:Forest clearing areas and the rare species of wildlife including bird species are analyzed qualitatively.

Scoping No.	Survey	Locations	Methods and Duration	Items Subject to Investigation	Method of Assessment and Estimation of Impacts
			in may – July 2016		
1.7	Wildlife Reserve/ Sancuary	NH-40: 4 locations (approximately every 20km)	• Field Survey • Document survey • Hearing Survey on manger of parks and experts. • Bird survey (hearing survey on NGO/ Experts, Field Survey) Present conditions examined in may – July 2016	Exiting wildlife reserves adjacent to the project area	Assessment of the Impact: Based on the field observation and secondary data, baseline data are determined. Estimation of the Impact:Forest clearing areas and the rare species of wildlife including bird species are analyzed qualitatively.
1.7	Wildlife/Plant Distribution	NH-40: 4 locations (approximately every 20km)	• Field Survey • Document survey • Hearing Survey on manger of parks and experts. • Bird survey (hearing survey on NGO/ Experts, Field Survey) Present conditions examined in may – July 2016	Rare species, breeding colony of wildlife, wetland, forest reserves and other areas based on the local knowledge on the plants and wilidlife.	Assessment of the Impact: Based on the field observation and secondary data, baseline data are determined. Estimation of the Impact: Forest clearing areas and the rare species of wildlife including bird species are analyzed qualitatively.
1.7	Forest	NH-40 : within ROW and trees which will be hindrance to construction	• Hearing Survey, Filed Survey (counting of deforestation trees), review of documents Present conditions examined in may – July 2016	Number, type, height, girth of trees, and forest areas subject to clearing for the Project.	Assessment of the Impact: Based on the field observation and secondary data, baseline data are determined. Estimation of the Impact: Forest area clearing area (ha), number of trees subject to cutting are estimated quantitatively as well as qualitatively.
1.10	Landscape	Entire Project Area	• Field survey and hearing survey along the project area	• Field survey on the existing landscape and viewpoint areas	Assessment of the Impact: Based on the secondary data and field survey, impact areas are

Scoping No.	Survey	Locations	Methods and Duration	Items Subject to Investigation	Method of Assessment and Estimation of Impacts
			• Present conditions examined in may – July 2016	Investigation of the secondary data on the viewpoint construction works	assessed. Estimation of the Impact: Qualitative analysis on the assessed impacts based on the past incidents.
1.11	Natural Disaster	Entire Prject Area	• Field survey and hearing survey along the project area • Present conditions examined in may – July 2016	• Field survey on the existing landscape and viewpoint areas • Areas subject to cut and fill slope createon	Assessment of the Impact: Based on the secondary data and field survey, impact areas are assessed. Estimation of the Impact: Qualitative analysis on the assessed impacts based on the past incidents.
Living Environment					
2.1	Air Quality	<u>NH-40:</u> 9 locations (approximately every 10km)	• Continuously 24 hours per location (1 weekday) • Accordance with environmental standard in India • Present conditions examined in May – July 2016	• SPM, RPM, NOx	Assessment of the Impact: Baseline data obtained on site are compared against the Indian standard for quantitative analysis. Estimation of the Impact: General trend of increase of the traffic and vehicles are taken into account of CO2 increase is quantitatively analyzed.
2.3	Water Quality	<u>NH-40:</u> 9 locations (river crossing points and wells for approximately every 10km),)	• According to the environmental standard in India • Present conditions examined in may – July 2016	• Water temperature, odor, turbidity (NTU)、pH、BOD5 、 COD 、 total suspended solids	Assessment of the Impact: Baseline data obtained on site are compared against the Indian standard of water by CPCB for quantitative analysis. Estimation of the Impact: Water use during the construction period and operation and maintenance

Scoping No.	Survey	Locations	Methods and Duration	Items Subject to Investigation	Method of Assessment and Estimation of Impacts
					period is analyzed
2.5	Soil Contamination	NH-40: 9 locations (approximately every 10km)	• Soil sampling and labolatory analysis • Present conditions examined in may – July 2016	• Based on IS2770 Method	Assessment of the Impact: Baseline data obtained on site are compared against the Indian standard put out by CPCB for quantitative analysis. Estimation of the Impact: Monitoring and analysis during the construction period and operation and maintenance period for soild analysis.
2.7	Noise and Vibration	NH-40: 9 locations (approximately every 10km)	• Continuously 24 hours per location (1 weekday) in accordance with noise standard in India and international standard for vibration • Present conditions examined in may – July 2016	• Noise level and noise-level-based traffic vibration	Assessment of the Impact: Baseline data obtained on site are compared against the Indian standard of noise by CPCB for quantitative analysis. Estimation of the Impact: Based on noise measurement result, framework of traffic vibration prediction is suggested.
2.9	Solid Waste	Entire Project Area	• Solid waster produced during the construction period • Present conditions examined in may – July 2016	• Solid waste production and disposal during the construction period • Solid waste produced during the maintenance works of the IProject •	Assessment of the Impact: Field observantion during the construction period based on the Central/State Pollution Controll Board Estimation of the Impact: Field observantion during the maintenance period based on the Central/State Pollution Controll Board

Scoping No.	Survey	Locations	Methods and Duration	Items Subject to Investigation	Method of Assessment and Estimation of Impacts
Social Environment					
3.1	Involuntary Resettlement	NH-40: within ROW	• Census and inventory Interview Survey, Land property survey, Livelihood survey • Hearing Survey, Filed Survey • Focused Group Discussion	• Census and inventory using questioners. Resettlement cost will be calculated based on the survey result.	- Estimate the number of Involuntary resettlement affected by ROW and evaluate the result in quantitative by Census study. - Evaluate affected land and property of PAHs in quantitative by survey. - Evaluate socio-economic situation in quantitate by survey.
3.2	Land Use	NH-40: within ROW	• Hearing Survey, Filed Survey	• Land utilization , Range of Impact by project	Estimate the impact and evaluate the result in quantitative based on result of Field Survey, Review of Document and Similar Examples
3.3	Utilization of Local Resources	NH-40 : villages along the proposed alignment	• Hearing Survey, Filed Survey • Focused Group Discussion	• Utilization of Resource, Industrial Structure	Estimate the impact based on result of Field Survey, Review of Document and Similar Examples
3.4	General, Regional / City Plans	NH-40 : villages along the proposed alignment	• Hearing Survey, Filed Survey	• Development of region, City planning	Estimate the impact based on result of Hearing Survey, Review of Document and Similar Examples
3.5	Social Institutions and Local Decision-making Institutions	NH-40 : 100m from the proposed alignment	• Hearing Survey, Filed Survey • Focused Group Discussion	• Social Institution, Decision –making institution, the relationship	Estimate the impact based on result of Field Survey, Review of Document and Similar Examples
3.6	Social Infrastructure and Services	NH-40 : villages along the proposed alignment	• Hearing Survey, Filed Survey • Focused Group Discussion	• Name of Institution, distant from ROW, location, Accessibility	Estimate the impact based on information of water facility, sewage treatment facility, power distribution facility, telecommunication facility /public facilities(medical,

Scoping No.	Survey	Locations	Methods and Duration	Items Subject to Investigation	Method of Assessment and Estimation of Impacts
					education, religious, culture)
3.7	Local Economy and Livelihood	NH-40 : villages along the proposed alignment	• Hearing Survey, Filed Survey • Focused Group Discussion	• Economy situation, social structure, livelihood, situation of burn agriculture	Estimate the impact and based on result of Field Survey, Review of Document and Similar Examples
3.8	Unequal Distribution of Benefit and Damage	NH-40 : villages along the proposed alignment	• Hearing Survey, Filed Survey • Focused Group Discussion	• Livelihood, PAPs, Utilization of Affected Land	Estimate the impact based on result of Field Survey, Review of Document and Similar Examples
3.9	Local Conflicts of Interest	NH-40 : villages along the proposed alignment	• Hearing Survey, Filed Survey • Focused Group Discussion	• Livelihood, PAPs, Utilization of Affected Land, Social relationship	Estimate the impact based on result of Field Survey, Review of Document and Similar Examples
3.12	Religious Facilities	NH-40 : 100m from the proposed alignment	• Hearing Survey, Filed Survey • Focused Group Discussion	• Name of Institution, distant from ROW, location, local information, Photograph	Estimate the impact based on result of Field Survey, Review of Document and Similar Examples
3.13	Sensitive Facilities (e.g. hospital, school, precision machine factory)	NH-40 : 100m from the proposed alignment	• Hearing Survey, Filed Survey • Focused Group Discussion	• Name of Institution, distant from ROW, location, local information, Photograph	Estimate the impact based on result of Field Survey, Review of Document and Similar Examples
3.14	Poor People	NH-40 : villages along the proposed alignment	• Hearing Survey, Filed Survey • Focused Group Discussion	• Social structures, traditional livelihood, rehabilitation policy considering the above..	Estimate the impact based on result of Field Survey, Review of Document and Similar Examples
3.15	Minority/ Indigenous People	NH-40: villages directly affected by the proposed alignment	• Hearing Survey, Filed Survey • Focused Group Discussion	• Social structures, traditional livelihood, rehabilitation policy considering the above..	Estimate the impact based on result of Field Survey, Review of Document and Similar Examples
3.16	Gender	NH-40 : villages along the proposed alignment	• Hearing Survey, Filed Survey	• Social Structure, Livelihood, Literacy,	Estimate the impact based on result of Field Survey, Review of

Scoping No.	Survey	Locations	Methods and Duration	Items Subject to Investigation	Method of Assessment and Estimation of Impacts
			• Focused Group Discussion	Condition of Employment	Document and Similar Examples
3.17	Children's Rights	NH-40 : villages along the proposed alignment	• Hearing Survey, Filed Survey • Focused Group Discussion	• Social Structure, Livelihood, Literacy, Condition of Employment	Estimate the impact based on result of Field Survey, Review of Document and Similar Examples
3.18	Public Health (sanitation and infectious diseases)		• Review of documents	• Rate of disease, epidemic and that of tendency	Estimate the rate of disease, epidemic and that of tendency by Review of Document and Similar Examples
3.19	Occupational Health and Safety (OHS)		• Review of documents	• Risk of Safety and Health, countermeasure	Estimate the impact based on Similar Examples
Others					
4.1	Accidents		•	•	
4.2	Climate Change	NH-40: within ROW	• Filed Survey • review of documents	• Square meters of deforestation	

Source: JICA Study Team

(1) Primary Data Collection

1) Air Quality

Ambient air quality was monitored along the road at selected sites. The locations selected were those of the city/town area, the market place and the rural areas. Entire stretch of the Project's present road section has been surveyed and screened are examined through NABL Accredited Laboratory. The air quality parameters considered for the study include Particulate Matter10 (PM10), Particulate Matter 2.5 (PM2.5), Nitrogen Oxides (NOx) Sulphur Di-oxide (SO2), and Carbon monoxide (CO).

a. Particulate Matters (PM10 & PM2.5)

PM10 and PM2.5 were monitored using a Respirable Dust sampler (RDS) and PM2.5 Sampler. A pre-conditioned and weighted glass fiber filter papers are placed on top of the RDS/PM2.5 samplers. A known quantity of the air was sucked through the filter paper in a prescribed sampling time. The flow was noted from the manometer. The multiplication of time with rate gave the total quantity of air passed through the filter paper. After sampling, the filter paper was removed, conditioned, and weighed finally for getting the concentrations in ambient air.

b. Sulphur Di-Oxides (SO_2)

A known quantity of the air was bubbled through impingers containing tetrachloromercurate. SO_2, formed a disulfiltomercurate complex, which gave a pinkish blue colour with p-rosaniline and formaldehyde solution. The intensity of colour produced was proportional to concentration of sulphur dioxide. The measurement was made by using spectrophotometer at the wavelength of 560 nm.

c. Nitrogen Di-Oxides (NOx)

A known quantity of air was passed through impingers containing sodium hydroxide-sodium arsenite solution. The estimation of NOx was done colorimetrically using hydrogen peroxide, sulfanilamide, NEDA, etc. The intensity of the colour was measured at 540 nm using a spectrophotometer.

d. Carbon Monoxide (CO)

FID based samplers are used to monitor the carbon monoxide levels.

2) Water Quality

Samples of ground water were collected from springs whereas samples of surface water were collected from rivers. To assess the water Quality of the area samples were tested for physico-chemical parameters.

3) Soil Quality

The samples were collected from 60 m corridor of the road, at 5-15 cm depth. Besides studying their particle size (sand/silt/clay ratio) they were monitored for physico-chemical parameters to assess the soil quality of the area.

4) Noise Level

The noise level (Leq) was measured using noise meter at various sites along the entire stretch of road during day (6.00 am to 10 pm) and night (10 pm to 6.00 am).

The noise levels is expressed as an equivalent noise level (Leq) which is the measurement duration of sound pressure level as the averaging time. It is calculated as follows:

$$Leq = 10\ Log10\ [\sum_1^n 10\ Li/10]$$

Where the basis of Leq is calculated by using Li (not shown in the above formula) = Instantaneous sound intensity level dB (A) and n = No. of observations

(2) Secondary Data Collection

1) Data Sources

The secondary data were collected from following sources:

Table 6-25: Secondary Data Collection

1.	General information	District Collector/Gazetteer Office
2.	Meteorological data	Indian Meteorological Department
3.	Statistical data	District Statistical Office
4.	Irrigation and hydrogeology data	Central Ground Water Board
5.	General Land use and Cropping Pattern	Asst. Director of Agriculture
6.	Relief and slope	Survey of India
7.	Rocks and minerals	Geological Survey of India
8.	Industries	District Industries Center
9.	Maps and Topo sheets	Survey of India
10.	Forests/Wild life/Bio-diversity	District Forest Office
11.	Flora and Fauna	District Forest Office
12.	Archaeological Data	Archaeological Survey of India

Source: JICA Study Team

2) Analyses, Compilation and Preparation of Report

The data collected by survey teams were compiled. Along with the field monitoring studies and secondary data, these were used to identify the environmental problem.

The following analyses were carried out based on compiled information:

a. The levels of environmental parameters were compared with the prescribed limits suggested by Central Pollution Control Board (CPCB). This gave a clear idea that special attention is paid in areas where the level of pollution is higher than desirable.

The mitigation measures have been suggested to reduce the adverse impacts due to the proposed widening and detailed EMP have been prepared covering both the phases i.e. construction and operation of highway.

6.7 Anticipated Environmental Impacts

6.7.1 Environmental Impact Matrix of NH40

Based on the scoping results and initial assessment of alternative options, JICA Study Team's two-lane widening of NH40 was the selected option subject to further studies and analysis. This option had made modifications to the bypass insertion option of DPR, carried out by NHIDCL's consulting firm. Anticipated environmental impacts are assessed as per Figure 6-24.

Table 10.1-xx Scoping Matrix on the Environment and Social Considerations
Two-lane widening of NH-40: JICA Study Team's Design

Category	No.	Project Activities / Items of the Environment Subject to Negative/Positive Changes	Overall Evaluation on the Project	Pre-construction Stage			Construction Stage									Post-construction Stage					
				Survey/Study on the Project	Information on the Project	Participation to the SH Meeting	Land Acquisition and Resettlement	Clearing Vegetation/Top Soil for Preparation of the Construction Works	Earth Moving; Cutting and Filling the Construction Works	Preparation of the Construction Areas, Work Camp and Mobilization of Construction Plant and Materials	Diversion of the Existing Road/Bypass Road Construction Works	Construction Works for Sidewalks and other Road Furniture	Emanation of Dust, Noise and Vibration	Localized Employment Opportunities of the Construction Works	Localized Business Opportunities Related to the Construction Works	Improvement of Traffic Congestion	Improvement of Bus Bays and Other Road Facilities	Improvement of Road Safety	Improvement of Employment Opportunities	Improvement of Road Transport-oriented Business	Improvement of Freight-oriented Business
Social Environment	1	Effects on the Livelihood of the Local Communities																			
		a. General	B+	-	-	-	A-	-	-	-	B-	-	-	B+	-	B+	-	-	A+	A+	-
		b. Socially and Physically Disadvantaged	B+	-	-	-	B-	-	-	-	-	-	-	-	-	B+	-	-	A+	A+	-
		c. Women and Children	B+	-	-	-	-	-	-	-	-	-	-	B+/ -	-	B+	-	-	A+	A+	-
		d. Ethnic Minority	B+	-	-	-	A-	-	-	-	-	-	-	B+	-	B+	-	-	A+	A+	-
	2	Social Cohesion and Physical Continuity of the Local Communities	-	-	-	-	B-	-	-	-	-	-	-	-	-	-		-	-	-	-
	3	Local Road Transportation System	A+	-	-	-	B-	-	-	-	-	-	-	-	-	A+	A+	-	-	-	-
	4	Distribution of the Benefit of the Project	B+	-	-	-	B-	-	-	-	-	-	-	B+	-	B+	-	-	A+	A+	-
	5	Effect on the Social and Cultural Events and Tradition	-	-	-	-	B-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	6	Effect on the Local Economic Activities																			
		a. Industrial Areas	B+	-	-	-	B-	-	-	-	-	-	-	-	-	B+	-	-	-	-	-
		b. Commercial and Busines Areas	B+/B-	-	-	-	B-	-	-	-	-	-	-	-	-	B+	-	-	-	-	-
	7	Effect on the Water Rights/Commons for Grazing etc.	-	-	-	-	B-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8	Public Hygiene and Health Care of the Local Communities	-	-	-	-	-	-	-	B-	-	-	-	-	-	-	-	-	-	-	-
	9	Vulnerability/Resilience of the Society to Natural Disaster	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10	Traffic Safety	B+	-	-	-	-	-	-	-	-	-	-	-	-	B+/B-	-	A+	-	-	-
	11	Changes on the Land Use and the Landscape	B-	-	-	-	A-	B-	B-		-	B-	-	-	-	-	-	-	-	-	-
Natural Environment	12	Geographical Conditions	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	13	Geological Conditions	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	14	Soil Erosion	-	-	-	-	-	C- to B-	C- to B-	C- to B-	C- to B-	C- to B-	-	-	-	-	-	-	-	-	-
	15	Faunal Ecology	-	-	-	-	-	B-	B-	B-	B-	B-	-	-	-	-	-	-	-	-	-
	16	Flora Ecology/Forest Area	-	-	-	-	-	A-	A-	A-	A-	A-	-	-	-	-	C+ to B+	-	-	-	-
	17	Effects on the Ground Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	18	Effect on the Surface Water Body (River, Lakes, etc)	-	-	-	-	-	C-	C-	C-	C-	C-	-	-	-	-	-	-	-	-	-
	19	Effect on the Coastal Environment	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	20	Oceanographic Changes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	21	Effect on the Natural/Ecological Reserves and Sanctuaries	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	22	Localised Climatic Changes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	23	Effect on the Global Warming Issues	-	-	-	-	-	C-	C-	C-	C-	C-	C-	-	-	C-	-	-	-	-	-
Pollution	24	Air Pollution	-	-	-	-	-	C-	C-	C-	C-	C-	C-	-	-	C-	-	-	-	-	-
	25	Water Pollution	-	-	-	-	-	B-	B-	B-	B-	B-	-	-	-	-	-	-	-	-	-
	26	Soil Pollution	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	27	Solid Waste and/or Industrial Discharge Management	-	-	-	-	-	B-	B-	B-	B-	B-	B-	-	-	-	-	-	-	-	-
	28	Noise and Vibration	-	-	-	-	-	C-	C-	C-	C-	C-	C-	-	-	C-	-	-	-	-	-
	29	Large Scale Ground Settlement	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	30	Emanating Odour	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	31	Pollution on the Water Bottom/Sludge and Its Effect on the Aquatic Life	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Legend: A - Significant changes expected; B - Relatively significant changes expected; C - Not significant but subject to further study; and D - No impact expected to occur
A+/A-, B+/B-, C+/C- indicates that there would be positive impact while negative impact could also occur. "-" indicates no impact takes place.
"A+" indicates that there would be positive impact only and "A-" indicates that there would be negative impact only.

Source: JICA Study Team

Figure 6-24: Environmental Impact Matrix

6.7.2 Major Impacts on the Natural Environment

(1) Survey Result

1) Flora of the Project Area

i) Secondary Sources of Flora in Meghalaya State

The forests of Meghalaya can be broadly grouped into tropical, subtropical and temperate types. The Indian Institute of Remote Sensing has classified the vegetation of Meghalaya into tropical evergreen, tropical semi-evergreen, tropical moist deciduous, subtropical broad leaved, subtropical pine and temperate forest types, grasslands and savannas. The general vegetation pattern along NH40 is discussed below. There are no sanctuaries, national parks, or biosphere reserves near the highway.

The temperate forests is found at 1,500 m and above, mostly along the southern slope of Khasi. The annual rainfall in these areas ranges from 200-500 cm with a severe winter from November to March. Ground frost is common during December and January. Subtropical pine forests have developed as a stable secondary community on the disturbed evergreen and semi-evergreen subtropical broad-leaved forest sites, which are seasonally dry and nutrient-poor. Such forests are found from Shillong to Mylliem, Umatyngar upto Pynursla; covering bypasses #1 to #5.

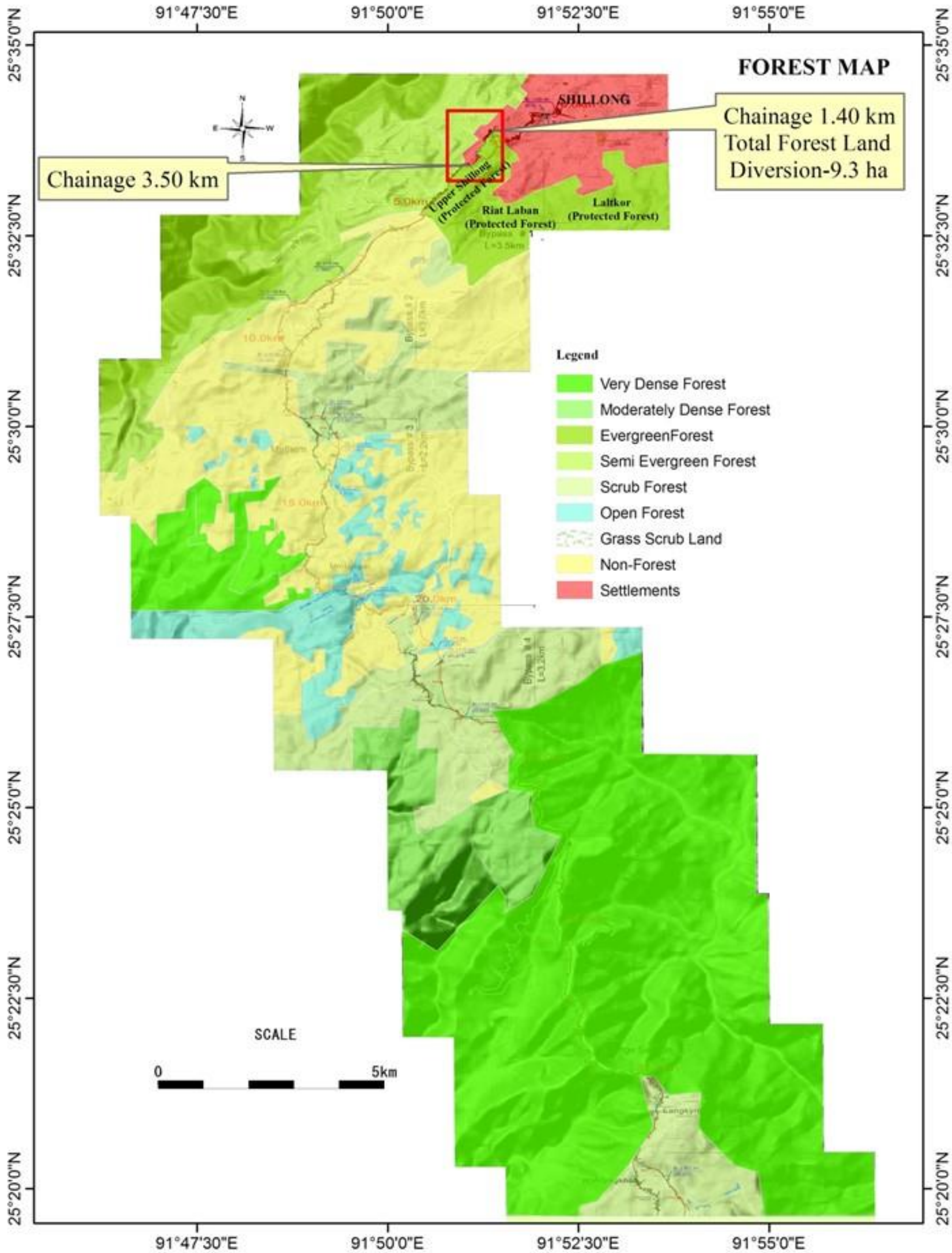
Tropical forests are found up to an elevation of 1,200 m where average annual rainfall ranges between 100 and 250 cm. They may be evergreen, semi-evergreen and moist deciduous depending on the annual rainfall. Mostly semi-evergreen and moist deciduous types of vegetation is observed closer to Dawki. The common species of semi-evergreens are Careya arborea, Dillenia pentagyna and Callicarpa arborea whereas Shorea robusta, Tectona grandis, Terminalia myriocarpa, Sterculia villosa, Logerstroemia flos-reginae, Artocarpus gameziana, Tetrameles nudiflora, Lannea coromandelica, Salmalia malabarica Erythrina stricta, Premna milliflora, Vitex peduncularis, Albizia lebbeck, Terminalia bellirica etc, represent the moist deciduous types of vegetation.

Grasslands are not a climax type but are the result of the removal of the original forest cover. The rolling grasslands covering large areas can be seen all along the NH40. Such grasslands are more frequent in the temperate forests region.

ii) Method of Assessment

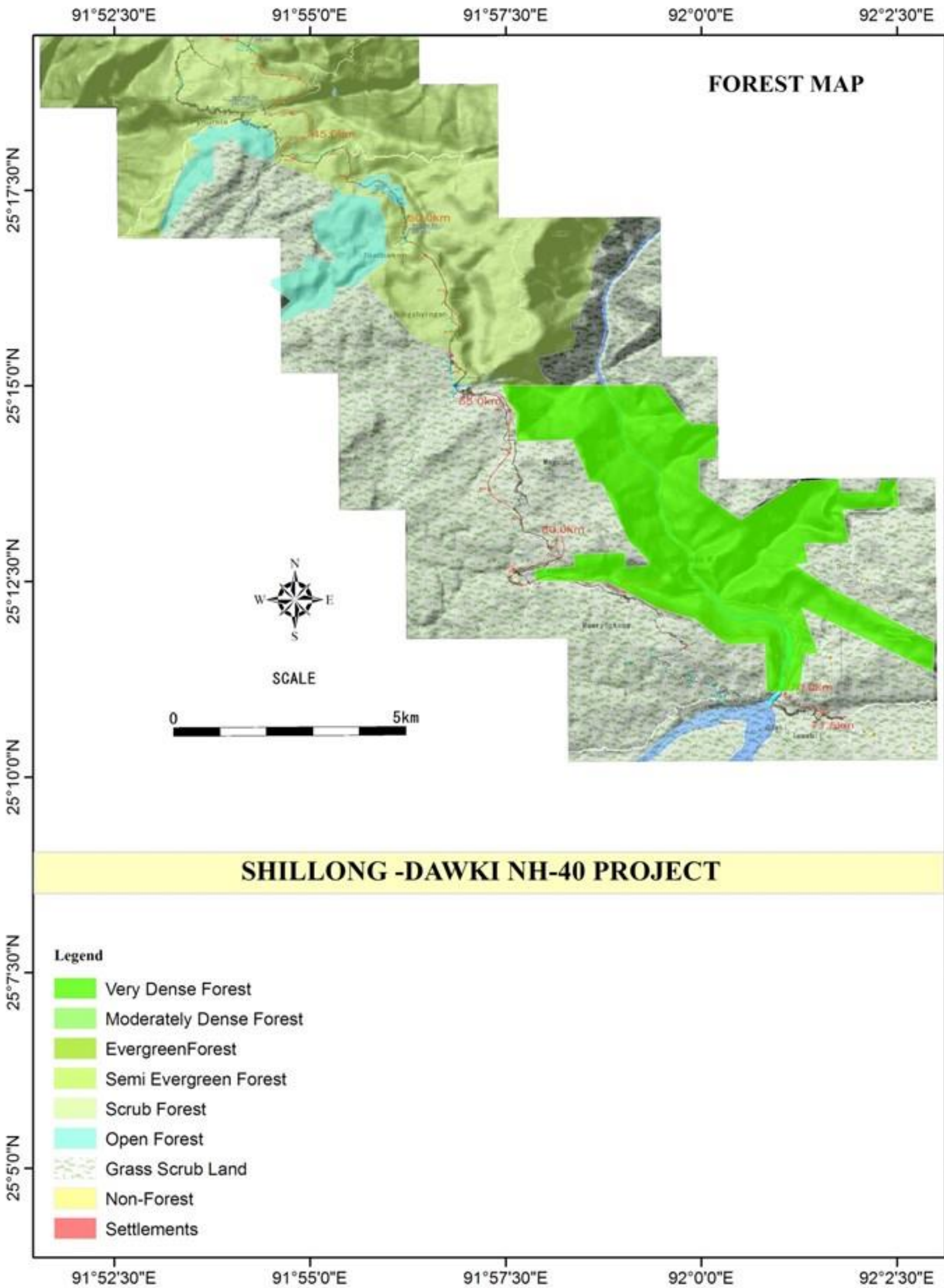
Floral / vegetation assessments were carried out through quadrate methods: for trees 10 m x 10 m, for shrubs 5 m x 5 m and for herbs 1 m x 1 m square shaped quadrates were used. Quadrates were laid randomly in the corridors on the upside and downside of the road. All species in the quadrates were recorded and ecological parameters including density and frequency were calculated. Also, the Meghalaya government records were referred to for the flora and fauna. Faunal species were recorded with visual observation during site visits, and supplemented with secondary data from the Environment and Forest Department as well as information from the local community. While impacts on the river and river ecosystem are expected to be negligible, the aquatic ecosystem of Umngot River, the major river that NH40 passes through, has been summarized based on a review of literature. The assessment of flora and fauna along the NH40 was carried out in the month of May and June of 2016.

General distribution of forest areas and plants along the project area is shown in Figure 6-25 and Figure 6-26.



Source：JICA Study Period

Figure 6-25: Forest and Plant Distribution of The Project Area (0 km – 39.5 km)



Source：JICA Study Period

Figure 6-26: Forest and Plant Distribution of The Project Area (39.5 km – 71.5 km)

iii) Forest Species

The Forest and Environment Department of Meghalaya classified the forests in the state into six types. A growing stock for each of the forest types which is defined below has been presented in the report. The six forest types have been identified on the basis of economically important tree species.

- **a. Khasi Pine Forest -** Forest where Khasi pine constitutes more than 50% of the stand.
- **b. Teak Forest** – Forest in which Teak trees constitute more than 20% of the stand.
- **c. Sal Forests -** Forest in which Sal trees constitute more than 20% of the stand.
- **d. Hardwood Mixed with Conifers** – Forest where the Conifers and broad-leaved tree species exist in equal proportions.
- **e. Upland hardwood** – Forest above 1000 m altitude with predominance of hardwood species.
- **f. Miscellaneous –** Forest which does not belong to any of the above types.

iv) Plant Distribution of the Project Area

The following tables give a summary of the growing stock for each of the forests.

There are a number of forested areas known as the “Sacred Forest” in East Khasi Hill. A clan in the project area generally forming a village owns each “Sacred Forest”. However, based on the hearing survey, there is no “Sacred Forest” that is directly affected by the project.

The widening of NH40 involves the construction of a number of shortcuts in order to ease vehicle movements and avoid traffic congestions. Where bypasses are inserted, built-up areas are avoided to minimize unwanted resettlements. Due to these improvements of NH40, the existing flora and fauna along the highway is assessed to see if protected species or any other important species are adversely affected. Table 7-26 to Table 6-34 show the major plant species of Meghalaya state.

Table 6-26: Major Tree Species in Meghalaya State

Botanical name	Local name
1 Ammora wallichii	Amari
2 Lagerstroemia	Ajhow, Jarul, Sida spp.
3 Phoebe goalparensis	Bonsum
4 Ailanthus grandis	Borpat
5 Tetrameles nudiflora	Bhelu
6 Chukrassia velutina	Bogipoma
7 Dysoxylum binecteri ferum	Bandordima
8 Morus laevigata	Bola
9 Terminalia spp.	Bahera, Bhomda
10 Michelia spp.	Champ, Sopa
11 Canarium resiniferum	Dhuna
12 Gmelina arborea	Gamari
13 Cinnamomum spp.	Gonsordi
14 Terminalia myriocarpa	Hollock
15 Castanopsis indica	Hingori
16 Pterospermum acerifolium	Hatipolia
17 Albizzia spp. ,	Hiraru, Moroi, Sundi, Saw
18 Altingia excelsa	Jutuli
19 Lannea coromondelica	Jia
20 Syzigium jambosa	Jam, Jamoon
21 Cedrela toona	Jatipoma, Poma
22 Duabanga grandiflora	Khokan, Ramdala
23 Anthocephalus cadamba	Kadam
24 Machilus spp.	Kowla
25 Talauma phellocarpa	Kharikasopa
26 Schima wallichii	Makrisal, Nagaplu
27 Phoebe cooperiana	Makahi
28 Mesua ferrea	Nahar
29 Dillenia indica	Outenga
30 Kydia calycina	Pichola
31 Garuga pinnata	Rahimula, Thutmala
32 Artocarpus	Sam, Champ, Kathal
33 Bombax ceiba	Simul
34 Pinus kesiya	Pine
35 Aquilaria agallocha	Agar, Diang Agar & Bolagar
36 Artocarpus lakoocha	Haldu
37 Adina oligocephala	Chamkoroi
38 Albizzia odoratissima	Haldu
39 Adina cordiflolia	Boal
40 Caroya arborea	Kum
41 Ficus spp.	Dimonu
42 Podocarpus nerifolia	Jinari
43 Quercus spp.	Oak
44 Shorea robusta	Sal
45 Trewia nudiflora	Bhura
46 Callicarpa arborea	Maksi
47 Tectona grandis	Teak

Source: Forest and Environment Department, Government of Meghalaya

Table 6-27: General Tree Species

Sl. No.	Scientific Name	Family
1.	*Lannea coromandelica*	Anacardiaceae
2.	*Mangifera indica*	Anacardiaceae
3.	*Spondias piñata*	Anacardiaceae
4.	*Spondisas axillaris*	Anacardiaceae
5.	*Areca catechu*	Arecaceae
6.	*Caryota urens*	Arecaceae
7.	*Bombax ceiba*	Bombacaceae
8.	*Calophyllum polyanthium*	Clusiaceae

9.	*Anogeissus acuminata*	Combretaceae
10.	*Terminalia bellirica*	Combretaceae
11.	*Terminalia myriocarpa*	Combretaceae
12.	*Dillenia pentagyna*	Dilleniaceae
13.	*Shorea robusta*	Dipterocarpaceae
14.	*Glochidion arborescens*	Euphorbiaceae
15.	*Albizia chinensis*	Fabaceae
16.	*Albizia lebbeck*	Fabaceae
17.	*Albizia odoratissima*	Fabaceae
18.	*Albizia procera*	
19.	*Bauhinia variegata*	Fabaceae
20.	*Erythrina arborescens*	Fabaceae
21.	*Erythrina stricta*	Fabaceae
22.	*Persea parviflora*	Lauraceae
23.	*Careya arborea*	Lecythidaceae
24.	*Logerstroemia parviflora*	Lythraceae
25.	*Melia azedarach*	Meliaceae
26.	*Artocarpus chaplasha*	Moraceae
27.	*Artocarpus gameziana*	Moraceae
28.	*Artocarpus heterophyllus*	
29.	*Ficus amplissima*	Moraceae
30.	*Ficus semicordata*	Moraceae
31.	*Morus laevigatus*	Moraceae
32.	*Syzygium grande*	Myrtaceae
33.	*Pinus kesiya*	Pinaceae
34.	*Podocarpus nerifolia*	Podocarpaceae
35.	*Neolamarckia cadamba*	Rubiaceae
36.	*Citrus grandis*	Rutaceae
37.	*Sterculia villosa*	Sterculiaceae
38.	*Callicarpa arborea*	Verbenaceae
39.	*Callicarpa tomentosa*	Verbenaceae
40.	*Premna milliflora*	Verbenaceae
41.	*Tectona grandis*	Verbenaceae
42.	*Vitex peduncularis*	Verbenaceae

Source: Forest and Environment Department, Government of Meghalaya

Table 6-28: Scrub Species

Sl. No.	Scientific Name	Family
1.	*Mimosa himalayana*	Fabaceae
2.	*Bauhinia acuminata*	Leguminosae
3.	*Ficus tinctoria*	Moraceae
4.	*Canthium gracillepes*	Rubiaceae
5.	*Glycosmis mauritiana*	Rutaceae
6.	*Brugmansia suaveolens*	Solanaceae
7.	*Solanum kurzii*	Solanaceae
8.	*Symplocos chinensis*	Symplocaceae
9.	*Daphne cannabina*	Thymelaeaceae
10.	*Clerodendron serratum*	Verbenaceae
11.	*Clerodendron viscosum*	Verbenaceae
12.	*Duranta plumerii*	Verbenaceae
13.	*Duranta repens*	Verbenaceae
14.	*Leea indica*	Vitaceae

Source: Forest and Environment Department, Government of Meghalaya

Table 6-29: Herb Species

Sl. No.	Scientific Name	Family
1.	*Adhatoda vasica*	Acanthaceae
2.	*Andrographis wrightiana*	Acanthaceae
3.	*Justicia simplex*	Acanthaceae
4.	*Achyranthes aspera*	Amaranthaceae
5.	*Alternanthera sessilis*	Amaranthaceae
6.	*Amaranthus spinosus*	Amaranthaceae
7.	*Hydrocotyl javanica*	Apiaceae
8.	*Acorus calamus*	Araceae
9.	*Alocasia acuminate*	Araceae
10.	*Arisema tortuosum*	Araceae
11.	*Aegyratum conyzoides*	Asteraceae
12.	*Artemesia parviflora*	Asteraceae
13.	*Blumea heiracifolia*	Asteraceae
14.	*Eclipta prostrata*	Asteraceae
15.	*Mikania scandens*	Asteraceae
16.	*Xantihum strumarium*	Asteraceae
17.	*Sonchus aspera*	Asteraceae

18.	*Vernonia cineria*	Asteraceae
19.	*Chenopodium album*	Chenopodiaceae
20.	*Commelina paludosa*	Commelinaceae
21.	*Ipomoea linifolia*	Convolvulaceae
22.	*Ipomoea carnea*	Convolvulaceae
23.	*Euphorbia hirta*	Euphorbiacea
24.	*Phyllanhus fraternus*	Euphorbiaceae
25.	*Croton bonplandianum*	Euphorbiaeae
26.	*Cassia tora*	Fabaceae
27.	*Mucuna pruriens*	Fabaceae
28.	*Desmodium concenum*	Fabaceae
29.	*Flemingia involucrata*	Fabaceae
30.	*Anisomeles indica*	Lamiaceae
31.	*Hyptis suaveolens*	Lamiaceae
32.	*Leucas aspera*	Lamiaceae
33.	*Pogostemon benghalensis*	Lamiaceae
34.	*Polygonum barbatum*	Polygonaceae
35.	*Polygonum hydropiper*	Polygonaceae
36.	*Hedyotis auriculata*	Rubiaceae
37.	*Hedyotis diffusa*	Rubiaceae
38.	*Clerodendron nutans*	Verbenaceae
39.	*Phyla nodiflora*	Verbenaceae
40.	*Costus speciosus*	Zingiberaceae
41.	*Zingiber zerumbet*	Zingiberaceae

Source: Forest Department, field study and public consultation

Table 6-30: Grass Species

Sl. No.	Scientific Name	Family
1.	*Cyperus diffusus*	Cyperaceae
2.	*Cyperus distans*	Cyperaceae
3.	*Cyperus rotundus*	Cyperaceae
4.	*Fimbristylis dichotoma*	Cyperaceae
5.	*Kyllinga bulbosa*	Cyperaceae
6.	*Cynodon barberi*	Poaceae
7.	*Cynodon dactylon*	Poaceae
8.	*Eragrostis gangetica*	Poaceae
9.	*Eragrostis nutans*	Poaceae

10.	*Heteropogon contortus*	Poaceae
11.	*Ischaemum rugosum*	Poaceae
12.	*Oplismenus compositus*	Poaceae
13.	*Panicum notatum*	Poaceae
14.	*Panicum repens*	Poaceae
15.	*Thysanolaena maxima*	Poaceae

Source: Forest Department, field study and public consultation

Table 6-31: Bamboo Species

Sl. No.	Scientific Name	Family
1.	*Bambusa arundinacea*	Poaceae
2.	*Bambusa pallida*	
3.	*Bambusa tulda*	
4.	*Dendrocalamus strictus*	

Source: Forest Department, field study and public consultation

Table 6-32: Orchid Species

Sl. No.	Scientific Name	Family
1.	*Cymbidium elegans*	Orchidaceae
2.	*Dendrobium herbaceum*	
3.	*Habenaria commelinifolia*	
4.	*Nervilia prainiana*	
5.	*Vanda tessellata*	

Source: Forest Department, field study and public consultation

Table 6-33: Bryophytes Species

Sl. No.	Scientific Name	Taxonomic Category
1.	*Anthoceros fusiformis*	Anthocerotopsida
2.	*Anthoceros laevis*	Anthocerotopsida
3.	*Bryum apiculatum*	Bryopsida
4.	*Polytrichum xanthopilum*	Bryopsida
5.	*Riccia discolor*	Hepaticopsida
6.	*Riccia melanospora*	Hepaticopsida
7.	*Marchantia polymorpha*	Marchantia

Source: Forest Department, field study and public consultation

Table 6-34: Pteridophyte Species

Sl. No.	Scientific Name	Taxonomic Category
1.	*Adiantum caudatum*	Maiden Hair Fern
2.	*Adiantum pedatum*	Maiden Hair Fern
3.	*Azolla pinnata*	Aquatic fern
4.	*Botrychium virginianaum*	Moonwort fern
5.	*Drynaria mollis*	Polypodiaceae fern
6.	*Equisetum diffusum*	Horse tails
7.	*Equisetum sylvaticum*	Horse tails
8.	*Gleichenia linearis*	Wild fern
9.	*Lycopodium cernum*	Lycopodium
10.	*Marsilea hirsuta*	Aquatic fern
11.	*Marsilea minuta*	Aquatic
12.	*Ophioglossum nudicaule*	*Ophioglossum nudicaule*
13.	*Pteris cretica*	
14.	*Salvinia auriculata*	Aquatic fern

Source: Forest Department, field study and public consultation

2) Fauna of the Project Area

Table 6-35 to Table 6-38 shows common wildlife species known to exist in Meghalaya State. In the area of East Khasi Hills as a whole, there is a number of wildlife known to exist such as Hoolock, Golden Cat, Leopard Cat, Jungle Cat, Indian Civet, Binturong or Bear Cat, Himalayan Black Bear, Barking Deer and Pangolin. However, there was no information from the local residents about observing any of them during the past few decades.

A study and survey of birds (resident, migratory), land animals including mammals, reptiles and insects and aquatic flora and fauna including fish species was undertaken during the study period. There are no large game animals such as deer and hence there is no hunting of animals. None of the species observed in the ROW is reported to be rare, endangered, endemic or threatened species. Though more than 110 mammal species are reported from the Meghalaya Forests, none is endemic to the state. There are no national parks or sanctuaries or biosphere reserves or other protected areas within the study area.

As far as the larger vertebrates including carnivores and reptiles are concerned, the data is based mainly on secondary sources corroborated by local residents. Birds have studied using binoculars and interactions with local people. Fauna of Meghalaya (Volume I and II) published by the Zoological Society of India, Meghalaya Flora and Fauna by the Directorate of Information and Public relations, Government of Meghalaya, and published scientific reports have been used as references.

Table 6-35: Mammalian Fauna

Sl. No.	Common Name	Latin name	IUCN status	WPA Schedule
1.	Rhesus monkey	*Macaca mulatto mulatto*	Common	II
2.	House shrew	*Suncus murinus*	Common	II
3.	Indian fulvus fruit bat	*Rousettus leschenaultia*	Common	II
4.	Jackal	*Canis aureus*	Occasional	II
5.	Jungle cat	*Felis chaus affinis*	Occasional	II
6.	Mongoose	*Herpestes eduardsii*	Occasional	II

Source: Meghalaya State Department of Biology

Table 6-36: Avi Fauna

Sl. No.	Common Name	Latin name	Residential status	WPA Schedule
1.	Little cormorant	*Phalacrocorax niger*	Local migrant	IV
2.	Eastern Grey Heron	*Ardea cinerea*	Local migrant	IV
3.	Little egret	*Ardea alba*	Local migrant	IV
4.	Cattle Egret	*Bubulcus ibis*	Local migrant	IV
5.	Common Pochard	*Aythya ferina*	Local migrant	IV
6.	Black winged kite	*Elanus caeruleus*	Local migrant	IV
7.	Indian Red jungle Fowl	*Gallua gallus murghi*	Resident	IV
8.	Common sandpiper	*Tringa hypoleucos*	Resident	IV
9.	Indian Blue rock Pigeon	*Columba livia*	Resident	IV
10.	Indian Ring Dove	*Streptopelia decaocto*	Resident	IV
11.	Northern Ring nosed Parakeet	*Psittacula krameri*	Resident	IV
12.	Indian Cuckoo	*Cuculus micropterus*	Local migrant	IV
13.	Indian Koel	*Eudynamis scolopacea*	Local migrant	IV
14.	Indian Pied Kingfisher	*Ceryle rudis*	Local migrant	IV
15.	Indian Pied Myna	*Sturnus contra*	Resident	IV
16.	Indian House Crow	*Corvus splendens*	Resident	IV
17.	Eastern Jungle Crow	*Corvus macrorhynchos*	Resident	IV
18.	Black headed Bulbul	*Pycnonotus atriceps*	Resident	IV

Source: Meghalaya State Department of Biology

Table 6-37: Reptilian Fauna

Sl. No.	Common Name	Latin name	IUCN status	WPA Schedule
1.	Garden Lizards	*Calotes versicolor*	Common	IV
2.	Lizards	*Gecko gecko*	Common	II
3.	House Gecko	*Hemidactylus brooki*	Common	II
4.	Common skink	*Mabuya craniata*	Common	IV
5.	Rat snake	*Ptyas korros*	Common	II
6.	Banded Krait	*Bungarus fasciatus*	Scarce	II
7.	Checkered keel-back	*Natrix piscator*	Occasional	IV

Source: Meghalaya State Department of Biology

Table 6-38: Fishes (Pisces)

Sl. No.	Latin name	Common name	Local name (Khasi)	Status
1.	*Cirrhinus mrigala*	Mrigala	Kha mirka	Very common
2.	*Cyprinus carpio*	Carp	Kha dkhar	Very common
3.	*Labeo bata*	Major Carp	Kha bah	Common
4.	*Labio rohita*	Rohu		Very common
5.	*Barilius barila*		Kha Ilong	Common
6.	*Mystus vittatus*		Kha tynkriong	Very Common
7.	*Anabas testudineus*		Kha Koi	Scarce
8.	*Channa orientalis*		Dohthli	Common
9.	*Puntius chola*	Climbing Perch	Shalynni	Common

Source: Meghalaya State Department of Biology

2) Wildlife Reserves/Sanctuaries

Environmental Information System (ENVIS)of India is sponsored by MOEFCC and in collaboration with Birlife International, it has listed up a number of important wildlife areas including "Upper Shillong Important Bird Area", which is approximately 1,248 ha wide. As is shown in Figure 7-26, there is an "Important Bird Area (IBA)" next to the project area.

Within the IBA, there is a protected forest administered by Meghalaya State Department of Environment and Forestry. The area is 766 ha and within this forest Buass No.1 is inserted that it requires 9.3 ha of forest land area subject to clearing.

There is no formally declared by the Government of India wildlife reserve or sanctuary.

3) Vulnerable Species of the Project Area

As is shown in Figure 7-27, Bird Life International (http://www.birdlife.org) reports that there is an Important Bird Area of "Tawny-breasted Wren-babbler (Spelaeornis longicaudatus)" in Meghalaya state.

It is one of the threatened species according to the Red Book of The International Union of the Conservation of Nature (IUCN). The Important Bird Area, one of the important habitats of bird species, appears to be limited to the area in the south of Shillong where the area is covered with relatively thick forest. As shown in Table 6-39, there are a number of causes threatening the birds, mainly the rapid deterioration of the forest area.

Source: http://www.birdlife.org/datazone/speciesfactsheet.php?id=7900

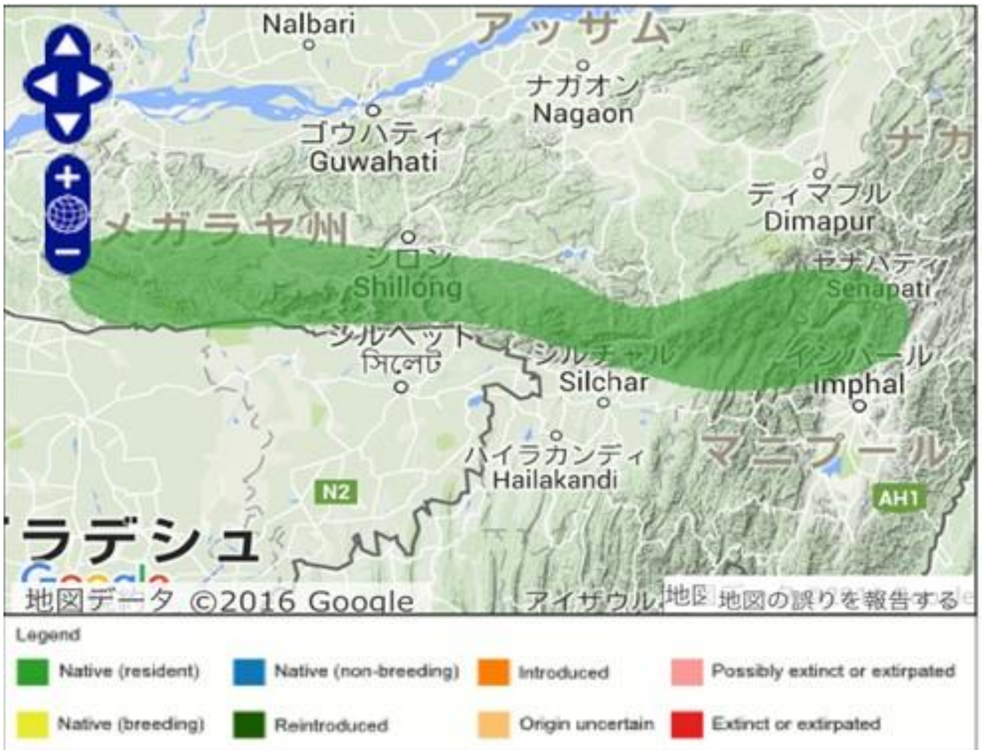
Figure 6-27: Vulnerable Bird Species of the Project Area

Table 6-39: Causes of the Threats to the "Tawny-breasted Wren-babbler"

Cause	Threating Activities	Timing of Threat	Scope of Habitat	Severity
Agriculture and Aquaculture	Annual & perennial non-timber crops - small-holder farming	Happening now	Small area/few individuals (<10%)	Slow but significant deterioration
Biological Resource Use	Gathering terrestrial plants - unintentional effects (species being assessed is not the target)	Happening now	Small area/few individuals (<10%)	Slow but significant deterioration
	Logging & wood harvesting - unintentional effects: subsistence/small scale	Happening now	Small area/few individuals (<10%)	Slow but significant deterioration
Human Intrusions and Disturbance	Work and other activities	Happening now	Small area/few individuals (<10%)	Slow but significant deterioration
Residential and CommercialD development	Housing and urban areas	Likely in short term (within 4 years)	Small area/few individuals (<10%)	Very rapid to severe deterioration
Transportation and Service Corridors	Roads and railroads	Likely in short term (within 4 years)	Small area/few individuals (<10%)	Doderate to rapid deterioration

Source: http://www.birdlife.org/datazone/speciesfactsheet.php?id=7900

While Meghalaya state controls 4.4 % of the forest area in the state, local tribes control most of the forest area. Because of the rapid deterioration of their habitat, logging has been ceased since 2009. Based on the 2016 observation of Bird Life International (http://www.birdlife.org), the current habitat of "Tawny-breasted Wren-babbler (Spelaeornis longicaudatus)" along with other bird species appears to have been concentrating in the area in the south of Meghalaya state as shown in Figure 7-28. The habitat spans over NH40. Since transportation development appears to be causing habitat deterioration within 4 years as per Table 6-39, the habitat of "Tawny-breasted Wren-babbler (Spelaeornis longicaudatus)" could continuously be affected.



Source: http://www.birdlife.org/datazone/species/factsheet/22716137

Figure 6-28: Vulnerable Bird Species of the Project Area

(2) Anticipated impacts and Mitigation Measures

1) Geography/ Geomorphology

Impacts

There is no significant impact caused by the project for geographyc and/geomorphological changes. However, a number of cut and fill slopes are created. Most of them are within the range of 5 m high at locations where geometry of road alignment is improved. Some of the cut and fill can go up to 20 m high at locations where bypass roads are inservet. At these places, permanent changes of geographic conditions should take place.

Mitigation Measures

During the construction period, protection measures agains heavy rains should be provided as much as possible in order to avoid soil erosion, natural disaster and deterioration of the cut and fill slopes.
Upon commencement of the operation and maintenance, slope protection measures should stabilize the changed geographical conditions over time.

2) Hydrogeography

Impacts

During the construction period, temporary diversion or blockade of the rivers, streams or agricultural canals are implemented in order to construct road and its structures such as bridges, culverts and side ditches. Protection measures are always provided to these areas in order to avoid soil erosion, accidental changes of topography as well as the natural disasters.

Mitigation Measures

While during the construction period, protection provided to each construction area should prevent any accidents and unwanted changes of hydrogeography.

During the operation and maintenance period, not changes of hydrogeography takes place i.e. mitigation measures is not necessary.

3) Ecological Conditions/Biological Diversity

Impacts

No significant wildlife species including bird species or plants and trees of any ecological values are observed during the study period. On ther other hand, while the local residents are banned from logging and shifting agriculture, the project has to clear relatively large area of forest. This should create some questions on the socio-ecological issues.

Mitigation Measures

Afforestation program is carried out in order to rejuvenate the forest area lost for the project. Monitoring of the ecologican conditions for elaboration of further mitigation measures should be carried out.

4) Climatic Conditions

Impacts

No significant climatic conditions should take place as a result of the implementation o the project. However, because of the road construction project itself emit greenhouse gas, it causes to a certain extent causes global changes of the climate.

Mitigation Measures

Afforestation program is carried out in order to help fighting to reduce atmospheric temperatures of global warming. It aso rejuvenate the forest area lost for the project. Monitoring of the ecologican conditions for elaboration of further mitigation measures should be carried out.

5) Soil Erosion

Impacts

There is no significant impact on the soil within the project area. However, as stated above, a number of cut and fill slopes are created causing certain amount of soil erosion on each construction area. Most of them are within the range of 5 m high at locations where geometry of road alignment is improved. Some of the cut and fill can go up to 20 m high at locations where bypass roads are inservet. At these places, permanent changes of geographic conditions should take place.

Mitigation Measures

During the construction period, protection measures agains heavy rains should be provided as much as possible in order to avoid soil erosion, natural disaster and deterioration of the cut and fill slopes.

Upon commencement of the operation and maintenance, slope protection measures should stabilize the changed geographical conditions over time.

6) Ground Water

Impacts

There is no contamination of grund water during the construction period as well as the operation and maintenance period.

7) Forest

Impacts

In terms of the impacts on the natural environment, the most significant impacts caused by the project is the permanent loss of 123 ha of the existing forest area as is shown in Table 6-40. The project area goes through habitat of bird species such as “Tawny-breasted Wren-babbler (Spelaeornis longicaudatus)”, one of the vulnerable species.

Bypass No.1 subject to inserting into the Meghalaya State’s protected forest has to clear 9.3 ha of forest mainly of Kashi Pine forest. It is inside the “Upper Shillon Protected Forest. This is also an “Important Bird Area”, which, as stated above, ENVIS Centre on Wildlife and Protected Area and Birdlife International asserts that the area next to NH-40 on the northern slope of Khasi Hills is an “Important Bird Area” for the indigenous birds including “Tawny-breasted Wren-babbler (Spelaeornis longicaudatus)”. Thus it is the area most significantly affected by the Project.

Bypass No.6 has to cut through very thick riparian forest and approximately 35 ha of forest area has to be cleared for the Project. This is also an important area of which such thick forest area would contribute to function as carbon sequestration area for fighting against global warming.

The Government of India will thoroughly examine the area of forest subject to clearing and that it demands to plant trees for which the area of afforestation should be the same as the forest area subject to clearing. As is explained in the Section 7.3.5, Meghalaya State Forest Department examines the area of forest subject to clearing while at the same time it designates the area of afforestation. By the same token, it would be the measures to mitigate the loss of forest subject to clearing for the Project.

Table 6-40: Forest Areas Subject to Clearance by The Project

Location		Area (ha)	Trees for Felling (No.)	Remarks
1	Bypass No. 1	9.3	11,160	Protected Forest (Adm. By Megalaya State Dept. of Environment and Forest)
2	Bypass No. 1-2	2.8	3,360	Private/Clan-owned Forest
3	Bypass No. 2	3.6	4,320	Private/Clan-owned Forest
4	Bypass No. 3	5	6,000	Private/Clan-owned Forest
5	Bypass No. 3-4	1	1,200	Private/Clan-owned Forest
6	Bypass No. 4	3.2	3,840	Private/Clan-owned Forest
7	Bypass No. 4-5	44.4	53,280	Private/Clan-owned Forest
8	Bypass No. 5	0.6	720	Private/Clan-owned Forest
9	Bypass No. 5-6	17.5	21,000	Private/Clan-owned Forest
10	Bypass No. 6&7	34.9	41,880	Private/Clan-owned Forest
11	Bypass No. 7-end	0.7	840	Private/Clan-owned Forest
	合計	123.0	147,600	—

Source: JICA Study Team

Mitigation Measures

Because of the significant loss of forested area, the same area of afforestation program has to be carried out and that the progress should be monitored closely until such time that 123 ha of afforestation is achieved.

8) Afforestation for Mitigation Measures Agains Global Warming

Impacts

Any road project is subject to which emission of greenhouse gas as a result of project implementation is inevitable. The World Bank has put out “Greenhouse Gas Emissions Mitigation in Road Construction and Rehabilitation” in 2010. Based on this report, this Project emits 794 tons of greenhouse gas for every km of construction work as is shown in Table 6-41.

Table 6-41: Greenhouse Gas Emission of Road Project

Parameter \ Category of Road	Express-way	National Rod	Provincial Road	Rural Road (Gravel)	Rural Road (Dirt)
Emissions (t CO2 eq./km)	3,234	794	207	90	103
Factor Equivalent to Expressway	100	25	6	3	3

Source: “Greenhouse Gas Emissions Mitigation in Road Construction and Rehabilitation” 2010, WB

This project runs for 71.5km of NH-40 improvement project, effect of greenhouse gas emission for the lifetime of the Project (Estimated at 10 years) is calculated as follows:

794 (t CO_2 eq./km) x 71.5 km = 56,771 t (CO2 eq.)

Mitigation Measures

Because of afforestation is the most popular and inexpensive method of carbon sequestration, the following method of calculation is carried out in order to find the area of afforestation.

1 ton of Carbon = 3.666 tons of CO_2

Not : Atomic volume of CO_2 is 44; it is divided by Carbon whose atomic volume is 12.

Because of the experiences of which 1 ha of forest sequester 125.5 tons of carbon[23], 1 ha of forest should sequester 125.5 tons x 3.666 tons of CO_2 = 460.2/ha of CO_2. Thus:

59,356 t (CO2 eq.) / 460.2 ton/ha = Forest Area of 128.98 ha

is obtained. Provided that 13 ha of afforestation are carried out, greenhouse gas is sequestered over 10 year period. Such afforestation should contribute to recover the area lost in the past decades as a result of slush-and-burn agriculture. It should also contribute to safeguard forest area of water resources while it contributes to fight against global warming.

9) Impact on Wildlife Reserve

Impacts

There is no wildlife or sanctuary formally declared by the Government of India within the 5 km radious of

[23] The following reports have been consulted.

3) United States Department of Agriculture, Forest Service, Methods for Calculating Forest Ecosystem and Harvest Carbon with Standard Estimates for United States Forest Types, 2006, http://www.treesearch.fs.fed.us/pubs/22954.

4) US Department of Agriculture, Forest Service, Carbon Storage and Accumulation in United States Forest Ecosystems, 1992, http://www.nrs.fs.fed.us/pubs/gtr/gtr_wo059.pdf.

the project area. However, ENVIS Centre on Wildlife and Protected Area and Birdlife International jointly listed up a number of important bird areas. One of them is "Upper Shillong Important Bird Area" that NH-40 borders a portion of the bird area. It is a habitat of a large number of indigenous birds including "Tawny-breasted Wren-babbler (Spelaeornis longicaudatus)", one of the vulnerable species listed by IUCN as VU (vulnerable) species.

Within this area, Meghalaya State Department of Environment and Forest maintains "Upper Shillong Protected Forest" of 766 ha, within which Bypass No.1 has to go through and 9.3 ha of protected forest has to be cleared.

Mitigation Measures

Because of a large forested area is lost for ROW of the road construction project as well as the road construction project as being one of the greenhouse gas emitter, compensatory afforestation program in total of 253 ha should be considered as mitigation measures.

10) Impacts on Wildlife

Impacts

As is shown in Figure 7-31, Birdlife International asserts that an area on the north slope of Khasi Hills that is facing Shillong City is an Important Bird Area (IBA). The area is to the east of NH-40 from 0 km to 6 km post. IUCN declares that "Tawny-breasted Wren-babbler (Spelaeornis longicaudatus)" is vulnerable species that are very likely to inhibit in the area. The Government of India does not officially declare the area as wildlife or bird sanctuary. However, it appears to be ecologically sensitive area adjacent to the project area.

As is shown in Figure 7-32, almost a half of southern region of Meghalaya State is the area of birdlife including "Tawny-breasted Wren-babbler (Spelaeornis longicaudatus)". The entire project area goes through this birdlife area and a total of 123 ha of forested areas are subject to clearing.

11) Landscape

Impacts

While the landscape viewed along NH-40 itself remains intact, there are a number of landscape viewpoints created for tourism purposes. These areas are generally "landscaped area" where parking place, safety rails, teahouses, etc. During the construction period, these viewpoints are closed temporarily for construction works.

Mitigation Measures

Viewpoints are generally closed during the construction period while in the operation and maintenance period, all of the viewpoints are open for the general public.

6.7.3 Major Impacts on Living Environment

(1) Survey Results

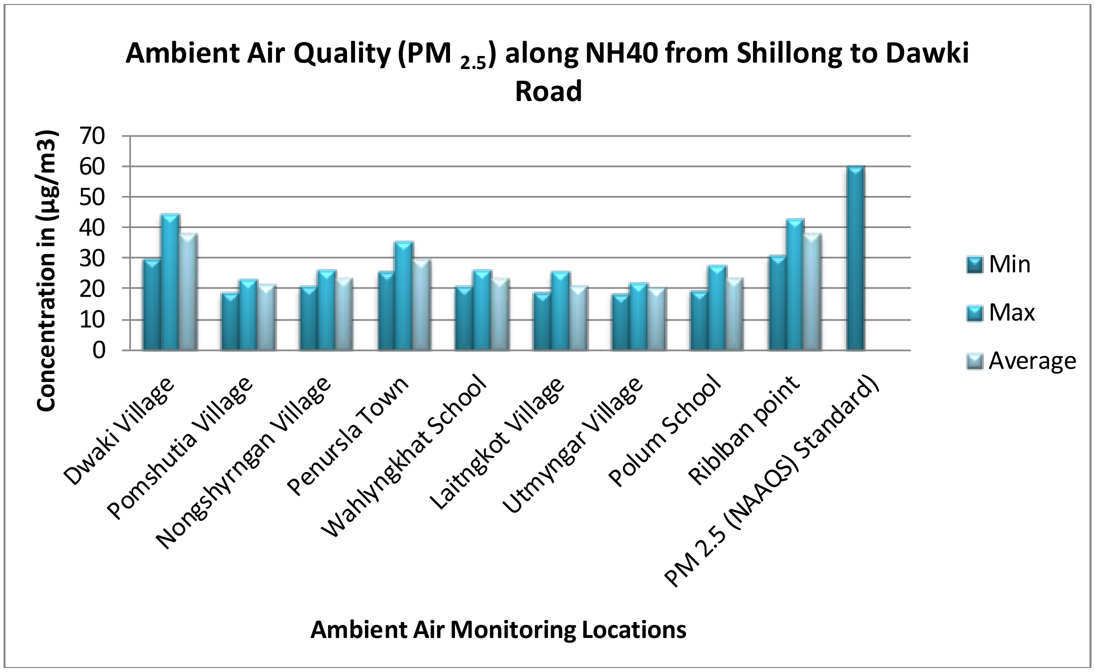
1) Ambient air quality

Ambient air sampling was carried out during May – June 2016 at nine locations along the project area. The results are presented in Table 6-42. Comparative charts for various ambient air quality parameters are presented from Figure 7-29 to Figure 7-33. Measured values are 24 hour values. Thus, based on National Ambient Air Quality Standard (NAAQS), tandard values of CO_2: 80 μ g/m3, NO_x: 80 μ g/m3, PM10: 100 μ g/m3, PM2.5: 60 μ g/m3 have been compared with the measured values. As a result all of the measured values of the project study is lower than the values of standard.

Table 6-42: Ambient Air Quality of the Project Area

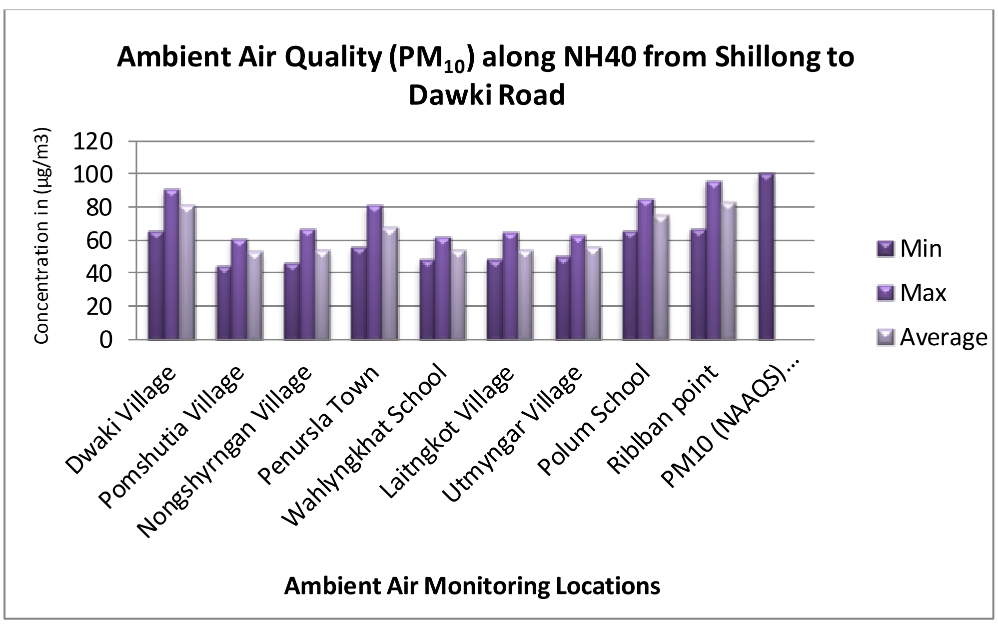
Dwaki near PWD guest house (Latitude 25^0 11' 98.0" & Longitude 92^0 01' 11.4")					
	PM2.5,µg/m3	**PM10,µg/m3**	**SO_2 µg/m3**	**NOx µg/m3**	**CO, µg/m3**
Min	29.8	65.6	5.6	10.5	910
Max	44.5	90.8	7.8	14.4	1140
Average	38.1	81.0	6.7	11.8	1021.3
Pomshutia village (Latitude 25^0 12' 49.4" & Longitude 91^0 52' 46.5")					
	PM2.5,µg/m3	**PM10,µg/m3**	**SO_2 µg/m3**	**NOx µg/m3**	**CO, µg/m3**
Min	18.5	44.5	4.8	9.5	280
Max	22.8	60.8	7.7	12.8	440
Average	21.3	52.9	6.6	11.4	361.7
Nongshyrngan Village (Latitude 25^0 15' 29.4" & Longitude 91^0 56' 54.8")					
	PM2.5,µg/m3	**PM10,µg/m3**	**SO_2 µg/m3**	**NOx µg/m3**	**CO, µg/m3**
Min	20.5	46.4	5	9.4	430
Max	25.9	66.8	7.8	13.6	640
Average	23.2	53.7	6.7	11.7	546.7
Penursla Town (Latitude 25^0 18' 19.7" & Longitude 91^0 54' 39.3")					
	PM2.5,µg/m3	**PM10,µg/m3**	**SO_2 µg/m3**	**NOx µg/m3**	**CO, µg/m3**
Min	25.4	55.6	6.1	10.6	740
Max	35.6	80.6	8.8	15.5	990
Average	29.4	67.1	7.2	12.4	886.3
Wahlyngkhat School (Latitude 25^0 20' 11.1" & Longitude 91^0 53' 20.5")					
	PM2.5,µg/m3	**PM10,µg/m3**	**SO_2 µg/m3**	**NOx µg/m3**	**CO, µg/m3**
Min	20.5	47.6	5.8	9.6	480
Max	25.9	61.2	8.8	15.2	650
Average	23.2	53.6	7.0	12.2	593.3
Laitngkot Village (Latitude 25^0 26' 25.2" & Longitude 91^0 50' 47.9")					
	PM2.5,µg/m3	**PM10,µg/m3**	**SO_2 µg/m3**	**NOx µg/m3**	**CO, µg/m3**
Min	18.8	48.4	5.5	8.1	330
Max	25.5	64.8	8.1	10.5	560
Average	20.9	53.8	6.4	9.1	458.8
Umtyngar Village (Latitude 25^0 29' 37.8" & Longitude 91^0 49' 07.9")					
	PM2.5,µg/m3	**PM10,µg/m3**	**SO_2 µg/m3**	**NOx µg/m3**	**CO, µg/m3**
Min	18.3	50.3	5.2	10.2	450
Max	21.9	62.7	8.9	13.5	650
Average	20.3	55.6	7.0	11.7	583.3
Polum School (Latitude 25^0 31' 47.5"& Longitude 91^0 48' 38.8")					
	PM2.5,µg/m3	**PM10,µg/m3**	**SO_2 µg/m3**	**NOx µg/m3**	**CO, µg/m3**
Min	19.4	65.6	6	9.8	650
Max	27.8	85.2	8.4	14.6	990
Average	23.4	74.6	7.1	11.8	872.1
Rilban point (Latitude 25^0 34' 16.0"& Longitude 91^0 52' 07.4")					
	PM2.5,µg/m3	**PM10,µg/m3**	**SO_2 µg/m3**	**NOx µg/m3**	**CO, µg/m3**
Min	30.6	66.7	5.4	8.9	810
Max	42.5	95.6	8.8	15.2	1180
Average	37.9	83.1	6.9	12.1	989.2

Source: Field monitoring from May-June, 2016, JICA Study Team



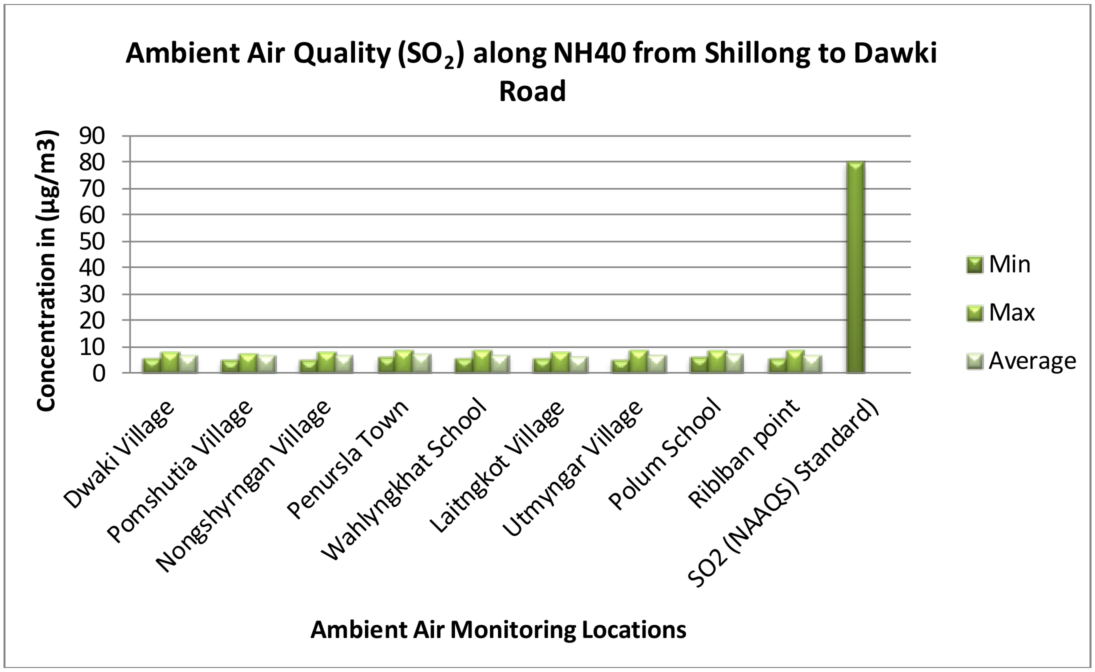
Source: Field monitoring from May-June, 2016, JICA Study Team

Figure 6-29: Ambient Air Quality (PM 2.5) of the Project Area



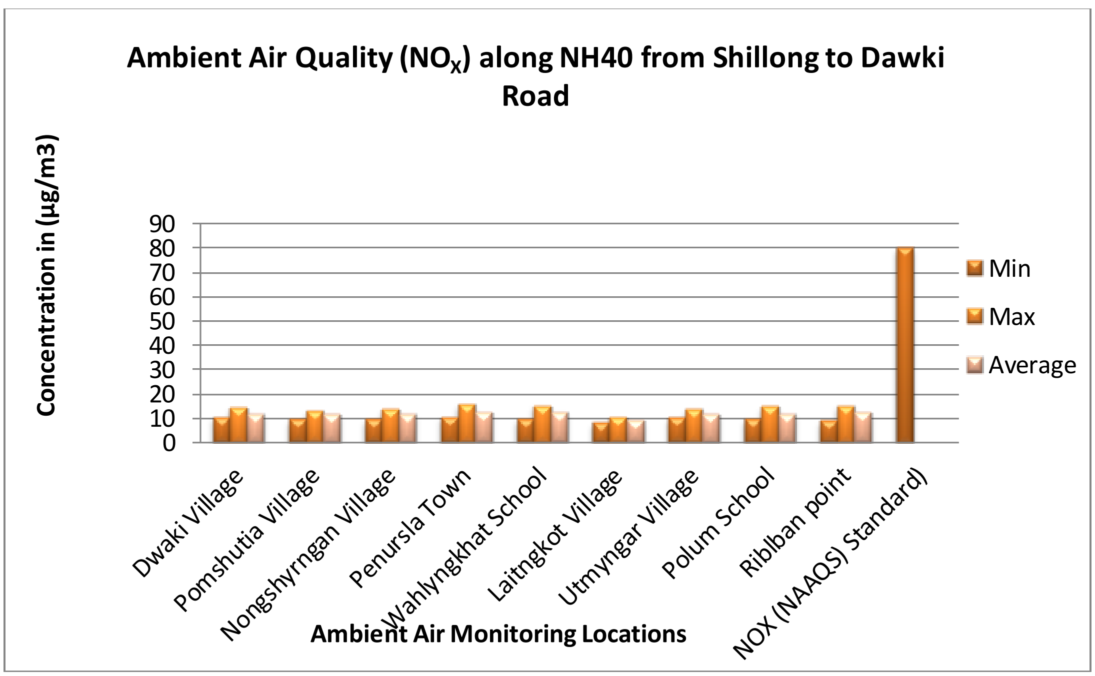
Source: Field monitoring from May-June, 2016, JICA Study Team

Figure 6-30: Ambient Air Quality (PM10) of the Project Area



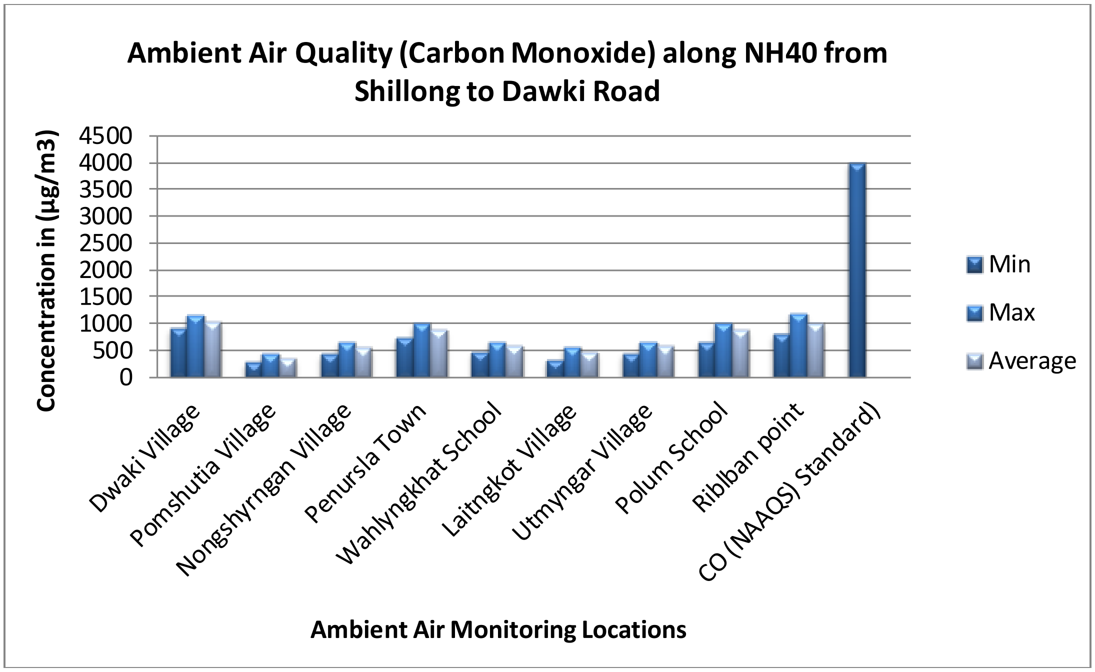
Source: Field monitoring from May-June, 2016, JICA Study Team

Figure 6-31: Ambient Air Quality (SO2) of the Project Area



Source: Field monitoring from May-June, 2016, JICA Study Team

Figure 6-32: Ambient Air Quality (NOX) of the Project Area



Source: Field monitoring from May-June, 2016, JICA Study Team

Figure 6-33: Ambient Air Quality (Carbon Monoxide) of the Project Area

The Meghalaya Pollution Control Board periodically measures the air quality at Shillong (Police Bazar), which is approximately 3 km to the east of the 0 km point of the project. The study team measured the ambient air quality along the project area at 9 locations and the measured values are well within the limits described in the standards set by CPCB.

2) Water Quality

There are no major pollution sources such as chemical factories, oil / coal burning thermal power generators, etc., along the project area. Thus the water quality along NH40 is generally good. As a matter of conducting a standardized environmental study, however, monitoring of the water quality has been carried out at nine locations from May-June, 2016 in accordance to the Indian Standard Drinking Water Specification – IS 10500: 1991. The results of water monitoring tests are presented in Table 6-43 to Table 6-45.

Table 6-43: Water Quality of the Project Area: 0 km – 23 km

Sl. No.	Parameters	Unit	Limit (as per IS:10500-2012)		Surface Water - River	Tap Water	Surface Water - River
					Rilban Point Near Army Area	Polum Secondary School	Umtyngar Village
			Desirable Limit	Permissible Limit	N 25° 34' 16.0" E 91° 52' 07.4")	N 25° 31' 47.5" E 91° 48' 38.8")	N 25° 29' 37.8" E 91° 49' 07.9")
1	pH	-	6.5-8.5	No Relaxation	7.15	7.36	7.11
2	Colour	Hazen	5	25	<5	<5	<5
3	TSS	Mg/l	-	-	7.5	BDL	8.4
4	Dissolved Oxygen	% By Mass	5	10	6.6	7.1	5.8
5	BOD (at 27°C 3-Days)	mg/l	-	-	7	BDL	8
6	COD	mg/l	-	-	25	BDL	28
7	TKN	mg/l	-	-	3.4	2.2	2.4
8	Total Hardness (as $CaCO_3$)	mg/l	200	600	110.8	131	95
9	Calcium (as $CaCO_3$)	mg/l	75	200	82	90	78
10	Magnesium (as $CaCO_3$)	mg/l	30	100	28.8	41	17
11	Ammonia (NH3)	mg/l			2.5	BDL	2.4
12	Electrical Conductivity	Microm/hos/cm	-		410.85	398.81	318.39
13	Chloride (as Cl)	mg/l	250	1000	54.7	44.8	34.2
14	Sulphate (as SO_4)	mg/l	200	400	32.5	36.7	25.6
15	Phosphates	mg/l	-	-	<0.1	<1.0	1
16	Nitrate (as NO_3)	mg/l	45	No Relaxation	0.89	0.93	0.74
16	Fluoride (as F)	mg/l	1	1.5	0.14	0.21	0.18
17	Arsenic (As)	mg/l	-	-	BDL	BDL	BDL
18	Lead (as Pb)	mg/l	-	-	<0.01	<0.01	<0.01
19	Mercury(as Hg)	mg/l	-	-	<0.0001	<0.0001	<0.0001
20	Phenols	mg/l	-	-	<0.01	<0.01	<0.01
21	Cyanides	mg/l	-	-	BDL	BDL	BDL
22	TDS	mg/l	500	2000	267.05	259.23	206.95
23	Iran (as Fe)	mg/l	0.3	1	0.21	0.18	0.16
24	Alkalinity as ($CaCO_3$)	mg/l	200	600	86.7	96.7	71.3
25	Sodium (as Na)	mg/l	-	-	33	19.7	25
26	Potassium (as K)	mg/l	-	-	12	6.6	9
27	Faecal Coliform	MPN/100 ml	Shall Not be Detectable		750	Absent	230
28	Total Coliform	MPN/100 ml	Shall Not be Detectable		1200	Absent	1350

Source: Field monitoring from May-June, 2016, JICA Study Team

Table 6-44: Water Quality of the Project Area: 23 km – 46 km

Sl. No.	Parameters	Unit	Limit (as per IS:10500-2012)		Tap Water	Spring Water	Tap Water
					Wahlyngkhat Village	Nongthymmai Village	Nongshyrngan Village
			Desirable Limit	Permissible Limit	N 25⁰ 20' 11.1" E 91⁰ 53' 20.5"	N 25⁰ 25' 56.2" E 91⁰ 51' 77.0"	N 25⁰ 15' 29.4" E 91⁰ 56' 54.8"
1	pH	-	6.5-8.5	No Relaxation	7.28	6.95	7.34
2	Colour	Hazen	5	25	<5	<5	<5
3	TSS	Mg/l	-	-	BDL	6.6	BDL
4	Dissolved Oxygen	% By Mass	5	10	5.6	6.9	4.5
5	BOD (at 27⁰C 3-Days)	mg/l	-	-	BDL	6.2	BDL
6	COD	mg/l	-	-	BDL	18	BDL
7	TKN	mg/l	-	-	2.4	2.2	1.4
8	Total Hardness (as $CaCO_3$)	mg/l	200	600	148	128	140
9	Calcium (as $CaCO_3$)	mg/l	75	200	108	96	110
10	Magnesium (as $CaCO_3$)	mg/l	30	100	40	32	30
11	Ammonia (NH3)	mg/l			BDL	2.3	BDL
12	Electrical Conductivity	Microm/hos/cm	-		372.49	383.32	385.86
13	Chloride (as Cl)	mg/l	250	1000	54.4	40.2	44.2
14	Sulphate (as SO_4)	mg/l	200	400	38	27.9	32
15	Phosphates	mg/l	-	-	<1.0	<1.0	<1.0
16	Nitrate (as NO_3)	mg/l	45	No Relaxation	0.84	0.97	0.82
16	Fluoride (as F)	mg/l	1	1.5	0.16	0.16	0.15
17	Arsenic (As)	mg/l	-	-	BDL	BDL	BDL
18	Lead (as Pb)	mg/l	-	-	<0.01	<0.01	<0.01
19	Mercury(as Hg)	mg/l	-	-	<0.0001	<0.0001	<0.0001
20	Phenols	mg/l	-	-	<0.01	<0.01	<0.01
21	Cyanides	mg/l	-	-	BDL	BDL	BDL
22	TDS	mg/l	500	2000	242.12	249.16	250.81
23	Iran (as Fe)	mg/l	0.3	1	0.14	0.23	0.12
24	Alkalinity as ($CaCO_3$)	mg/l	200	600	64.5	106	96
25	Sodium (as Na)	mg/l	-	-	18	16.4	14
26	Potassium (as K)	mg/l	-	-	6	5	6
27	Faecal Coliform	MPN/100 ml	Shall Not be Detectable		Absent	250	Absent
28	Total Coliform	MPN/100 ml	Shall Not be Detectable		Absent	1100	Absent

Source: Field monitoring from May-June, 2016, JICA Study Team

Table 6-45: Water Quality of the Project Area: 46 km – 75 km

Sl. No.	Parameters	Unit	Limit (as per IS:10500-2012)		Spring Water	Tab Water	Surface Water
					Pomshutia Village	PWD Gust House Near Dwaki	Piyang River Near Dwaki
			Desirable Limit	Permissible Limit	N 25° 12' 49.4" E 91° 52' 46.5"	N 25° 11' 98.0" E 92° 01' 11.4"	N 25° 11' 20.2" E 92° 01' 01.9"
1	pH	-	6.5-8.5	No Relaxation	6.98	7.16	7.13
2	Colour	Hazen	5	25	<5	<5	<5
3	TSS	Mg/l	-	-	5.5	BDL	8.4
4	Dissolved Oxygen	% By Mass	5	10	6.9	4.8	6.1
5	BOD (at 27°C 3-Days)	mg/l	-	-	5.3	BDL	5
6	COD	mg/l	-	-	15.6	BDL	21
7	TKN	mg/l	-	-	2.8	1.6	2.6
8	Total Hardness (as $CaCO_3$)	mg/l	200	600	98	148	113.5
9	Calcium (as $CaCO_3$)	mg/l	75	200	80	112	81
10	Magnesium (as $CaCO_3$)	mg/l	30	100	18	36	32.5
11	Ammonia (NH3)	mg/l			2.3	BDL	2.6
12	Electrical Conductivity	Microm/hos/cm	-		338.44	399.31	329.55
13	Chloride (as Cl)	mg/l	250	1000	21.8	42.6	22.7
14	Sulphate (as SO_4)	mg/l	200	400	18.6	28	30.5
15	Phosphates	mg/l	-	-	<0.1	<1.0	<1.0
16	Nitrate (as NO_3)	mg/l	45	No Relaxation	0.53	0.78	0.82
16	Fluoride (as F)	mg/l	1	1.5	0.1	0.14	0.15
17	Arsenic (As)	mg/l	-	-	BDL	BDL	BDL
18	Lead (as Pb)	mg/l	-	-	<0.01	<0.01	<0.01
19	Mercury(as Hg)	mg/l	-	-	<0.0001	<0.0001	<0.0001
20	Phenols	mg/l	-	-	<0.01	<0.01	<0.01
21	Cyanides	mg/l	-	-	BDL	BDL	BDL
22	TDS	mg/l	500	2000	219.99	259.55	214.21
23	Iran (as Fe)	mg/l	0.3	1	0.17	0.12	0.22
24	Alkalinity as ($CaCO_3$)	mg/l	200	600	112	110	95.1
25	Sodium (as Na)	mg/l	-	-	18.6	12	14
26	Potassium (as K)	mg/l	-	-	6	5	4.2
27	Faecal Coliform	MPN/100 ml	Shall Not be Detectable		320	Absent	720
28	Total Coliform	MPN/100 ml	Shall Not be Detectable		850	Absent	1480

Source: Field monitoring from May-June, 2016, JICA Study Team

Water quality data measured by the Meghalaya Pollution Control Board (MPCB) is available for pH DO, BOD and total coliform for various water bodies while the study team monitored other parameters along the project area. In general, the coliform value were found to be on the high side in the case of surface water and needs treatment before use as drinking water if so desired.

3) Soil Analysis

Analysis of the soil quality has been carried out at nine identified locations during May-June, 2016 in accordance to the Indian Standard. Result of Soil monitoring are presented in Table 6-46 to Table 6-48 エラー! 参照元が見つかりません。.

Table 6-46: Soil Analysis of the Project Area

S.No.	PARAMETERTS	TEST METHOD	UNIT	Sampling Location		
				Rilban Point Near Army Area N25° 34' 16.0" E91° 52' 07.4"	Polum Secondary N25° 31'47.5" E91° 48' 38.8"	Umtyngar Village N25° 29' 37.8" E 91° 49' 07.9"
1	pH(1:5 suspension)	IS:2720(Part-26)	-	7.26	7.38	7.47
2	Electrical Conductivity at 25°C (1:2suspension.)	IS:2720(Part-21)	µS/cm	346	356	440
3	Calcium Sulphates	STP/SOIL	mg/kg	BDL	BDL	BDL
4	Magnesium (as Mg)	STP/SOIL	mg/kg	36.2	35.6	42.8
5	Organic Matter	IS:2720(Part-22)	% by mass	5.1	5.3	5.7
6	Potassium (as K)	STP/SOIL	mg/kg	106.7	115.3	122.4
7	Water Holding Capacity	STP/SOIL	% by mass	25.83	26.45	29.45
8	Porosity	STP/SOIL	% by mass	19.62	18.92	22.81
9	Sand	STP/SOIL	% by mass	48.92	47.55	51.23
10	Clay	STP/SOIL	% by mass	37.25	35.68	38.25
11	Silt	STP/SOIL	% by mass	11.23	16.77	10.52
12	Sodium Sulphates	STP/SOIL	mg/kg	15.4	12.31	15.63
13	Sodium Absorption Ratio	STP/SOIL	-	4.25	4.23	4.55
14	Nitrogen	STP/SOIL	% by mass	0.061	0.055	0.063
15	Phosphorus	STP/SOIL	mg/kg	14.3	14.8	16.34
16	Bulk Density	STP/SOIL	gm/cc	1.23	1.32	1.44
17	Texture	STP/SOIL	-	Sandy Clay	Sandy Clay	Sandy Clay
18	Moisture Retention capacity	STP/SOIL	%by mass	19.2	18.5	20.55
19	Infiltration Rate	STP/SOIL	mm/hr	19.8	21.3	18.47
20	Moisture	STP/SOIL	%	16.2	16.12	16.78
21	Sulphates	STP/SOIL	mg/1000g	15.72	12.96	18.25
22	Available Sulphur (as S)	STP/SOIL	mg/kg	0.06	0.075	0.063
23	Available Manganese (as Mn)	STP/SOIL	mg/kg	0.046	0.042	0.048
24	Available Iron(as Fe)	STP/SOIL	mg/kg	0.69	0.63	0.72
25	Exchangeable Sodium Percentage	STP/SOIL	mg/kg	0.06	0.051	0.066

Source: JICA Study Team

Table 6-47: Soil Analysis of the Project Area

S.No.	PARAMETERTS	TEST METHOD	UNIT	Sampling Location		
				Laityngargkot Village N25° 26' 25.2" E91° 50' 47.9	Wahlyngkot Village N25° 20' 11.1" E 91° 53' 20.5"	Penursla Town N25° 18' 19.7" E91° 54' 39.3"
1	pH(1:5 suspension)	IS:2720(Part-26)	-	7.38	7.24	7.64
2	Electrical Conductivity at 25°C (1:2suspension.)	IS:2720(Part-21)	µS/cm	430	432	428
3	Calcium Sulphates	STP/SOIL	mg/kg	BDL	BDL	BDL
4	Magnesium (as Mg)	STP/SOIL	mg/kg	39	31.6	40.4
5	Organic Matter	IS:2720(Part-22)	% by mass	5.4	5	5.8
6	Potassium (as K)	STP/SOIL	mg/kg	121	113.8	124.4
7	Water Holding Capacity	STP/SOIL	% by mass	27.98	25.5	27.47
8	Porosity	STP/SOIL	% by mass	20.5	19.78	18,57
9	Sand	STP/SOIL	% by mass	49.9	48.56	50.1
10	Clay	STP/SOIL	% by mass	36.98	35.57	38.11
11	Silt	STP/SOIL	% by mass	15.9	16.06	14.61
12	Sodium Sulphates	STP/SOIL	mg/kg	13.75	14.68	12.98
13	Sodium Absorption Ratio	STP/SOIL	-	4.2	4.67	4.24
14	Nitrogen	STP/SOIL	% by mass	0.06	0.054	0.056
15	Phosphorus	STP/SOIL	mg/kg	14.78	15.36	16.29
16	Bulk Density	STP/SOIL	gm/cc	1.3	1.4	1.26
17	Texture	STP/SOIL	-	Sandy Clay	Sandy Clay	Sandy Clay
18	Moisture Retention capacity	STP/SOIL	%by mass	19.4	21.42	20.8
19	Infiltration Rate	STP/SOIL	mm/hr	18.5	20.4	19.8
20	Moisture	STP/SOIL	%	16.59	16.82	16.4
21	Sulphates	STP/SOIL	mg/1000g	14.56	12.08	16.96
22	Available Sulphur (as S)	STP/SOIL	mg/kg	0.074	0.065	0.076
23	Available Manganese (as Mn)	STP/SOIL	mg/kg	0.045	0.042	0.046
24	Available Iron(as Fe)	STP/SOIL	mg/kg	0.07	0.073	0.062
25	Exchangeable Sodium Percentage	STP/SOIL	mg/kg	0.055	0.067	0.065

Source: JICA Study Team

Table 6-48: Soil Analysis of the Project Area

S.No.	PARAMETERTS	TEST METHOD	UNIT	Sampling Location		
				Nongshymgan Village	Pomshutia Village	Dowki
				N25°15' 29.4" E 91° 56' 54.8"	N 25° 12' 49.4" E 91° 52' 46.5"	N 25° 11' 98.0" E 92° 01' 11.4"
1	pH(1:5 suspension)	IS:2720(Part-26)	-	7.4	7.36	7.43
2	Electrical Conductivity at 25°C (1:2suspension.)	IS:2720(Part-21)	µS/cm	358	396	423
3	Calcium Sulphates	STP/SOIL	mg/kg	BDL	BDL	BDL
4	Magnesium (as Mg)	STP/SOIL	mg/kg	40.5	41.8	39.4
5	Organic Matter	IS:2720(Part-22)	% by mass	5.8	5.2	5.4
6	Potassium (as K)	STP/SOIL	mg/kg	119.8	120.3	113.5
7	Water Holding Capacity	STP/SOIL	% by mass	30.76	28.05	31.67
8	Porosity	STP/SOIL	% by mass	23.56	22.56	20.34
9	Sand	STP/SOIL	% by mass	50.45	47.65	52.51
10	Clay	STP/SOIL	% by mass	37.45	35.78	33.04
11	Silt	STP/SOIL	% by mass	15.45	12.28	11.98
12	Sodium Sulphates	STP/SOIL	mg/kg	13.67	14.32	15.67
13	Sodium Absorption Ratio	STP/SOIL	-	4.34	4.23	4.76
14	Nitrogen	STP/SOIL	% by mass	0.06	0.056	0.051
15	Phosphorus	STP/SOIL	mg/kg	15.2	16.5	14.9
16	Bulk Density	STP/SOIL	gm/cc	1.39	1.4	1.3
17	Texture	STP/SOIL	-	Sandy Clay	Sandy Clay	Sandy Clay
18	Moisture Retention capacity	STP/SOIL	%by mass	19.5	18.9	21
19	Infiltration Rate	STP/SOIL	mm/hr	21.2	19.3	20.6
20	Moisture	STP/SOIL	%	16.54	16.11	16.72
21	Sulphates	STP/SOIL	mg/1000g	15.67	12.34	16.34
22	Available Sulphur (as S)	STP/SOIL	mg/kg	0.061	0.069	0.07
23	Available Manganese (as Mn)	STP/SOIL	mg/kg	0.045	0.042	0.049
24	Available Iron(as Fe)	STP/SOIL	mg/kg	0.73	0.69	0.65
25	Exchangeable Sodium Percentage	STP/SOIL	mg/kg	0.067	0.059	0.06

Source: JICA Study Team

3) Noise Levels

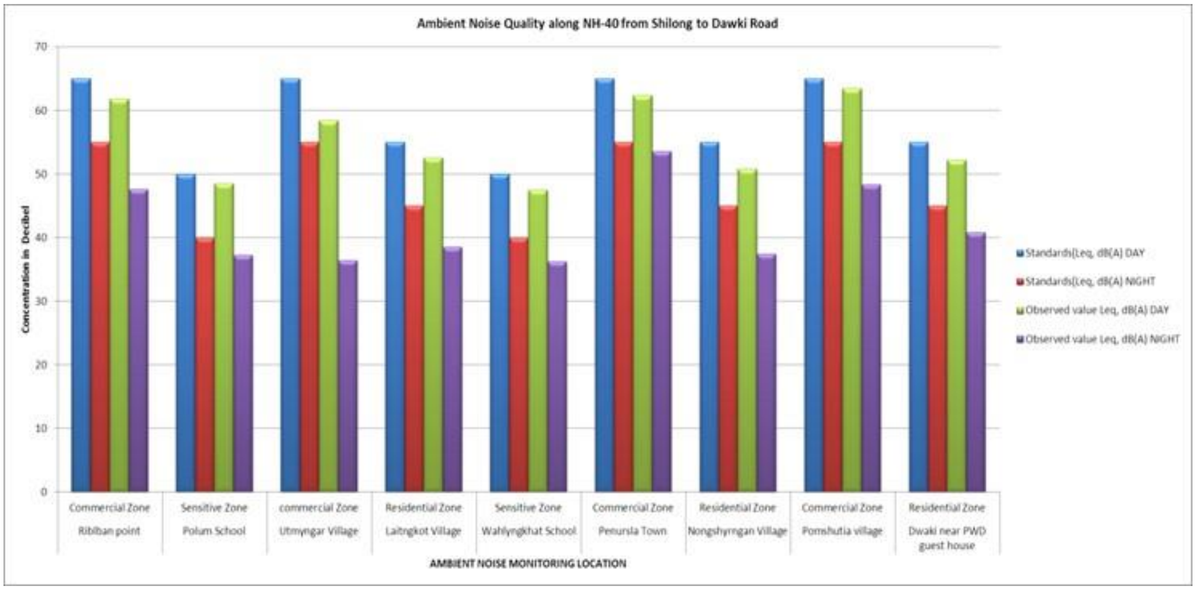
Monitoring of noise levels was carried out at nine locations along the project area from May-June, 2016 at the same time that the ambient air quality standard was carried out. The noise levels found along the project area with reference to the Noise Standard of India 2000 are presented in Table 6-49 and the location-wise comparative chart for noise levels are presented in Figure 6-34.

Table 6-49: Noise Levels along NH40 from Shillong to Dawki Road

No	Location	ZONE	Standard (Leq, dB)		Observed value (Leq, dB)	
			DAY	NIGHT	DAY	NIGHT
1	Rilban point (Latitude 25^0 34' 16.0" & Longitude 91^0 52' 07.4")	Commercial Zone	65	55	61.8	47.6
2	Polum School (Latitude 25^0 31' 47.5" & Longitude 91^0 48' 38.8")	Sensitive Zone	50	40	48.5	37.2
3	Utmyngar Village (Latitude 25^0 29' 37.8s & Longitude 91^0 49' 07.9s)	Commercial Zone	65	55	58.4	36.4
4	Laitngkot Village (Latitude 25^0 26' 25.2" & Longitude 91^0 50' 47.9")	Residential Zone	55	45	52.6	38.5
5	Wahlyngkhat School (Latitude 25^0 20' 11.1" & Longitude 91^0 53' 20.5")	Sensitive Zone	50	40	47.5	36.2
6	Penursla Town (Latitude 25^0 18' 19.7" & Longitude 91^0 54' 39.3")	Commercial Zone	65	55	62.4	53.6
7	Nongshyrngan Village (Latitude 25^0 15' 29.4" & Longitude 91^0 56' 54.")	Residential Zone	55	45	50.8	37.4
8	Pomshutia village (Latitude 25^0 12' 49.4" & Longitude 91^0 52' 46.5")	Commercial Zone	65	55	63.5	48.3
9	Dwaki near PWD guest house (Latitude 25^0 11' 98.0" & Longitude 92^0 01' 11.4")	Residential Zone	55	45	52.2	40.8

Source: Field monitoring from May-June, 2016, JICA Study Team

There is no regulation in India regarding vibrations for road projects. Therefore, data on vibration was not measured and is not applicable to the project as excessively heavy vehicles are not expected to run along the NH40.



Source: Field monitoring from May-June, 2016, JICA Study Team

Figure 6-34: Ambient Noise Quality Results

4) Traffic Vibration

The Government of India has adapted "ISO 4866: 1990 Mechanical vibration and shock-Vibration of buildings-Guidelines for the measurement of vibrations and evaluation of their effects on buildings" as Indian Standard.

Vibration is usually associated with noise. There is a noise emanation standard put out by CPCB while there is no such standard of vibration. On the other hand, if there was a complaint on the vibration, the current standard of noise in India could be used as an indicator of vibration, generally coming from the on-going traffic in relation to the case of road construction project.

As is shown in Table 6-50, there is a standard of noise limit that the complaint could be made by the general public in Japan. Thus this is the standard value for which traffic vibration has to be investigated if the level of noise should exceed the indicated values.

Within the framework of the Project, traffic vibration as "Man-made Vibration" is in question. Most of the structures receiving frequency range of 1 Hz - 150 Hz gets some sort of damages. In Table 6-50, frequency and amplitude values that could cause damages to structures are shown. In the case of traffic vibration, occurring frequencies are from 1 Hz to 80 Hz. Itself does not cause significant damages but length of time of receiving such frequencies and amplitude as well as the conditions of road, geology and the structure determines damages made to the structure.

In the countries adapting "ISO 4866: 1990" generally considers that structures are damaged when a few millimeters per second of molecule vibration i.e. intensity of the vibration measured by frequency and amplitude as well as other conditions. Thus, other than noise values, various parameters related to vibration has to be investigated at the time of complaints made by the local residents.

Table 6-50: Limit of Noise Pollution Associated with Vibration in Japan

Classification of Land Use		Limit of Complaints	
1	Regular Residential Area High-rise Residential Area Other Residential Area	Day	65 dB
		Night	60 dB
2	Out-skirt of Urban Area Commercial Area Industrial Area	Day	70 dB
		Night	65 dB

Source: http://www.city.toyohashi.lg.jp/4292.htm

In the "International Journal of Advanced Technology in Engineering and Science (www.ijates.com), Volume No.03, Issue No. 03, March 2015 ISSN (online): 2348–7550", it explains that "BS 5228-2:2009 "Code of practice for noise and vibration control on construction and open sites, Part 2: Vibration" describes that the construction workers and residents should be protected from the noise emanated in the open-air. It suggests that the control of construction noise should be reduced by various measures. However, there is no "inexpensive" established method of noise barrier in order to protect construction workers or the residents adjacent to the construction site.

In the case of NH-40 improvement project, local resident along the project area should feel vibration during the construction period. During the operation and maintenance period, if heavy vehicles travel on the road, there should be significant vibration. However, this should depend much on the local conditions of geology, provided that the road surface is brand new and cause little vibration. Old structures without modern vibration-resisting framework could also be the receptor of traffic vibration.

Thus based on the noise monitoring and public complaints, if there was any significant vibration causing damages to structures, further monitoring on the 1) moving vehicles; 2) Conditions of the road surface, if any; 3) investigation of geological conditions; and 4) Conditions of the foundation and structure of the building subject to investigation. Table 6-51 shows Vibration Range Causing Damages to the Structures.

Table 6-51: Vibration Range Causing Damages to the Structures

Vibration forcing function	**Frequency range** Hz	**Amplitude range** µm	**Particle velocity range** mm/s	**Particle acceleration range** m/s2	**Time charac-teristic**	**Measuring quantities**
Traffic road, rail, ground-borne	1 to 80	1 to 200	0.2 to 50	0.02 to 1	C/T	pvth
Blasting vibration ground-borne	1 to 300	100 to 2 500	0.2 to 500	0.02 to 50	T	pvth
Pile driving ground-borne	1 to 100	10 to 50	0.2 to 50	0.02 to 2	T	pvth
Machinery outside ground-borne	1 to 300	10 to 1 000	0.2 to 50	0.02 to 1	C/T	pvth/ath
Acoustic traffic, machinery outside	10 to 250	1 to 1 100	0.2 to 30	0.02 to 1	C	pvth/ath
Air over pressure	1 to 40				T	pvth
Machinery inside	1 to 1 000	1 to 100	0.2 to 30	0.02 to 1	C/T	pvth/ath
Human activities a) impact b) direct	0.1 to 100 0.1 to 12	100 to 500 100 to 5000	0.2 to 20 0.2 to 5	0.02 to 5 0.02 to 0.2	T	pvth/ath
Earthquakes	0.1 to 30	10 to 105	0.2 to 400	0.02 to 20	T	pvth/ath
Wind	0.1 to 10	10 to 105	-	-	T	ath
Acoustic Inside	5 to 500	-	-	-		

NOTES C = continuous T = transient

pvth = particle velocity time history ath = acceleration time history

1 The ranges quoted are extremes but indicate the values which may be experienced and which may have to be measured (see also note 3). Extreme ranges of amplitude of displacement and frequency have not been used to derive particle velocity and acceleration.

2 The frequency range quoted refers to the response of buildings and building elements to the particular type of excitation. It is indicative only

3 Vibration values within the ranges given may cause concern. There are no standards which cover all varieties of building, condition and duration of exposure, but many national codes associate the threshold of visible effects with peak particle velocities at the foundation of a building of more than a few millimetres per second. A significant probability of some damage is linked to peak particle velocities of several hundred millimetres per second. Vibration levels below the threshold of human perception (see ISO 2631-2) may be of concern in delicate and industrial processes.

Source: Indian Bureau of Standard

(2) Anticipated Impacts and Mitigation Measures

1) Air Quality

Impacts

Based on the US Environmental Protection Agency's data (https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle-0#pane-3) typical passenger car emit 4.7 tons/year of CO_2; Truck emit CO_2 in general 6.0 tons/year.

On the other hand, based on the demand forecast of the project study, forecasted increase of the vehicles (Table 4-24) should increase CO_2 over time. Table **7-52**,Table 6-53 show projected increase of CO_2 at the section from the intersection in Shillong to 8.56 km post i.e. the section with the highest projected increae of vehicles on NH-40 while it is partly on the western border of "Upper Shillong Important Bird Area". As a result, the following is noted:

a. Section 1 - 2

- ✓ PM2.5 Value in Section 1 exceeds the standard before the Year 2020 and for Section 2 by the Year 2020-2025;
- ✓ PM10 Value in Section 1 exceeds already and for Section 2 by the Year 2020;
- ✓ SO_2 Value in Section 1 exceeds by the Year 2035 as the value of the "Ecological Sensitive Area" While for Section 2, the value exceeds the standard before the Year 2035.
- ✓ NOx Value in Section 1 and 2 exceeds the standard of the "Ecological Sensitive Area" before the Year 2030-2035;
- ✓ CO Value in Section 1 and 2 exceeds the standard by the Year 2030-2035

Table 6-52: Projected Increase of Vehicular Emission（0km-8.56km）

Sec- tion	Km	Item	Measurement at Nearest Location	2016	2020	2025	2030	2035	Standard of Air Quality1
1	0-2.26km	Annual Increase of Vehicles	–	17,822	23,341	32,383	43,131	46,800	–
		CO2 Emission/Ton.Year	–	30,573,641	40,041,486	55,553,037	73,991,231	80,285,400	–
		Rate of Increase of Emission	–	–	31%	82%	142%	163%	–
		PM2.5,μg/m3	37.9	–	49.6	68.9	91.7	99.5	**40/40**
		PM10,μg/m3	83.1	–	108.8	151.0	201.1	218.2	**60/60**
		SO_2 μg/m3	6.9	–	9.0	12.5	16.7	18.1	**50/20**
		NOx μg/m3	12.1	–	15.8	22.0	29.3	31.8	**40/30**
		CO, μg/m3	989.2	–	1,295.5	1,797.4	2,394.0	2,597.6	**2000/2000**
2	2.26-8.56km	Annual Increase of Vehicles	–	12,807	16,733	23,271	30,955	40,817	–
		CO2 Emission/Ton.Year	–	21,970,409	28,705,462	39,921,401	53,103,303	70,021,564	–
		Rate of Increase of Emission	–	–	31%	82%	142%	219%	–
		PM2.5,μg/m3	23.4	–	30.6	42.5	56.6	74.6	**40/40**
		PM10,μg/m3	55.6	–	72.6	101.0	134.4	177.2	**60/60**
		SO_2 μg/m3	7.1	–	9.3	12.9	17.2	22.6	**50/20**
		NOx μg/m3	11.7	–	15.3	21.3	28.3	37.3	**40/30**
		CO, μg/m3	872.1	–	1,139.4	1,584.7	2,107.9	2,779.5	**2000/2000**

Note : 1 - Emission Standard is shown as "Residential Area/Ecologically Sensitive Area".

Source: JICA Study Team

b. Section 3 - 4

Section 3 and 4 are in the moutaneous area where the increase of vehicles is relatively low. As a result of projected increase of vehicles, increase of emission is projected as follows:

- ✓ PM2.5 Value in Section 3 exceeds the standard by the Year 2025-2030 and for Section 4 by the Year 2020-2025;
- ✓ PM10 Values in Section 3 and 4 exceeds abefore the Year 2020;
- ✓ SO_2 Values in Section 3 and 4 do not exceeds standard of the “Residential Area” well after the Year 2035;
  While for Section 2, the value exceeds the standard before the Year 2035.
- ✓ NOx Values in Section 3 and 4 do not exceeds standard of the “Residential Area” well after the Year 2035;
- ✓ CO Values in Section 3 and 4 do not exceeds standard of the “Residential Area” well after the Year 2035;

Table 6-53: Projected Increase of Vehicular Emission（8.56km – 49.26km）

Sec-tion	Km	Item	Measurement at Nearest Location	2016	2020	2025	2030	2035	Standard of Air Quality1
3	8.56-19.99km	Annual Increase of Vehicles	—	5,935	7,773	10,784	14,363	18,915	—
		CO2 Emission/Ton.Year	—	10,181,493	13,334,582	18,499,952	24,639,727	32,448,683	—
		Rate of Increase of Emission	—	—	31%	82%	142%	219%	—
		PM2.5,μg/m3	20.3	—	26.6	36.9	49.1	64.7	**40/40**
		PM10,μg/m3	55.6	—	72.8	101.0	134.6	177.2	**60/60**
		SO_2 μg/m3 ,	7.0	—	9.2	12.7	16.9	22.3	**50/20**
		NOx ,μg/m3	11.7	—	15.3	21.3	28.3	37.3	**40/30**
		CO, μg/m3	583.3	—	763.9	1,059.9	1,411.6	1,859.0	**2000/2000**
4	19.99-49.26km	Annual Increase of Vehicles	—	2,925	3,831	5,315	7,079	9,322	—
		CO2 Emission/Ton.Year	—	5,017,838	6,572,081	9,117,883	12,144,025	15,991,891	—
		Rate of Increase of Emission	—	—	31%	82%	142%	219%	—
		PM2.5,μg/m3	23.2	—	30.4	42.2	56.1	73.9	**40/40**
		PM10,μg/m3	53.6	—	70.2	97.4	129.7	170.8	**60/60**
		SO_2 μg/m3 ,	7.0	—	9.2	12.7	16.9	22.3	**50/20**
		NOx ,μg/m3	12.2	—	16.0	22.2	29.5	38.9	**40/30**
		CO, μg/m3	593.3	—	777.1	1,078.1	1,435.9	1,890.9	**2000/2000**

Note : 1 - Emission Standard is shown as "Residential Area/Ecologically Sensitive Area”.

Source: JICA Study Team

c. Section 5 - 6

Section 5 and 6 are in the lowland area where the increase of vehicles is comparatively lower than other sections. As a result of projected increase of vehicles, increase of emission is projected as follows:

- ✓ PM2.5 Values in Section 5 and 6 exceeds standard of the “Residential Area” by the Year 2020-2025;
- ✓ PM10 Values in Section 5 exceeds abefore the Year 2020;
- ✓ SO_2 Values in Section 5 and 6 do not exceeds standard of the “Residential Area” well after the Year 2035;

- ✓ NOx Values in Section 5 and 6 do not exceeds standard of the "Residential Area" well after the Year 2035;
- ✓ CO Values in Section 5 and 6 do not exceeds standard of the "Residential Area" well after the Year 2035 while the Section 6 could exceed the standard of "Residential Area" by the Year 2025-2030.

Table 6-54: Projected Increase of Vehicular Emission（49.26km – 81.26km）

Sec-tion	Km	Item	Measurement at Nearest Location	2016	2020	2025	2030	2035	Standard of Air Quality1
5	49.26-80.26km	Annual Increase of Vehicles	—	1,596	2,090	2,900	3,863	5,087	—
		CO2 Emission/Ton.Year	—	2,737,938	3,585,395	4,974,950	6,626,977	8,726,749	—
		Rate of Increase of Emission	—	—	31%	82%	142%	219%	—
		PM2.5,μg/m3	23.2	—	30.4	42.2	56.2	73.9	**40/40**
		PM10,μg/m3	53.7	—	70.3	97.6	130.0	171.2	**60/60**
		SO_2 μg/m3	6.7	—	8.8	12.2	16.2	21.4	**50/20**
		NOx μg/m3	11.4	—	14.9	20.7	27.6	36.3	**40/30**
		CO, μg/m3	361.7	—	473.7	657.2	875.5	1,152.9	**2000/2000**
6	80.26-81.26km	Annual Increase of Vehicles	—	1,588	2,080	2,885	3,843	5,061	—
		CO2 Emission/Ton.Year	—	2,724,214	3,568,240	4,949,218	6,592,667	8,682,146	—
		Rate of Increase of Emission	—	—	30%	81%	141%	217%	—
		PM2.5,μg/m3	38.1	—	49.7	68.9	91.7	120.8	**40/40**
		PM10,μg/m3	81.0	—	105.6	146.4	195.0	256.9	**60/60**
		SO_2 μg/m3	6.7	—	8.7	12.1	16.1	21.2	**50/20**
		NOx μg/m3	11.8	—	15.4	21.3	28.4	37.4	**40/30**
		CO, μg/m3	1021.3	—	1,331.0	1,846.1	2,459.2	3,238.6	**2000/2000**

Note : 1 - Emission Standard is shown as "Residential Area/Ecologically Sensitive Area".
Source: JICA Study Team

Mitigation Measures
During the construction period, construction plants should be equipped with mufflers on the exhaust pipe, monitoring works of the vehicular emission, periodical maintenance of the construction plant should reduce excessive emission.

The above projected increase of vehicular emission during the operation and maintenance period is in need of further elaborated for acculacy. Thus, monitoring works during the operation and maintenance period is inevitable.

2) Water

Impacts
Depending on the water sources, water quality during the construction period could temporarily deteriorate. There will be no contamination of drinking water during the operation and maintenance period.

Mitigation Measures
In oorder to avoid permanent contamination, fuel, oils and other foreignmatters should be strictly administered for storage during the construction period. No mitigation measures are required during the operation and maintenance period.

3) Bottom Sediment

Impacts

Bottom sediment in the rivers and streams as well as agricultural waterways could be blocked with construction debris, or contaminated by fuel, oil and other foreign matters. Unless a large scale operation is carried out for maintenance works during the operation and maintenance period, there will be no siginificant impact induced by the Project.

Mitigation Measures

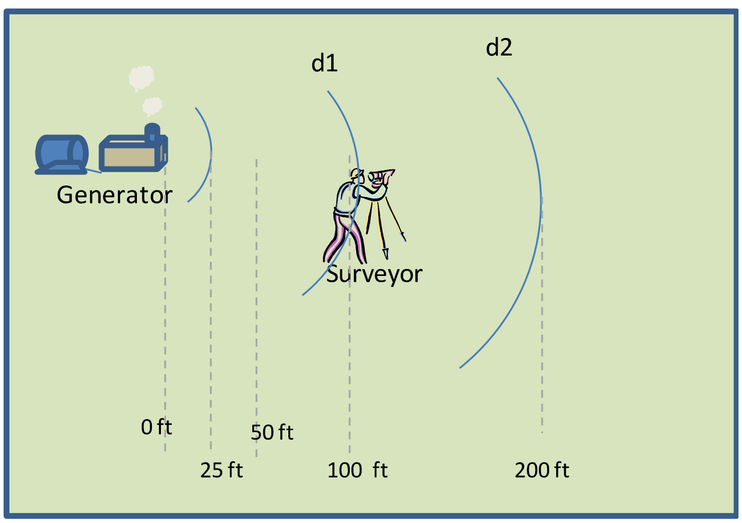
Strict prevention measreus for which construction works carried out in the vicinity of rivers and streams as well as agricultural waterways provide silt trap and other measures.

4) Noise

Impacts

During the construction period, construction noise could be strongly felt by the local residnets in and around built-up areas. In the forest area, construction noise has to scare wildlife including birds. While wildlife including birds will not return to the original forest.

It is ideal to carry out construction works away from the residential areas. As is shown in Figure 6-35, noise level is reduced by 6 dB at every 100 ft (30 m). Thus, source of noise at 85 dB emanated by diesel generator, for instance, reduced to 79 dB as a person moves to a place 200 ft (60m) away from the source of noise.



Source: https://www.faa.gov/air_traffic/nas/nynjphl_redesign/

Figure 6-35: Noise Level Increase and Decrease by Distance

During the operation and maintenance period, traffic noise is psychologically accepted in most cases uless otherwise excessive noise and vibration is felt ashyspeed traffic including heavy vehicles emanate high level of noise.

Mitigation Measures
Noise measurement during the construction period has to be constantly carried out at the time of construction plants in operation. Mufflers should be installed on the exhaust pipes of the construction plants, periodical maintenance of construction should be carried out in order to reduce excessive noise. Where construction works are carried out in the vicinity of residential areas, noise barriers should be provided especially in the area near schools and hospitals.

During the operation and maintenance period, increase of traffic volume, speed of vehicles and increase of heavy vehicles could cause excessive noise. Although the local residents gets to be accustomed with high level of noise over time, periodical monitoring of noise level measurement has to be carried out in order to elaborate further measures on the noise level management.

5) Vibration

Impacts
In India, "ISO 4866 : 1990 Mechanical vibration and shock-Vibration of buildings-Guidelines for the measurement of vibrations and evaluation of their effects on building" has been adapted as "Indian Standard" without major changes in terms of the vibration caused to the structures. While it is the case, there is no concrete standard of vibration such as the noise level associated with vibration, which generally comes from the natural phenomena (wind, earthquake, etc) and man-made vibrations induced by blasting, traffic, etc. Because of the road improvement project, it would be appropriate to discuss traffic vibration in this section.

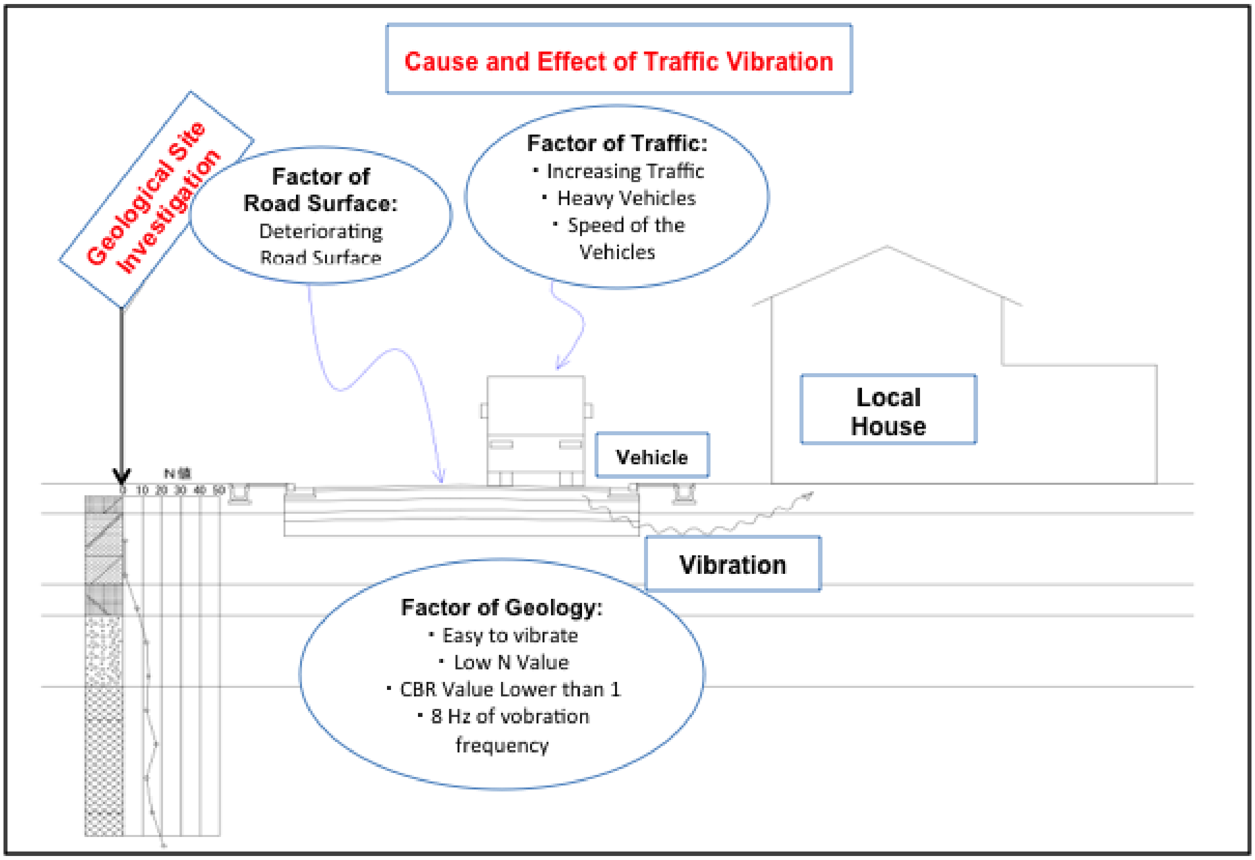
In Table 6-55 limit of noise level that the vibration is associated is shown. It is very likely that the local residents tend to complain on traffic vibration when the ambient noise exceed as is shown in the table.

Table 6-55: Noise Limit Associated with the Complaint on Vibration

Classification of Land Use		Limit of Complaints	
1	Regular Residential Area High-rise Residential Area Other Residential Area	Day	65 dB
		Night	60 dB
2	Out-skirt of Urban Area Commercial Area Industrial Area	Day	70 dB
		Night	65 dB

Source: http://www.city.toyohashi.lg.jp/4292.htm

As is shown in Figure 6-36, there are a number of factors necessary to cause vibration to the local house and structures such as 1) Passing Vehicles; 2) Conditions of the Road Surface; and 3) Conditions of the Local Geology. Further, the structure itself could easily vibrate from the ground as vibration recepter which depend much on the conditions of the structure.



Source: http://www.crearia.co.jp/

Figure 6-36: Cause of Traffic Vibration

Depending on the country adapting "ISO 4866: 1990" as a standard of traffic vibration, the frequency range of vibrations depends upon the distribution of spectral content over the frequency range of the excitation and upon the mechanical response of the building. This pinpoints the spectral content as a most important property of vibration input. For simplicity's sake, the International Standard of ISO 4866: 1990 deals with frequencies ranging from 0.1 Hz to 500 Hz that it covers the response of buildings of a wide variety and building elements to excitation.

The reaction of buildings and building components to dynamic excitation depends upon response characteristics. For example natural frequencies, mode shapes and modal damping as well as the spectral content of the excitation should cause damages to the building. Cumulative effects should also be considered, especially at high response level and long exposure times where fatigue damage is a possibility. Table 6-56 shows typical range of structural response for various sources.

Table 6-56: Typical Range of Structural Response

Vibration forcing function	Frequency range Hz	Amplitude range µm	Particle velocity range mm/s	Particle acceleration range m/s2	Time charac-teristic	Measuring quantities
Traffic road, rail, ground-borne	1 to 80	1 to 200	0.2 to 50	0.02 to 1	C/T	pvth
Blasting vibration ground-borne	1 to 300	100 to 2 500	0.2 to 500	0.02 to 50	T	pvth
Pile driving ground-borne	1 to 100	10 to 50	0.2 to 50	0.02 to 2	T	pvth
Machinery outside ground-borne	1 to 300	10 to 1 000	0.2 to 50	0.02 to 1	C/T	pvth/ath
Acoustic traffic, machinery outside	10 to 250	1 to 1 100	0.2 to 30	0.02 to 1	C	pvth/ath
Air over pressure	1 to 40				T	pvth
Machinery inside	1 to 1 000	1 to 100	0.2 to 30	0.02 to 1	C/T	pvth/ath
Human activities a) impact b) direct	0.1 to 100 0.1 to 12	100 to 500 100 to 5000	0.2 to 20 0.2 to 5	0.02 to 5 0.02 to 0.2	T	pvth/ath
Earthquakes	0.1 to 30	10 to 105	0.2 to 400	0.02 to 20	T	pvth/ath
Wind	0.1 to 10	10 to 105	-	-	T	ath
Acoustic Inside	5 to 500	-	-	-		

NOTES C = continuous T = transient
pvth = particle velocity time history ath = acceleration time history

1 The ranges quoted are extremes but indicate the values which may be experienced and which may have to be measured (see also note 3). Extreme ranges of amplitude of displacement and frequency have not been used to derive particle velocity and acceleration.

2 The frequency range quoted refers to the response of buildings and building elements to the particular type of excitation. It is indicative only

3 Vibration values within the ranges given may cause concern. There are no standards which cover all varieties of building, condition and duration of exposure, but many national codes associate the threshold of visible effects with peak particle velocities at the foundation of a building of more than a few millimetres per second. A significant probability of some damage is linked to peak particle velocities of several hundred millimetres per second. Vibration levels below the threshold of human perception (see ISO 2631-2) may be of concern in delicate and industrial processes.

Source: Indian Bureau of Standard

In the event if there were significant damages, road surface improvement and/or vibration measurement, geological site investigation would have to be carried out in order to assess vibration receptor's structural damages. In order to carry out such investigation, it is obvious that the exceeding the noise level at the location should become an indicator for investigation.

Mitigation Measures
As is described above, noise monitoring is an indicator of excessive vibration. Holding village meeting before the commencement of the construction works is important for the increase of understanding among the local residents. Interviewing the local residents during the construction period must be carried periodically.

Continuous noise monitoring works should be carried out during the operation and maintenance period in order to which values of noise level should be used as an important indicator.

6) Dust

Impacts
During the construction period, in the dry season, dust emanation from the construction area could cause public nuisance. During the rainy season, mud on the road could also cause public nuisance both against pedestrians and traffic.

There will be no dust emanated during dry season and mud during the rainy season after the completion of the construction works and that NH-40 is put into operation.

Mitigation Measures
The Contractor is requested to sprinkle water during the dry season within the construction area. During the rainy season, mud barriers should be provided in order to prevent mud from spilling over to the live road and sidewalk.

There is no dust emanation or mud spillage during the operation and maintenance period.

7) Traffic Jam

Impacts
Because of the heavy traffic concentrating at the intersection in Shillong, 0 km post of the Project, heavy traffic congestion is expected. In Dowki, road construction works should cause heavy traffic jam because of the concentration of trucks transporting stone materials to Bangladesh.

No significant traffic jam should take place during the operation and maintenance period.

Mitigation Measures
The Contractor should provide a number of traffic guides, traffic barriers, signboards, color cones and movable signais in order to maintain smooth flow of live traffic during the construction period.

No mitigation measures is required during the operation and maintenance period.

8) Solid Waste

Impacts

Various types of waste could be produced during the construction period ranging from oil, spare parts of the construction plants including electrical parts, waste from workforce camp, removal of old structures, etc. Based on the CPCB's rules as per Table 6-57.

No significant amount of waste will be produced during the operation and maintenance period.

Table 6-57: Rules of the Disposal for Various Types of Waste

Municipal Solid Waste (Management and Handling) Rules, 2000	Basic rule of solid waste management CPCB put out for all the municipalities of India. State government is requested to follow the rules. It was amended on 29th March 2016 in order to manage construction debris.
Hazardous and Other Waste (Management and Handling) Rules, 1989	Amended in 2000, 2003, and changed in 2008 including method of disposal and transportation beyond state/international borders. Further amendment was made in 2016 for utilization of hazardous material.
Bio-medical Waste (Management and Handling) Rules, 1998	Amended in 2003 and further amended in March 2016 in order to handle medical waste produced hospitals, veterinary institutions, pathological laboratories, blood banks, etc.
Plastic Waste (Management and Handling) Rules, 1999	Amended in 2003 and further amended in 2016 in order to control thick plastic materials.
e-Waste (Management and Handling) Rules, 2001	Amended in 2016, it deals with disposal of all electrical waster ranging from led-batteries, parts of electrical appliances in terms of reuse and disposal.

Source: Central Pollution Control Board, India

Mitigation Measures

These various types of waste should be separated using boxes/cases for disposal and reuse during the construction period. Depending on the type of waste, the Contractor should transport them to the locations designated by the Meghalaya State Pollution Control Board.

Unless otherwise carried out a large operation of maintenance works, no significant waste will be produced i.e. no mitigation measures is required during the operation and maintenance period.

9) Other Measures for Climate Change

Impacts
No significant impact is induced by the implementation of Climate Change Measures.

Mitigation Measures
Implementation of climate change measures is carried out in order to provide further safety measures of the road construction project in view of the recent changes of climatic conditions, especially unpredictably amount of rainfall.

In proper maintenance of road facilities such as sediment deposition in culverts can cause natural disasters or exacerbate their impacts. NHIDCI will be responsible for regular maintenance of road facilities to reduce the risk of natural disaster during the operation period.

Frequency and intensity of heavy rain is likely to increase due to climate change in addition to the present heavy rainfall patterns in Meghalaya State. In the project area, a drastic increase of annual rainfall or unexpected drought could happen for the period from 2021 to 2050. The design of various components of the road (slope protection, drainage etc.) takes into account likely effect of climate change. With the predicted increase of the rainfall frequency and intensity, river water and groundwater level are expected to be high, which could cause inundation and damage to the road facilities. For designing the road and bridges, data value of the 50-year event of rainfall has been taken into account. Thus Table 6-58 shows adaptation measures for climate change taken into consideration in the road design.

Table 6-58: Adaption Measures for Climate Change in NH40

Factor	Design Policy considering Adaptation
Side Slope	· Retaining wall is built all along the road. · Slope protection work is constructed on some weathered and loosen slopes. · Cut slope is covered with vegetation works to prevent erosion and collapse. · Replacement of subgrade and subsurface drainage are planned as counter measure against sinking.
Embankment	· Proper materials are used for the embankment. · Flood level is confirmed in site reconnaissance and interview survey near river bank in south of NH40.
Bridge & Drainage System	· Rainfall intensity is carefully determined based on the authorized data : ATLAS of State wise Generalized ISO PLUVIAL MAPs of Eastern India published by Indian Counter range is applied.Meteorological Department. The pluvial value from higher edge of counter range is applied. · The capacity of all structures is determined to be capable for the discharge of 50 years return period.
Pavement	· Super elevation or camber is installled properly. · Pavement material is examined not to rise over 60 °C on the surface.
Road Sign	· Wind load and visibility is taken into consideration.

Source: JICA Study Team

6.7.4 Major Impacts on Social Environment

(1) Involuntary Resettlement

As per the preliminary ROW design, the project will affect 309 households (299 houses, 48 shops, 5 workshops and 1 other structures; some households overlap). The public structures including a school, church, and resort etc., will only be partially affected in terms of land and not in terms of the building. The total number of affected people is approximately 1,450, though some of the households will not be subject to permanent resettlement.

Table 6-59: Summary of Households with their Structures Affected

Large Classification	Medium Classification	Small Classification	No. of HHs
Villages Under the Project 28 villages	HHs with their Structures Affected	Houses	299
		Shops	48
		Workshops	5
		Other Buildings	1
		Total※1	309

*1) 44 households are affected in terms of both house and shop.
Source: JICA Study Team

<u>Mitigation</u>
Relocation sites shall be secured within same area as much as possible. Appropriate compensation and rehabilitation shall be provided.

(2) Land Use

The project will lead to significant changes in land use especially at the bypass sections. Moreover, the development of the resettlement sites to accommodate relocated households and the construction of spoil banks is likely to cause changes in land use patterns, potentially affecting existing agricultural and plantation activities.

For sections where NH40 passes through a community forest, jhum area and plantation, engineering work should be scheduled in a way that minimizes the disruption of access to such areas by local people. At the same time, proper management of effluent and soil erosion shall be carried out to avoid negative impacts on such resources.

Table 6-60: Summary of Households of Lands Affected

Large Classification	Medium Classification	Small Classification	No. of HHs
Villages Under the Project 28 villages	Households of Lands Affected	Agricultural/open field	46
		Stone and sand quarry	146
		Betel nut Plantation owners	75
		Total	135

Source: JICA Study Team

<u>Mitigation</u>
Relocation sites shall be secured within same area as much as possible. Appropriate compensation and rehabilitation shall be provided.

(3) Utilization of Local Resources

This project shall use mass-scale of local resources such as sand and quarrying, in short term, may hinder the ability of local purposes to utilize it for other purpose. After completion of construction, further influx of outsiders and economic development may lead negative impact for local employment or business.

Mitigation

For construction material, actual utilization of local resources shall be considered. In designing livelihood restoration plan, the impact mentioned above shall be examined.

(4) Social Institutions and Local Decision-Making Institutions

Meghalaya is a state predominantly inhabited by the Scheduled Tribes. The traditional leaders/headmen, the *Durbar Shnong* and chieftains, must be involved in the decision-making process of the project from the planning stages. Their support and influence can facilitate the smooth execution of the project, and reduce impediments. The activities of RAP and rehabilitation and resettlement (R&R) should be built on existing social institutions; the local people are the best guide and have the expertise to guide the project based on their traditions and cultures. To minimize any potential disturbance and avoid the risk of conflicts, however, the resettlement will be planned within the village where relocation takes place.

(5) General, Regional/City Plans

The project will create new opportunities for village and district-level development planning. In particular, the construction of a spoil bank will create a large area of flat land where such surface space is a scarce commodity. The development of a spoil bank, therefore, should be coordinated with the village/district's development plan so that the land will benefit the community. Similarly, the development of the resettlement site should be coordinated with the village development plan to ensure proper supply of basic utilities and integration of new sites with the existing village area.

(6) Social Infrastructure and Services

The Shillong-Dawki road is the connecting road not only to the people along the area, but is also the connecting road that is being used every day by people from Shillong who go to their work/office in various blocks and sub divisions. The road also serves as the connecting link for school and college-going children in the periphery of Shillong (BP 1 and 2) who attend school in the main part of Shillong. The construction period will affect the aforementioned activities greatly.
Proposed alignments shall not avoid the Health center at the end point Dawki, so that it will be necessary to be resettled. Noise pollution is as shown in 7.7.3(2) 4).

Mitigation

In order to alleviate negative impact by access inhibition to social infrastructure and social service, preparation must be made before implementation. Discussions and assistance can be taken with District Authorities and link with the traffic police. Any construction activity that may require road blockade, the community must be made aware at least 24 hours in advance.

Health center mentioned above shall be constructed in alternative place in advance of main project. PIU shall pay the cost.

(7) Local Economy and Livelihood

One of the major outcomes from the project will be the increased business ventures and opportunities that the area will be exposed to, and in terms of tourism, social events and increased trade and commerce with neighboring villages and the state as a whole. The people along the project road especially towards the end, are very enterprising and it is expected that they will take advantage of the project in a positive manner.

While the project overall will have significant positive impacts on the local and regional economy, the improved transport network may pose a risk to some groups, at least in the short and medium-term.

(8) Unequal Distribution of Benefits and Damages and Local Conflicts of Interest

Roadside locations offer critical advantages for local businesses (tea stalls, restaurants, petty shops). Resettlement from the roadside to an inner part of the village may significantly undermine the viability of these businesses, and therefore, business owners to be affected may be worse off compared with farmers to be relocated. Likewise, the allocation of plots in the resettlement site may become a source of conflicts among the affected households who wish to be relocated to more advantageous plots.

Mitigation

A sound arbitration and conflict resolution mechanism by local leaders should be in place for the smooth implementation of RAP and R&R activities.

(9) Religious and Sensitive Facilities

Access to religious structures such as churches, temples, and mosques may be rendered difficult because of the construction. People should not be stopped from attending their religious duties because of the construction. The majority of the people in the project area are Christians, and they will go to church every Sunday and other weekdays when necessary.

Mitigation

Access to these places must be built temporarily built for this matter. Noise pollution is as shown in 7.7.2 (5).

Sacred Groves

Sacred forests are an integral part of the Khasi culture and beliefs. Sacred forests are found in various parts of the state, wherein clans, traditional heads/dorbar, declare a section of their forests as sacred and revere as a place of sanctity. People who visit these forests are warned not to misuse or abuse the forest creatures and vegetation. The sacred grove in Mawphlang is one such grove and is located near the project road, a few kilometers away from Pomlum village. It is one of the largest and oldest sacred groves in the state. The Mawphlang Sacred grove will not be affected by this project.

While “Raid Shabong Law Adong” in Wahpathew-urksew near Pynursla is located in a few hundred meters west of the current road of NH40, Bypass 5 is designed in the east to current road and it shall not disturb the forest. Moreover, while “Law Lyngdoh Mawshun” in Mawshun is located within 1 Km east of current road of NH40, the alignment is designed in west to current road of proposed design, therefore, it shall avoid it. Both are distant from proposed construction areas so that negative impact by drainage shall not be expected.

Source: JICA Study Team

Figure 6-37 : Location of Sacred Groves along NH40

Table 6-61: Sacred Groves in East Khasi Hills and Jaintia Hills

Name	Location	Area (Ha)	Name	Location	Area (Ha)
District - East Khasi Hills			District - Jaintia Hills		
Diengkain	Wmwai	400.0	Blai Law	Raliang	50.0
Dienglienqbah	Rngiksheh	0.50	Dpepat Myndihati	Sutnga	15.0
Ingkhrum	Cherrapunji	0.25	Ka Pun Lyngdoh	Raliang	15.0
Ingkhrum	Cherrapunji	0.25	Khlaw Blai	Dien Shynrum	15.0
Kharai Law Lyngdoh	Nongkhieng	150.0	Khlaw Byrsan	Raliang	50.0
Khlaw Ram Jadong	Mawsmai	50.0	Khloo Lyndoh	Jowai	15.0
Kynsang	Mawlong	150.0	Khloo Paiu Ram Pyrthai	Jowai	150.0
Law Adong	Mawsmai	400	Law Kyntang	Shanpung	400.0
Law Adong Laitryngkew	Laitryngkew	20.00	Lawianlong	Jowai	12.0
Law Adong, Khlieh Shnong	Cherrapunji	90.0	Lumtiniang Mokaiaw	Syndai	25.0
Law Blei Beh	Mawsmai	120.0	Mokhain	Jowai	45.0
Law Dymmiew	Sohrarim	200	Poh Lyndoh	Shanpung	30.0
Law Kyntang, Khlieh Shnong	Cherrapunji	90.0	Poh Moorang	Raliang	20.0
Law Lieng	Sohrarim	20.0	Poh Puja Ko Patti	Raliang	4.0
Law Lyngdoh	Mawphlong	75.0	Trepale Jowai	Jowai	70.0
Law Lyngdoh Lyting Lyngdoh	Lyntilew	100.00			
Law Lyngdoh Mawshun	Mawshun	100.00			
Law Lyngdoh, Smit	Nongkrem	6.0			
Law Mawsaptur	Sohrarim	50.0			
Law Nongshim	Mawmihthied	5.0			
Law Suidnoh	Lait-Ryngew	80.0			
Law-ar-Liang	Lait-Ryngew	25.0			
Lawthymmal	Cherrapunji	2.00			
Law–u-Niang	Lait-Ryngew	10.0			
Lum Diengjri	Khada Snoing	25.0			
Lum Shillong	Laitkor	7.0			
Madan Jadu	Lait-Ryngew	5.0			
Maw Kyrngah	Wmwai	1200.00			
Mawlong Syiem	Mawsmai	120.0			
Mawlot	Phyllut	20.0			
Raid Shabong Law Adong	Wahpathew-urksew in Pynursla	700.0			
Niangdoh	Wahlong	0.0			
Mawmang	Khada Snoing	15.0			
Mawryot	Wahlong	40.0			
Mawsawa	Mawmluh	50.0			
Mawthoh	Wmwai	30.0			
Nongbri	Pyndeng-Nongbri	5.0			
Pohsurok	Cherrapunji	0.50			
Pom Shandy	Mawsmai	80.0			

Rangbaksaw	Cherrapunji	1			
Rilaw Khaiti	Wahlong	35			
Swer	Lum Swer	12			
Umkatait	Dieng Ksiar	100			
Umthri	Nongduh	80			
Umtong	Wmwai	400			
Wahkhem	Khadar Blang	10			
Wanning Sawkpoh	Shngimawlein	7			
Lum Shyllong	Laitkor	7			
Rijaw	Wahlong	35			
Dienglingbah	Rngiksheh	0.50			

Source: C.P.R Environmental Education Center

Monoliths

Monolith are traditional structures and are sacred to the Khasi people, especially those who still follow the indigenous religion. In the view of land use, ROW and securement of slope, 7 Monoliths placed along the planning roads is difficult to avoid, so that it was confirmed whether it shall be relocated or not.

Table 6-62: List of Monoliths

Sl. No.	Distance from starting point (0.00 Km)	Side from existing road from Shillong	Distance from the center point of the existing road	Altitude	Latitude	Longitude	Photographs of Monolith	Monolith location on satellite image	GPS Datum	Remarks	Within ROW or not	If yes, feasibility of relocation / protection
1	4.88km	R.H.S	14 to 15 meters	1739 m	25°33' 6.27" N	91°50' 35.87" E			WGS 84	These monoliths are memorial where the ashes of the deceased are deposited in cairns.	Outside of ROW	Avoid
2	5.79 km	R.H.S	6 meters	1783 m	25°32' 46.72" N	91°50' 14.87" E			As above	As above	Within ROW	May be in carriage way. Located in land of State government. Details were already confirmed and consulted by Block Development Officer
3	6.06 km	R.H.S	10 meters	1789 m	25°32' 44.99" N	91°50' 5.18" E			As above	As above	Within ROW	May be in carriage way. Located in land of State government. Details were already confirmed and consulted by Block Development Officer
4	8.14 km	L.H.S	7 meters	1768 m	25°32' 00.00" N	91°49' 13.80" E			As above	As above	Within ROW	Section excluded from NH40.
5	17.88 km	R.H.S	8 meters	1691 m	25°27' 57.01" N	91°49' 18.70" E			As above	As above	Within ROW	Relocation will be done in consultation with the local people as Monolith does not belong to any specific clan
6	18.11km	R.H.S	Median	1687 m	25°27' 56.70" N	91°49' 25.70" E			As above	As above	Outside ROW	Avoid

Sl. No.	Distance from starting point (0.00 Km)	Side from existing road from Shillong	Distance from the center point of the existing road	Altitude	Latitude	Longitude	Photographs of Monolith	Monolith location on satellite image	GPS Datum	Remarks	Within ROW or not	If yes, feasibility of relocation / protection
7	21.3km	-	-	1839 m	25˚27' 0.40"N	91˚50 '45.68"E					Within ROW	May be under flyover. Relocation were already confirmed by land owner and Block Development Officer. Consensus and ritual ceremony will be examined by religious group. .
8	53.75 km	L.H.S	8 meters	830 m	25˚15' 29.48" N	91˚56' 54.93" E			As above	As above	Within ROW	Relocation will be done in consultation with the local people as Monolith does not belong to any specific clans.

Source: JICA Study Team

(10) Poor people

People from Below Poverty Line (BPL) or poor people in general must be considered when planning and executing R&R activities and RAP. It is noted that poor people are less exposed to big development projects and hence may feel intimidated and unable to voice concerns, grievances and suggestions. Improvement of transportation system will lead acceleration of market competition and accordingly it might expose a part of residents in short or medium-term. The project will make the positive impact in whole, although in case the poor have difficulty to be involved in market competition, their life may go worse furthermore.

Mitigation
Measures can be taken to ensure the poor are included into the project, and their grievances heard and redressed. Allowance shall be offered for the vulnerable people and the skill development shall be implemented in livelihood restoration plan.

(11) Indigenous People and Ethnic Minorities

The majority of Meghalayans are STs as per the Constitution of India. The majority of PAPs are Khasi, with few Garo and Bengali. STs will not be excluded from this project, however, there should be a conscious effort made to accommodate and include them in the decision-making and grievance redress processes.

Mitigation
Fee, prior and informed consultation shall be required in accordance with World Bank OP4.10 and social consent shall be confirmed. A rehabilitation policy will be elaborated considering traditional livelihoods. Details are shown in 7.11.11.

(12) Public Health (sanitation and infectious diseases) and Occupational Health and Safety (OHS)

The health and safety measures at the design, construction, and operation phases are outlined in Table 6-63.

Table 6-63: Health and Safety Measures

Design Stage	**Health and Safety Measures**
Geometric correction at critical curves	Critical curves have been rectified to maintain the project design speed and visibility. (IRC-86-1983 " Geometric Design for Road in Plains")
Construction Stage	
Health hazards to workers due to bad water and sanitation	At every workplace, good and sufficient potable water (as per Indian Standard (IS) codes) supply shall be ensured to avoid water-borne diseases and to ensure the health of workers. Adequate provision for drainage, sanitation, and waste disposal shall be provided at workplaces. Preventive medical care shall be provided to workers.
Health / social hazards, sexual harassment to female workers	Segregation of male and female areas in the construction camp.

Hygiene at construction camps	The contractor, during the progress of construction work will provide, erect and maintain necessary (temporary) living accommodation and ancillary facilities for workers that meet standards and scales approved by the resident engineer. There shall be provided within the precincts of every workplace and accommodation, latrines and urinals in an accessible place, as per standards set by the Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act. Except in workplaces provided with water-flushed latrines connected with a well-designed septic tank, all latrines shall be provided with low cost 'Twin Pit Latrine' system. The pit can be closed after the construction is over. There shall be adequate supply of water, close to latrines and urinals. All temporary accommodation shall be constructed and maintained in such a fashion that uncontaminated water is available for drinking, cooking and washing. The sewage system for the camp must be properly designed, built and operated so that no health hazard occurs and no pollution to the air, ground or adjacent watercourses takes place. Compliance with the relevant legislation must be strictly adhered to. Garbage bins must be provided in the camp and regularly emptied and the garbage disposed of in lined landfill sites. Construction camps are to be situated away from vulnerable people and adequate health care is to be provided for the work force. On completion of the works, the whole of such temporary structures shall be cleared away, all rubbish burnt, excreta or other disposal pits or trenches filled in and effectively sealed off, and the entire site left clean and tidy, at the contractor's expense, to the entire satisfaction of the engineer.
Abandoned quarry will accumulate water and act as a breeding ground for disease vectors.	Reclamation measures shall be adopted with garlands of trees around the periphery. The quarry dust and waste shall be used for refilling. The remaining portion shall be covered with trees. If the quarry site is porous, allow for groundwater recharging.
Risk from operations	The contractor is required to comply with all the precautions as required for the safety of the workmen as far as those are applicable to this project. The contractor shall supply all necessary safety appliances such as safety goggles, helmets, masks, etc., to the workers and staff. The contractor must comply with all regulations regarding safe scaffolding, ladders, working platforms, gangways, stairwells, excavations, trenches and safe means of entry and egress.
Risk from electrical equipment	Adequate precautions will be taken to prevent any danger from electrical equipment. No material at any of the sites will be so stacked or placed as to cause danger or inconvenience to any person or the public. All necessary fencing and lights will be provided to protect the public. All machines to be used in the construction will conform to the relevant IS codes, will be free from patent defects, will be kept in good working order, will be regularly inspected and properly maintained as per IS provisions and to the satisfaction of the engineer.
Risk at hazardous activity	All workers employed for mixing asphaltic material, cement, lime mortars, concrete etc., will be provided with protective footwear and protective goggles. Workers who are engaged in welding works, will be provided with welder's protective eye-shields. Stone-breakers will be provided with protective goggles and clothing and will be seated at sufficiently safe intervals. The use of any herbicide or other toxic chemicals shall be strictly in accordance with the manufacturer's instructions. The engineer shall be given at least 6 working day notice of the proposed use of any herbicides or toxic chemicals. A register of all herbicides and other toxic chemicals delivered to the site shall be kept and maintained up to date by the contractor. The register shall include the trade name, physical properties and characteristics, chemical ingredients, health and safety hazard information, safe handling and storage procedures, and emergency and first aid procedures for the product.

Risk of lead pollution	No men below the age of 18 years and no women shall be employed for the work of painting with products containing lead in any form. No paint containing lead or lead products will be used except in the form of paste or readymade paint. Face masks will be supplied for use by the workers when paint is applied in the form of spray or a surface having lead paint is dry rubbed and scrapped.
Risk caused by force majeure	All reasonable precautions will be taken to prevent danger of the workers and the public from fire, flood, drowning, etc. All necessary steps will be taken for prompt first aid treatment of all injuries likely to be sustained during the course of work.
Risk from explosives	Only if provided in the contract or ordered or authorized by the engineer, the contractor shall use explosives. The contractor shall at all times take every possible precaution and shall comply with appropriate laws and regulations relating to the importation, handling, transportation, storage and use of explosives and shall, at all times when engaged in blasting operations, post sufficient warning flagmen, to the full satisfaction of the engineer. The contractor shall at all times liaison with and inform well in advance and obtain such permission as is required from all government authorities, public bodies and private parties concerned or affected or likely to be concerned or affected by blasting operations.
Malaria risk	The contractor shall, at their own expense, conform to all anti-malarial instructions given to them by the engineer, including filling up any borrow pits which may have been dug.
Operation Phase	
Dwellers in settlements may rush to highway and have an accident	Specially designed urban sections and footpath sections shall be constructed at the necessary locations.
Vehicles parked in settlements may narrow the carriageway	Specially designed parking areas shall be made at the required locations.
Fast moving vehicles may threaten safety in settlements	Specially designed pedestrian crossings shall be constructed at required locations.
Accidents involving hazardous materials	The rules defined in Hazardous Waste Handling Act shall be followed. Vehicles delivering hazardous substances shall be marked with appropriate signs. In case of spillage, the report to relevant departments will be made and instructions will be followed in implementing the contingency measures.
Other safety measures	A traffic management plan shall be developed especially along congested locations. Traffic control measures including speed limits will be enforced strictly. Further growth of encroachment and squatting within ROW shall be discouraged. Fences are recommended between the road and quarry places.

Source: JICA Study Team

(13) Water Usage, Water Rights, and Communal Rights

The Khasi tribal community inhabits the major segment of NH40 from Shillong to Dawki falling within East Khasi Hills District, and in certain segments of NH40 falling within West Jaintia Hills District, particularly around the proposed bypass #6 and 7, the Pnars or Jaintia tribes predominately inhabit the area. Both the communities have maintained a close symbiotic relationship with the environment since time immemorial and their ethno-cultural traits have been greatly influenced by the natural surroundings. Like any other tribal group, the Khasis and Jaintias have a very close affinity to nature, and the forest is an important component of nature that is intricately linked to their daily lives.

Water sources are mostly located within forest and vegetation areas since trees and all varieties of forest act as catchment for recharging the aquifers and replenishing ground water level, which then provide water supply to natural springs and small rivulets. Traditional systems of conserving and sustaining all such sources have been practiced for generations by both the tribes, and this tradition continues even today.

6.7.5 Others

(1) Accidents

While implivement of curve can reduce traffic accident, increase of traffic volume and speed might increase risk of accidents.

<u>Mitigation</u>
Traffic sign shall be installed. Sidewalk and pedestrican crossing will be required. Delineator shall be utilized in fog area.

6.8 Impact Analysis

Comparison between scoping and survey result is as shown below.

Table 6-64: Scoping and Survey Result

Sl. No.	Item	Impact Assessments of Scoping			Impact Assessments of Study Result			Rationale of the Impact Assessment
		Pre-construction	Construction	Operation Stage	Pre-construction	Construction Stage	Operation Stage	
Natural Environment								
1.1	Climate/ Meteorological Phenomena	D	D	D	D	D	D	P: No impact is expected. C/O: A little influence occurs along the roadside
1.2	Topography	D	B-	D	D	B-	D	P: No impact is expected. C: Alteration of the topography (embankment / cut) on the roadside cannot be avoided. O: The modified terrain (including slope protection works) will stabilize over the long term.
1.3	Geology	D	D	D	D	D	D	P/C/O: No impact is expected.
1.4	Soil Erosion	D	B-	B- B	D	B-	B- B+	P: No impact is expected. C: Sediment collapse and soil erosion are likely to occur. O: The modified terrain (including slope protection works) will stabilize over the long term.
1.5	Hydrology	D	C	C	D	B-	B-	P: No impact is expected.。 C: The change of individual hydrological conditions is caused by routing of surface water by construction and embankment / cutting etc. O: Fine hydrological conditions limited to individual areas by the embankment/ cuts etc. are permanently altered.
1.6	Groundwater	D	D	D	D	D	D	P/C/O: No impact is expected.

Sl. No.	Item	Impact Assessments of Scoping			Impact Assessments of Study Result			Rationale of the Impact Assessment
		Pre-construction	Construction	Operation Stage	Pre-construction	Construction Stage	Operation Stage	
1.7	Ecosystem/Biodiversity Forest/Flora	D	A-	A-	D	A-	A-	P: No impact is expected. C: Logging is inevitable in broad forest areas by the road construction. The mountain ecosystem and biodiversity are affected during the construction period. cutting of forest areas as habitats of wild animals including birds is inevitable. O: Road construction facilitates access to forest areas. Therefore it makes it easier to hunt regardless of legal or illegal. Traffic volume increases and negative impact of ecosystem cannot be avoided. The increase in traffic increases the exhaust gas to existing forest areas. Plant trees in forested forests then restore forests.
1.8	Wildlife Reserve	D	D	D	D	D	B-	P: No impact is expected. C: There is no animal reserve. O: The increase in traffic increases the exhaust gas to existing forest areas. Easier access to road construction makes legitimate and illegal hunting easier.
1.9	Coastal Zone	D	D	D	D	D	D	P/C/O: There are no affected coastal areas.
1.10	Landscape	D	C	C	D	B-	B+	P: No impact is expected. C: Damage to the landscape by the road construction work is inevitable. O: Landscape gets better after construction. Dawki bridge will be new spot for scenery.
1.11	Natural Disasters	D	B-	B	D	B-	B+	P: No impact is expected. C: Natural disasters such as slope collapse may be punished depending on work during the construction period and strong rain. O: Stabilize the entire slope at completion by installing a slope protector.
Living Environment/ Pollution								
2.1	Air Pollution	D	B-	B-	D	B-	B-	P: No impact is expected. C: Air pollution and dust diffusion by construction heavy equipment are inevitable. O: Exhaust gas increases as traffic volume increases.
2.2	Offensive Odor	D	D	D	D	D	D	P/C/O: No impact is expected.
2.3	Water Pollution	D	B-	B-	D	B-	B-	P: No impact is expected. C: In the vicinity of a river there is a possibility that water quality of a river will be contaminated by the excavation work etc. By the construction workers' camps, there is a possibility that emissions will flow into rivers. Groundwater contamination other than excavation work does not occur.

Sl. No.	Item	Impact Assessments of Scoping			Impact Assessments of Study Result			Rationale of the Impact Assessment
		Pre-construction	Construction	Operation Stage	Pre-construction	Construction Stage	Operation Stage	
								O: The current flow path by the construction of the drainage channel is changed.
2.4	Bottom Sediment Contamination	D	D	D	D	B-	D	P: No impact is expected.
								C: Drainage by the construction machine washing etc. may also Bottom sediment contamination.
								O: This project does not emit sediment contaminants.
2.5	Soil Contamination	D	C	D	D	B-	D	P: No impact is expected.
								C: Drainage by the construction machine washing etc. may also Soil contamination.
								O: No impact is expected.
2.6	Ground Subsidence	D	D	D	D	D	D	P/C/O: No impact is expected.
2.7	Noise/Vibration	D	A-	B-	D	A-	B-	P: No impact is expected.
								C: Noise and vibration are generated by heavy equipment for construction during operation. Night work is not carried out near religious facilities, schools and hospitals, etc. It is mandatory to install mufflers in heavy machinery.
								O: Noise and vibration may increase as traffic volume increases.
2.8	Sunshine Obstruction	D	D	D	D	D	D	P/C/O: No impact is expected.
2.9	Waters/Hazardous Materials	D	B-	B-	D	B-	B-	P: No impact is expected.
								C: Construction waste is generated during construction. However, they are processed by the end of the construction.
								O: Waste is generated during maintenance work of the road, but it does not have important influence on the natural environment or social environment.
Social Environment								
3.1	Involuntary Resettlement	A-	D	D	A-	A-	D	P: Though bypasses are planned to avoid densely-populated areas, the alignment still affect house structures of approximately 300 HHs, of which 70% need to be resettled.
								C: While resettlement will be completed before construction begins, temporary resettlement will be required for construction yard and worker's accommodation.
								O: Resettlement will be completed before construction begins
3.2	Land Use	A-	A-	A-	A-	A-	A-	P: Land acquisition and involuntary resettlement are likely to cause changes in the existing land use patterns.
								C: The bypass construction section affects existing cultivated land or agriculture and forestry. Changes in land use necessary for securing construction yards are short-term.
								O: This project requires permanent modification of land use.
3.3	Utilization of	D	A-	D	D	A-	D	P: No impact is expected.

Sl. No.	Item	Impact Assessments of Scoping			Impact Assessments of Study Result			Rationale of the Impact Assessment
		Pre-construction	Construction	Operation Stage	Pre-construction	Construction Stage	Operation Stage	
	Local Resources							C: Procurement of large quantities of materials locally could affect demand. O: No impact by the project.
3.4	General, Regional / City Plans	D	D	B +	D	D	B +	P/C : No impact is expected. O: Improvement of the road transport network may bring about the influx of residents from the outside and economic development.
3.5	Social Institutions and Local Decision-making Institutions	B-	B-	B-	D	D	D	P/C/O: Resident relocation may affect existing social organizations and regional decision making organizations.
3.6	Social Infrastructure and Services	B-	B-	B +	B-	B-	B +	P: Access to social infrastructure may be hindered due to resettlement and land acquisition. C: For improvement work, traffic congestion may occur and access to social infrastructure may be hindered. O: Improvement of road transport network contributes to improvement of convenience.
3.7	Local Economy and Livelihood	A-	A-	B	A-	A- /B +	B +	P: Loss of income source and livelihood due to involuntary resettlement and change in land usage are expected to negatively affect the local economy and livelihood. C: Construction work affects the lives and occupations of local residents. On the other hand, the construction work generates local employment and has a positive effect on the economy. O: Improvement of road transport network brings positive effect on regional economy by improving convenience. However, in the settlement of the bypass section, problems arise in access.
3.8	Unequal Distribution of Benefit and Damage	A-	A-	B-	A-	A- /B +	B- /B +	P: Land acquisition and involuntary resettlement will lead to unequal distribution of benefits and damage between those who are directly affected by the project and those who are not. C: Residents to be relocated are greatly affected. Meanwhile, neighboring residents may benefit from creation of employment opportunities by the construction work, and deviation occurs. O: There is a possibility that the uneven distribution of benefits will expand between settlements on the roadside after the widening and villages detoured by the bypass. It is expected that uneven distribution of damage and benefits will be resolved by long-term benefits of the whole area by improving the road network.
3.9	Local Conflicts of Interests	C	C	C	C	D	D	P: Conflict of interests may arise by the compensation problems, and conflicts may occur.

Sl. No.	Item	Impact Assessments of Scoping			Impact Assessments of Study Result			Rationale of the Impact Assessment
		Pre-construction	Construction	Operation Stage	Pre-construction	Construction Stage	Operation Stage	
								C/O: Conflict of interests may arise by the compensation problems, and conflicts may occur though relatively minor.
3.10	Water Usage, Water Rights and Communal Rights	D	D	D	D	D	D	P/C: It does not change the mechanism of water use, the impact of the project is small.
								O: No impact by the project.
3.11	Cultural and Historical Heritage	D	D	D	D	D	D	P/C/O: This road does not pass through a place with cultural and historical heritage.
3.12	Religious Facilities	B-	A-	D	A-	A-	D	P: A number of churches, several memorial stones and graves are located along the road. Several memorial stones are directly affected. Graves can be affected in private yards. The targeted roads do not traverse sacred groves of traditional religious beliefs.
								C: Neighboring religious facilities and cemetery may be affected by noise and vibration caused by construction.
								O: Consideration should be taken not to have any influence by the appropriate noise countermeasures.
3.13	Sensitive Facilities (ex. hospital, school, precision machine factory)	D	A-	D	A-	A-	D	P: Relocation of one Public Health Center will be required. School site will be partly affected.
								C: Schools and clinics along the road are affected by noise, vibration, and traffic congestion during construction.
								O : Consideration shall be made for preventing noise promelems.
3.14	Poor People	A-	A-	B +	A-	A- /B +	B- /B +	P: Given the limited coping capacity of the poor, it is necessary to assess their vulnerability and develop appropriate mitigation measures.
								C: Poor people may be more affected by negative influences. On the other hand, you can benefit from employment opportunities that occur in your business.
								P: In the long term, the economic development of the area that the project produces is thought to have a positive effect on the poor peoples.
3.15	Ethnic Minorities/ Indigenous People	A-	A-	D	A-	A-	D	P/C: Various specific schedules (Scheduled Tribes) live in the Meghalaya state of the target area. IPP shall be prepared with consideration of their unique culture and customs to implement resident relocation and to formulate a recovery plan for livelihood.
								O: Resident relocation will be completed before construction starts. Minimize the impact by considering relocation destinations and developing a recovery plan for livelihoods.
3.16	Gender	C	C	C	D	B +/ B-	D	P: There is a possibility that resettlement and land acquisition may influence the role sharing such as cultivation, harvesting and processing. But the impact is limited.

Sl. No.	Item	Impact Assessments of Scoping			Impact Assessments of Study Result			Rationale of the Impact Assessment
		Pre-construction	Construction	Operation Stage	Pre-construction	Construction Stage	Operation Stage	
								C: In consideration of regional cultural and social norms, employment opportunities are considered equally so that gender-derived conflicts do not arise. This project may influence role sharing such as cultivation, harvesting and processing.
								O: There is a possibility that this project may influence the role sharing such as cultivation, harvesting and processing. But the impact is limited.
3.17	Children's Rights	C	D	C	D	D	D	P: Child labor is prohibited by the Indian Constitution. Resettlement of residents and acquisition of land may affect the role of children helping at shops along roadside though impacts are minor.
								C : Child labor is prohibited by the Indian Constitution. In this project, we employ only adults and do construction work.
								O: Child labor is prohibited by the Indian Constitution. Resettlement of residents and acquisition of land may affect the role of children helping at shops along roadside though impacts are minor.
3.18	Public Health (sanitation and infectious diseases)	D	B-	B-	D	B-	B-	P: No impact is expected.
								C:The inflow of construction workers from the outside is expected to increase the risk of health, especially sexually transmitted diseases. Meanwhile, countermeasures against malaria are also necessary when constructing in areas where malaria is occurring.
								O:An increase in traffic volume has a negative impact on the health of roadside people.
3.19	Occupational Health and Safety (OHS)	D	B-	B-	D	B-	B-	P: No impact is expected.
								C:Hygiene at work site and health and safety of workers need to be properly managed through implementation of environmental management plan.
								O:Consider thoroughly the hygiene and safety of workers in charge of maintenance and repair work.
その他								
4.1	Accidents	D	B-	B +/ B-	D	B-	B +/ B-	P: No impact is expected.
								C:The risk of traffic accidents caused by heavy machinery and construction vehicles increases. Pay particular attention to the construction site especially in areas where thick fog occurs.
								O:The accident risk increases due to an increase in traffic volume and an increase in traffic speed. Particular care needs to be taken in the dense fog area, such as speed limit and thorough use of headlights / hazard lamps. On the other hand, the risk is reduced by measures such as installation of traffic safety signs and curved mirrors.

Sl. No.	Item	Impact Assessments of Scoping			Impact Assessments of Study Result			Rationale of the Impact Assessment
		Pre-construction	Construction	Operation Stage	Pre-construction	Construction Stage	Operation Stage	
4.2	Climate Change	B-	B-	B +/ B-	B-	B-	B +/ B-	P: CO2 emission and absorption/fixation will be lost due to deforestation.
								C: Greenhouse gas emissions are generated by construction and heavy equipment emissions such as production and laying of road materials.
								O: As the number of vehicles using roads increases, the emissions of greenhouse gases gradually increase.

Note:
C: Construction
O: Operation
A: Severe/irrevocable impact is expected (+: Positive impact, -: Negative impact)
B: Significant impact is expected (+: Positive impact, -: Negative impact)
C: Further study is required as impact is unknown
D: Impact with little significance occurs
Source: JICA Study Team

6.9 Environmental Management and Monitoring Plan

6.9.1 Environmental Management Plan

(1) Afforestation Program

Afforestion program for the loss of the existing forest of 123 ha, approximately 147,600 trees should be carried out. Meghalaya State Department of Environment and Forest will identify the area of afforestation and tree species at the time of the examination for forest clearance.

Further, because of the road construction project emit greenhouse gas, afforestation program in order to sequester the amount of greenhouse gas. This is also a policy of the Government of India in respect of “Paris Agreement” of COP 21 in terms of climate change measures. Thus approximately 131 ha including the greenhouse gas sequestration for the increase of vehicles, afforestation program has to be carried out.

In total 254 ha of afforestation program is planned to carry out. These afforestation programs also functions as habitat loss of the wildlife including bird species such as

(2) Prevention of Dust Emanation and Mud Spillage

Because of the dust emanatioin during the dry season and mud spillage during the rainy season, the Contractor has to sprinkle water in the construction area during the dry season. Barriers and sand bags should be provided during rainy season in order to prevent mud from spilling over to the road and side walks.

(3) Prevention of Traffic Jam

In the construction area within Shilling, the Contractor should provide a number of traffic guides, traffic barriers, signboards, color cones and movable signais in order to maintain smooth flow of live traffic during the construction period.

In Dowki, the Contractor shouldalso provide a number of traffic guides, traffic barriers, signboards, color cones and movable signais in order to maintain smooth flow of live traffic during the construction period.

(4) Noise Levels

The Contractor shold provide various measures in order to lower the noise level during the construction period as follows:

- The plants and equipment used for construction will strictly conform to Central Pollution Control Board (CPCB) noise standards. Vehicles, equipment and construction machinery shall be monitored regularly with particular attention to silencers and mufflers to maintain noise levels to a minimum.
- Workers in the vicinity of high noise levels must wear earplugs, helmets and should be engaged in diversified activities to prevent prolonged exposure to noise levels of more than 90dB(A).
- In construction sites within 150 m of human settlements, noisy construction will be stopped between 10 PM and 6 AM except for when laying the cement concrete pavement, for which a lower working temperature is a requirement.
- Noise barrier should be provided based on the measured values of noise level. Schools and hospitals should be protected from the noise with a provision of noise barriers.
- Near the sensitive receptors such as hospitals and schools, noise barriers such as earth, concrete, wood, metal or double-glazing of windows for façade insulation shall be used.
- Careful planning of machinery operation and scheduling of operations can reduce noise levels. Use of equipment emitting noise not greater than 90 dB(A) for the eight-hour operations shift and locating construction yards at a distance of at least 500 m from any residential areas should be adhered to.
- Use of noise shields on construction machinery and the provision of earplugs to the heavy machine operators are some of the mitigation measures, which should be followed by the contractors during the civil works.

Typical noise level emanated by the construction plant is shown in Table 6-65.

Table 6-65: Typical Noise Level Emanated by Construction Plants

Construction Equipment	Noise Level dB(A)
Bulldozer	80
Front end loader	72-84
Jack hammer	81-98
Crane with ball	75-87
Crane	75-77
Bulldozer	80
Backhoe	72-93
Front end loader	72-84
Cement & Dump trucks	83-94
Jack hammer	81-98
Scraper	80-93
Welding generator	71-82
Grader	80-93
Roller	73-75
Concrete mixer	74-88
Concrete pump	81-84
Concrete vibrator	76
Paver	86-88
Truck	83-94
Tamper	74-77
Air compressor	74-87
Pneumatic tools	81-98

Source: U.S. Environmental Protection Agency, Noise from Construction Equipment and Operations: Building, Equipment and Home Appliance. NJID. 300.1. December 31, 1971

(5) Solid Waste

Various types of waste could be produced during the construction period ranging from oil, spare parts of the construction plants including electrical parts, waste from workforce camp, removal of old structures, etc. Thus, the Contractor should provide a number of boxes/cases in order to separate waste for disposal and reuse. These waste are transported periodically to the locations designated by Meghalaya State Pollution Control Board.

6.9.2 Environmental Monitoring Plan

(1) Afforestation

NHIDCL is required to carry out monitoring program in respect to the afforestation program for the Project as follows:

a. Permanent loss of the forest areas including trees and plants within ROW;
b. Changes of sun shine and its effect to the forest areas remaining outside ROW;
c. Strict prohibition of damaging plant species outside ROW;
d. CO_2 Emission of the Construction plants and vehicles used during the construction period;
e. Dust and muds accumulated on the plants during the construction period; and
f. Achievement of the afforestation area, number of planted trees and species as well as their rate of survival of planted trees.

The afforestation program compensates permanent losses of forest species.

Wildlife including bird species should be monitored during the construction period as well as the operation and maintenance period. These monitoring result should be used in order to elaborate further environmental management plan.

(2) Illegal Logging and Poaching

Because of the access to forest area becomes easy as a result of road construction project, NHIDCL is required to monitor illegal logging and poaching periodically during the operation and maintenance period.

The project area goes through the habitat of bird species in the southern half of Meghalaya State. Its first 6-7 km borders the "Upper Shillong Important Bird Area". A number of bird species inhabit in the area including "Tawny-breasted Wren-babbler (Spelaeornis longicaudatus)".

Thus, the Contractors are requested to monitor the bird species during the construction period and the result has to be reported to the Meghalaya State Department of Environment and Forest. NHIDCL should carry out the same during the opratioin and maintenance period. Montoring result should be reported periodicaly to the Meghalaya State Department of Environment and Forest.

(3) Monitoing on the Ecological and Biodiversity

Above monitoring program will cover the monitoring program for the ecological and biodiversity.

(4) Air Quality and CO_2 Monitoring Works

Ambient air quality parameters recommended for monitoring road transportation developments are PM10, PM 2.5, Carbon Monoxide (CO), Oxides of Nitrogen (NOX), Sulphur Dioxide (SO2) and Lead (Pb) should be monitored based on the monitoring post in Shillong and Dowki established by the Meghalaya State Pollution Control Board and NHIDCL shold prvide monitoring cost.

In the event that measured values of these locations showing excessively high values, further monitong should be carried out in the mid point of the project area and/or strategic monitoing plan should be elaborated for further environmental management plan.

(5) Noise and Vibration Level

The Contractor is requested to carry out noise monitoring works during the construction period.

Based on the baseline data obtained during the study period, further noise level monitoring works should be carried out by NHIDCL during the operation and maintenance period. Monitoing timing should be on the clear day of May to July period in order to match the measured timing of the baseline data.

CPCB put out noise standard in the Year 2000 as per Table 6-66, exceeding the standard could mean vibration is also causing some sort of problems to the near-by structures. Thus, the measured values should be used as indicator of which traffic vibration is occurring.

In the event noise level is exceeding, interview survey should be carried out if any trobles are occurring on the structures caused by traffic vibration. Further monitoing strategy should be elaborated if near-by structures are receiving excessive traffic vibration.

Table 6-66: Standard of Noise Level

Area	Limits in dB(A) Leq*	
	Day Time	Night Time
Industrial Area	75	70
Commercial Area	65	55
Residential Area	55	45
Silence Zone	50	40

Note:
1. Day time shall mean from 6.00 a.m. to 10.00 p.m.
2. Night time shall mean from 10.00 p.m. to 6.00 a.m.
3. Silence zone is an area comprising not less than 100 m around hospitals, educational institutions, courts, religious places or any other area which is declared as such by the competent authority.
4. Mixed categories of areas may be declared as one of the four above-mentioned categories by the competent authority.

* dB(A) Leq denotes the time weighted average of the level of sound in decibels on scale A which is rela 表 to human hearing.

A "decibel" is a unit in which noise is measured.

"A", in dB(A) Leq, denotes the frequency weighting in the measurement of noise and corresponds to frequency response characteristics of the human ear.

Leq: It is an energy mean of the noise level over a specified period.

Source: Central Pollution Control Board, India

(6) Changes of Topography and Geographic Conditions

Cus and fill slopes are created during the construction period. Thus, monitoring works should be carried out in order to avoid unwanted changes of topography such as slope gradient and natural drainage system. The Contractor is to provide necessary protection works during the implementation of cut and fill slope works.

Because of the vegetation along the project area including plants used for slope protection will generally be rejuvenetaed over 7 years. Thus NHIDCL has to carry out periodical monitoring of slope stabilization over 7 years.

Quarry areas developed for obtaining construction materials should be monitored periodically in order to maintain slope gradient of cut slopes. Upon completion of the construction works, deposited topsoil should be back-filled in order to reinstate the environmental conditions. All these activities are subject to monitoring.

(7) Soil Erosion

As above, monitoring on the soil erosion is a part of the monitoing works for topographic and geographical changes.

(8) Hydrogeography

During the construction period, natural drainage system such as rivers and streams as well as agricultural waterways are subject to monitoring during heavy rains as well as after the rainfall period in order to avoid blockage of water flow caused by the construction debris. Periodical monitoinrg on the natural drainage should also be carried out.

(9) Monitoring on Natural Disaster

Natural disaster is associated with heavy rainfall in general. As explained above, monitoring works on the topographic and geographic changes, soil erosion and hydrogeography shoud all cover the monitoring of natural disaster which has to be carried out by NHIDCL. The way the Contractor is providing appropriate measures to prevent natural disaster during the construction period are also subject to monitoring by NHIDCL.

(10) Landscape

There is no significant impact on the changes of landscape. However, landscape viewpoints established along the road could be temporarily closed or changed its configuration, parking area, safety barriers, etc. These activeties should be closely monitored.

(11) Waste Management

Construction debris and other waste produced durin the construction period are subject to separateon for disposal and reuse. These are subject to transportation by the Contractor to the locateoins designated by SPCB. This activety is subject to monitoring in terms of compliance of the waste management rule of India.

(12) Climate Change Measures

Construction works related to the climate change measures such as cut and fill slope protection, bridges and culverts crossing over natural drainage system as well as agriculturel waterways and other measures designed to cope with the excessive rainfall shoul all be subject to monitoring if these are carried out as designed.

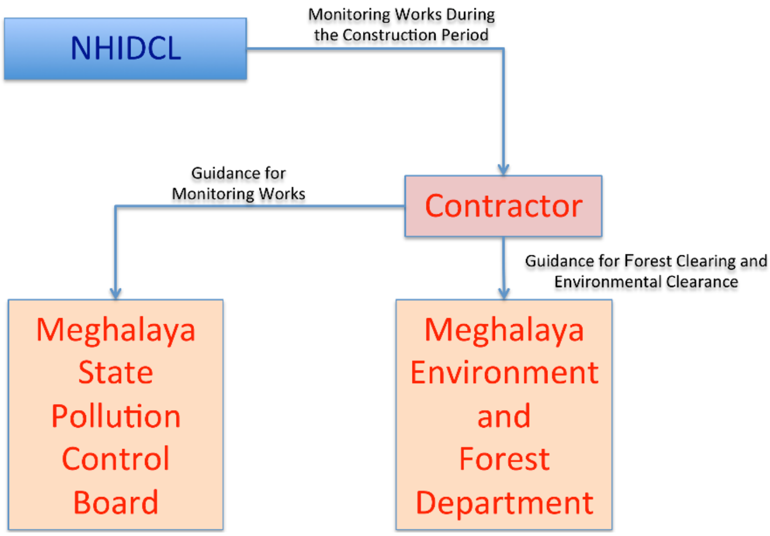
6.9.3 Organization of Environmental Management and Monitaring Plan

As is shown in Figure 6-38 and Figure 6-39, NHIDCL is the project implementation unit during the construction period as well as the operation and maintenance period. It is thus responsible for implementation of Environmental Management and Monitoring Plan. However, cost of monitoring works during the construction period is a part of construction contract.

During the operation and maintenance period, air quality monitoring works in Shillong and Dowki should be cost-wise responsibility of NHIDCL while actual measuring works could be entrusted to SPCB. Other 7 points of air quality monitoring locations should be subject to further monitoring works in the event excessive monitoring values at Shillong and Dowki are observed.

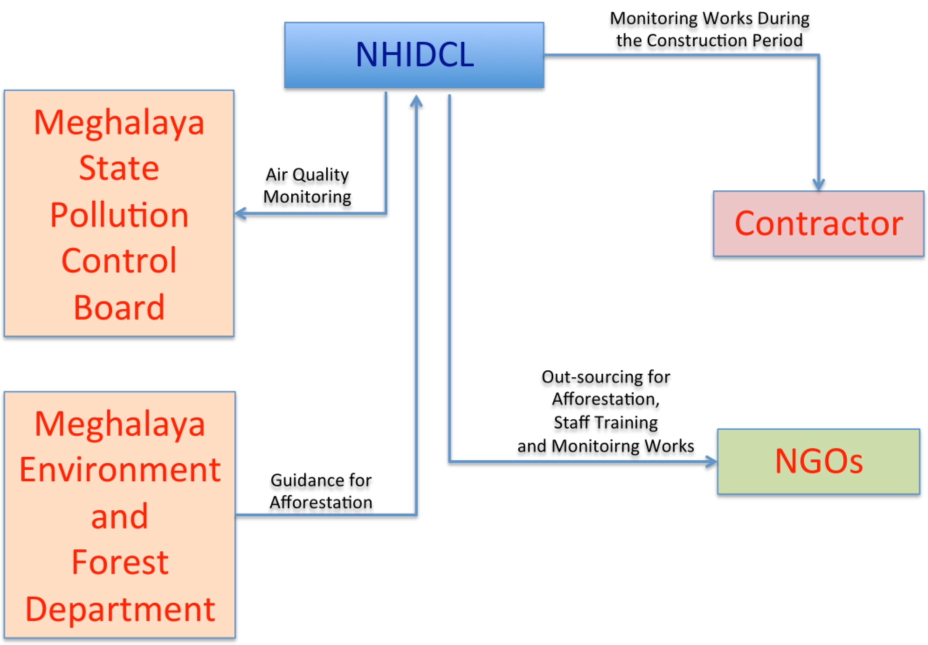
Afforestation program should begin as soon as the construction work is over. Area of afforestation, species of trees, rate of survival, achievement of afforestation, etc. should all be monitored. NGO could be employed for staff training on the monitoring of wildlife including bird species as well as to plant trees for 253 ha of afforestation area.

Meghalaya State Department of Environment and Forestry could play an important role for guidance in respect of afforestation program. NHIDCL should therefore follow the guidance of Meghalaya State Department of Environment and Forestry.



Source: JICA Study Team

Figure 6-38: Organization of Environmental Management and Monitoring Plan During the Construction Period



Source: JICA Study Team

Figure 6-39: Organization of Environmental Management and Monitoring Plan During the Operation and Maintenance Period

6.9.4 Outline of the Environmental Management and Monitoing Plan

Based on the above EMP, a matrix of the EMP for the construction period is shown in Table 6-67 shows the outline of the Environmental Management Plan and Table 6-69 shows the out line of the Environmental Monitoring Plan.

Table 6-67: Environmental Management Plan during the Construction Stage

Sl. No	Environmental Impacts/Issues	Mitigation Measures	Location	Time Frame	Responsibility	
					Implementation	Supervision
Soil						
C1	Soil Erosion in borrow pits	• The depth of borrow pits shall be restricted so that the sides of the excavation shall have a slope not steeper than 1:4, from the edge of the final section of the bank.	On approved locations of borrow pits	Construction Stage	Contractor and Supervision Consultant	PIU
C2	Loss of top soil in borrow pits	• Agricultural fields or productive land shall be avoided for borrowing earth. If unavoidable, topsoil shall be preserved and used for tree plantation.	On approved locations of borrow pits	Construction Stage	Contractor and Supervision Consultant	PIU
C3	Compaction of soil	• Construction equipment and vehicles shall be restricted to move only within a designated area to avoid compaction of productive soil.	Throughout the corridor	Construction Stage	Contractor and Supervision Consultant	PIU
C4	Soil erosion in embankments	• Pitching shall be done for slope stabilization as per the IRC guidelines.	At embankments	Construction Stage	Contractor and Supervision Consultant	PIU
C5	Contamination of soil from fuel and lubricants	• Construction vehicles and equipment shall be operated and maintained in such a manner so that soil contamination from spillage shall be at a minimum. • Fuel storage shall only be done on wasteland and will be kept away from drainage channels and natural water bodies.	Near the workers' camp and sites for the installation of construction machineries	Construction Stage	Contractor and Supervision Consultant	PIU
C6	Contamination of land from construction waste and quarry materials	• Debris generated due to the dismantling of the existing pavement structure and the cutting of the hill side for the widening shall be suitably reused in the proposed construction, such as for fill materials for embankments.	Solid waste dump site identified and approved by SPCB or competent authority. Throughout the area.	Construction Stage	Contractor and Supervision Consultant	PIU

Sl. No	Environmental Impacts/Issues	Mitigation Measures	Location	Time Frame	Responsibility	
					Implementation	Supervision
C7	Loss of top soil in land acquisition	• Topsoil shall be stripped, stored and shall be laid on ground for landscaping purposes.	Throughout the area	Construction Stage	Contractor and Supervision Consultant	PIU
Water						
C8	Contamination of water by fuel / oil spillage from vehicles	• Construction vehicles / equipment shall be operated and maintained in such a manner so as to avoid contamination of water bodies due to oil spillage. • Fuel storage shall only be done on wasteland and will be kept away from drainage channels and natural water bodies.	Near the workers' camp and sites for the installation of construction machineries	Construction Stage	Contractor and Supervision Consultant	PIU
C9	Contamination of stagnant water body by fecal matters from workers' camp	• Camp shall not be allowed near any of the water bodies. • Proper sanitation facilities shall be provided.	Preapproved locations away from water bodies.	Construction Stage	Contractor and Supervision Consultant	PIU
C10	Deposition of dust in open wells near construction site	• The mouth / opening of the well shall be covered with suitable material during any of the construction activities so as to prevent dust from entering the well.	All the wells along the project corridor	Construction Stage	Contractor and Supervision Consultant	PIU
C11	Using drinking water for construction purpose	• The contractor shall make arrangements for water required for construction in such a way that water availability and supply to nearby community is unaffected. • Wastage of water shall be kept to a minimum during construction.	At respective planned construction sites	Construction Stage	Contractor and Supervision Consultant	PIU
C12	Hand pump close to road may get affected in widening	• All the hand pumps shall be relocated to a suitable alternate place.	At the respective locations	Construction Stage	Contractor and Supervision Consultant	PIU
C13	Wells or water storage system may get affected in widening	• Alternate arrangements will be made for all wells or water storage systems	At the respective locations	Construction Stage	Contractor and Supervision Consultant	PIU
C14	Altering flow of natural drains	• Drain shall be channelized with slope protection – Gabion Structure.	At the respective locations	Construction Stage	Contractor and Supervision Consultant	PIU

Sl. No	Environmental Impacts/Issues	Mitigation Measures	Location	Time Frame	Responsibility	
					Implementation	Supervision
C15	Sanitation of waste disposal in construction camps	• The construction of camps will be done with sufficient buffer from any habitations. • At construction sites and camps, a sufficient number of latrines will be provided. • The sewage generated from the camps will be properly disposed of so that it does not affect water bodies.	Wherever workers' camp is located	Construction Stage	Contractor and Supervision Consultant	PIU
Air						
C16	Emission from construction vehicles and machinery	• All vehicles, equipment and machinery shall be selected to meet recognized international and national standards for emissions and shall be maintained and operated in a manner that ensures relevant air, noise and discharge rules are followed. • Only unleaded petrol and low sulphur diesel or sulphur free diesel shall be used as fuel for vehicles, equipment and machinery.	Wherever the hot mix plant and batching plant is setup	Construction Stage	Contractor and Supervision Consultant	PIU
C17	Air pollution from various plants affecting settlements	• The asphalt plants, crushers and batching plants shall not be sited less than 500 m in leeward direction from the nearest human settlement.	Locations near settlements	Construction Stage	Contractor and Supervision Consultant	PIU
C18	Air pollution may exceed the limits prescribed by the Central Pollution Control Board	• Regular monitoring or air quality parameters during the construction period as envisaged in the EMP.	Locations given in EMP	Construction Stage	Contractor and Supervision Consultant	PIU

Sl. No	Environmental Impacts/Issues	Mitigation Measures	Location	Time Frame	Responsibility	
					Implementation	Supervision
C19	Vehicles will generate dust and suspended particles	• The dust generated by vehicles on site shall be arrested using a water tanker fitted with a sprinkler capable of applying water uniformly at a controllable rate of flow to variable widths of surface but without any flooding.	Wherever the plants are set up and sensitive locations as suggested in monitoring plan	Construction Stage	Contractor and Supervision Consultant	PIU
Noise						
C20	Noise levels from vehicles, asphalt plants and equipment	• Vehicles and equipment used shall be fitted with silencer. • Any vehicle and machinery shall be kept in good working order and engines turned off when not in use. • Regular monitoring of noise Parameters (Leq) during the construction period as envisaged in the EMP. • Construction of noise barriers in the form of walls at sensitive locations upon consultation with stakeholders.	Wherever the plants are setup	Construction Stage	Contractor and Supervision Consultant	PIU
Flora and Fauna						
C21	Tree cutting for widening	• Three trees shall replace each tree cut for the project. • The engineer shall approve such felling only when the NHIDCL receives a "clearance" from the Forest Department applicable. • Trees felled shall be replaced as per the compensatory afforestation criteria in accordance with the Forests (Conservation) Act, 1980.	Throughout the project area	Construction Stage	Contractor, Supervision Consultant, and Forest Department	PIU

Sl. No	Environmental Impacts/Issues	Mitigation Measures	Location	Time Frame	Responsibility	
					Implementation	Supervision
C24	Damage or loss of important flora	• During construction, at any point in time, if rare / threatened / endangered flora species is found, it shall be conserved in a suitable manner in consultation with authorities.	Throughout the project area	Construction Stage	Contractor and Supervision Consultant	PIU
Health and Hygiene						
C25	Health hazard to workers due to bad water and sanitation	• At every workplace, good and sufficient potable water (as per IS 10500) supply shall be ensured to avoid water-borne diseases and to ensure the health of workers. • Adequate drainage, sanitation, and waste disposal shall be provided at workplaces. • Preventive medical care shall be provided to workers.	Wherever workers' camp is setup	Construction Stage	Contractor and Supervision Consultant	PIU
C26	Health hazard to workers by various construction activities	• Personal protective equipment shall be provided to workers as per the Factories Act.	Throughout the project area	Construction Stage	Contractor and Supervision Consultant	PIU
C27	Health / social hazard, sexual harassment to female workers	• Segregation of male and female areas in workers' camp.	Wherever workers' camp is setup	Construction Stage	Contractor and Supervision Consultant	PIU
C28	Hygiene at construction camps	• On completion of the works, the whole of such temporary structures shall be cleared away, all rubbish burnt, excreta or other disposal pits or trenches filled in and effectively sealed off and the whole of the site left clean and tidy, at the contractor's expense, to the satisfaction of the engineer.				

Sl. No	Environmental Impacts/Issues	Mitigation Measures	Location	Time Frame	Responsibility	
					Implementation	Supervision
C29	Abandoned quarry will accumulate water and act as a breeding ground for disease vectors	• Reclamation measures shall be adopted with garlands of trees around the periphery. The quarry dust and waste shall be used for refilling. The remaining portion should be covered with trees.	All quarry locations	Construction Stage	Contractor and Supervision Consultant	PIU
Safety						
C30	Safety of vehicles plying on road while the construction activity is going on	• Prior arrangement / traffic diversion for safe passage of vehicles shall be made with proper direction and signage at the construction site. • Detailed Traffic Control Plans shall be prepared and submitted to the site engineer / project director for approval 5 days prior to commencement of works on any section of the road. • The traffic control plans shall contain details of temporary diversions, details of arrangements for construction under traffic and details of traffic arrangement after cessation of work each day.	Throughout the project area	Construction stage	Contractor and Supervision Consultant	PIU

Sl. No	Environmental Impacts/Issues	Mitigation Measures	Location	Time Frame	Responsibility	
					Implementation	Supervision
C31	Risk from operations	• The contractor is required to comply with all the precautions as required for the safety of the workmen as far as those are applicable to this contract. • The contractor shall supply all necessary safety appliances such as safety goggles, helmets, masks, etc., to the workers and staff. The contractor must comply with all regulations regarding safe scaffolding, ladders, working platforms, gangway, stairwells, excavations, trenches and safe means of entry and egress.	All construction sites	Construction stage	Contractor and Supervision Consultant	PIU
C33	First Aid	• At every workplace, a readily available first aid unit including an adequate supply of sterilized addressing material and appliances will be provided.	At the construction site / workers' camp	Construction stage	Contractor	PIU
Disruption to Road Users						

Sl. No	Environmental Impacts/Issues	Mitigation Measures	Location	Time Frame	Responsibility	
					Implementation	Supervision
C34	Loss of access	• At all times, the contractor shall provide safe and convenient passage for vehicles, pedestrians and livestock to and from side roads and property accesses connecting the project road. Work that affects the use of side roads and existing accesses shall not be undertaken without providing adequate provisions to the prior satisfaction of the engineer. • The works shall not interfere unnecessarily or improperly with the convenience of the public or the access to, use and occupation of public or private roads, and any other access footpaths to or of properties whether public or private.	Throughout the project area, particularly in built-up areas	During Construction	Contractor	PIU

Source: JICA Study Team

Table 6-68: Environmental Management Plan During the Operation and Maintenace Period

Sl.No	Item	Mitigation Measures	Monitoirng Area	Organization Related to Environmenta Management Plan		
				Implementation Organization	Responsible Organization for Implementation and Cost Bearing	Cost of Afforestation （INR）
Compensatory Afforestation						
O-01	Compensatory Afforestation	Forest areas of 123ha lost to ROW of the Project as well as 130 ha of afforestation for greenhouse gas sequestration is carried out.	Area based on the Monitoring Plan and the guidance of Meghalaya State Department of Forestry.	NHIDCL Meghalaya State Department of Forestry. NGO Groups	NHIDCL	60,720,000
		Tree specie and the area of afforestation carried out in area of shifting agriculture is based on the guidance of Meghalaya State Department of Forestry.	ditto	ditto	ditto	-

Source: JICA Study Team
Note : O-01Denotes " No. 1 of the Operation and Maintenance Period"
Note 1 : Field works are assisted by Meghalaya State Department of Environment and Forest while cost implecation is the responsibility of NHIDCL.

Table 6-69: Environmental Monitoring Plan During the Construction Period

No.	Item (Unit)	Measured Value during the Study Period (Max.)	Standard of India	Cost (INR)	Monitoirng Location	Rewquency and Timing	Method of Monitoring
C-01: Air Quality							
	SO_2	7.8 µg/m3	National Ambient Air Quality Standard: NAAQS	1,215,000	Shillong and Dowki by SPCB and other 7 points are subject to further elaboration based on the measured values of Shillong and Dowki	Early Monsoon Period（May － July	Based on National Ambient Air Quality Standard: NAAQS
	NO_2	14.4 µg/m3	ditto	Including as above	ditto	ditto	ditto
	CO	1,141 µg/m3	ditto	ditto	ditto	ditto	ditto
	O_2	-	ditto	ditto	ditto	ditto	ditto
	PM10	90.8	ditto	ditto	ditto	ditto	ditto
	PM2.5	44.5	ditto	ditto	ditto	ditto	ditto
C-02: Water Quality							
	pH	7.15	Indian Standard Drinking Water	270,000	Based on the baseline data	Early Monsoon	Indian Standard Drinking Water

No.	Item (Unit)	Measured Value during the Study Period (Max.)	Standard of India	Cost (INR)	Monitoirng Location	Rewquency and Timing	Method of Monitoring
			Specification – IS 10500: 1991		location	Period（May - July	Specification – IS 10500: 1991
	SS	7.5	ditto	Including as above	ditto	ditto	ditto
	BOD／COD	7.0	ditto	ditto	ditto	ditto	ditto
	DO	6.6	ditto	ditto	ditto	ditto	ditto
	Total Nitrogen	0.89	ditto	ditto	ditto	ditto	ditto
	Total Phosphorous	<0.01	ditto	ditto	ditto	ditto	ditto
	Heavy Metals	<0.01	ditto	ditto	ditto	ditto	ditto
	Hydrocarbon/ Oil	<0.01	ditto	ditto	ditto	ditto	ditto
	Phenol	<0.01	ditto	ditto	ditto	ditto	ditto
	Syanide	BDL	ditto	ditto	ditto	ditto	ditto
	Temperatures	^{O}C	ditto	ditto	ditto	ditto	ditto
C-03: Solid Waste							
	Reuse	–	Municipal Solid Waste Disposal Rule (Amended in 2016)	-	Entire Construction Area	Twice a week	Observation
	Dispose	–	ditto	ditto	ditto	ditto	ditto
C-04: Noise and Vibration							

No.	Item (Unit)	Measured Value during the Study Period (Max.)	Standard of India	Cost (INR)	Monitoirng Location	Rewqency and Timing	Method of Monitoring
	Noise Level	61.8 dB	Noise Standard of India 2000	2,403,000	Based on the Baseline Data Locations	Early Monsoon Period（May - July	Noise Standard of India 2000
	Bibration	–	Noise Standard of India 2000 and ISO 4866 : 1990 Mechanical vibration and shock-Vibration of buildings- Guidelines for the measurement of vibrations and evaluation of their effects on buildings	–	–	–	Noise Standard of India 2000 and ISO 4866 : 1990 Mechanical vibration and shock-Vibration of buildings- Guidelines for the measurement of vibrations and evaluation of their effects on buildings
C-05: Plants and Wildlife Including Bird Species							
	Plants	–	–		Entire Construction Area	Any time at each construction section	–
	Wildlife and Bird species	–	–				–

Source: JICA Study Team
Note:"C-01 denotes No.1 of the construction period.
Cost of monitoring works during the construction period is included in the construction contract.

Table 6-70: Environmental Monitoring Plan During the Operation and Maintenance Period

No.	Item	Baseline Data	Indian Standard	Cost (INR)	Monitoring Location	Frequency/Timing	Method
O-01: Compensatory Afforestation							
	Afforestation	—	—	18,000,000	All afforestation areas in Meghalaya State	Every 3 months	Area of afforestation, achievement, name of tree species, survival rate of saplings
O-02:Others（Staff Training, Labolatory Test, Village meetings）							
		—	—	1,800,000	At the commencement of monitoring	—	—

Source: JICA Study Team
Note:”O-01 denotes No.1 of the Operationa and Maintenance Period.
Note 1 : Field works are assisted by Meghalaya State Department of Environment and Forest while cost implecation is the responsibility of NHIDCL.

6.9.5 Monitoring Forms

Table 6-71 to Table 6-80 indicates JICA's standardized monitoring form. Monitoring works should be carried out every six months unless otherwise specifically explained.

Table 6-71: Environmental Clearance

Monitoring Item	Conditions During the Reporting Period
Response to State Department's Comments/Guidance for Obtaining Environmental Clearance	

Source: JICA Study Team

Table 6-72: Air Quality

Item (Unit)	Measured Value of Baseline Data (Max.)	Measured Value of Monitoring (Max. Value)	Indian Standard	Referred International Standard	Remarks (Location、Frequency and Method of Measurement)
SO_2	7.8 µg/m3		National Ambient Air Quality Standard: NAAQS		Baseline data locations are duplicated, Measure at early monsoon (May-July), Based on the National Ambient Air Quality Standard: NAAQS
NO_2	14.4 µg/m3				
CO	1,141 µg/m3				
O_3	-				
PM10/ PM2.5	90.8/44.5				

Source: JICA Study Team

Table 6-73: Water Quality

Item (Unit)	Measured Value	Measured Value (Max. Value)	Indian Standard	International Standard	Remarks (Location、Frequency and Method of Measurement)
pH	7.15		Indian Standard Drinking Water Specification m. Monitoring wo		Baseline data locations are duplicated, Measure at early monsoon (May-July), Based on the Indian Standard Drinking Water Specification – IS 10500: 1991
SS	7.5				
BOD/COD	7.0				
DO	6.6				
Nitrogen	0.89				
Phosphorus	<0.01				
Heavy Metal	<0.01				
Hydrocarbon/ Mineral Oil	<0.01				
Phenol	<0.01				
Cyanide	BDL				
Temperatures	^{O}C				

Source: JICA Study Team

Table 6-74: Solid Waste

Monitoring Item	Conditions During the Reporting Period
Reused Debris	Urban Solid Waste (Management and Handling) Rules, 2016
Disposed Debris	

Source: JICA Study Team

Table 6-75: Noise and Vibration

Item (Unit)	Measured Value (Average)	Measured Value (Max. Value)	Indian Standard	Referred International Standard	Remarks（Location、Frequency and Method of Measurement）
Noise Level	61.8 dB		Noise Standard of India 2000		Baseline data locations are duplicated, Measure at early monsoon (May-July), Based on Noise Standard of India 2000
Vibration Level					

Source: JICA Study Team

Table 6-76: Odor

Monitoring Item/Parameter	Conditions During the Reporting Period
Identification of the Source of Offensive Odor	Location of the source/Emating extent of the area

Source: JICA Study Team

Table 6-77: Bio-diversity

Monitoring Item/Parameter	Conditions During the Reporting Period
Sample: Observation of Vulnerable Species	
Name of the Species:	
Location of the Observation	

Source: JICA Study Team

Table 6-78: Resettlement

	Major items of action	Specific action steps (sub-items)	Progress in quantity	Progress during the month in %	Cumulative Progress in %
1	Recruitment, training and deployment	Deployment of staff, Training and mobilization (MM)			

2	Adopting the Land Resettlement Plan	Review of RP, Approval of RP with corrections (%)			
3	Socioeconomic Survey	Field Survey and collection of data, Data analysis and report generation (%)			
4	Valuation of affected property	Collection of data (%)			
5	Information campaign	Distribute information brochure(books) Public consultation meetings/FGD(frequency)			
6	Relocation of Project Affected Persons	Payment of Transfer Grant(No.of person)			
7	Identification of Eps	Assigning ID numbers (No. of Person)			
8	Grievance Redress	Receiving complaints / claims from EPs (No.of case)			
9	Information Management/ Technical services	Finalization of resettlement budget, Preparation of information brochure, Designing ID card (%)			
10	Resettlement of Project Affected Persons.	Opening bank account (No.of case) Assist vulnerable EPs in resettlement(No.of case)			
11	Supervision and Management	Supply of manpower (MM)			
12	Performance Reporting	Inception / Monthly progress / Draft final report (books)			

Source: JICA Study Team

Table 6-79: Livelihood of PAHs

Monitoring Item/Parameters	Conditions During the Reporting Period
Training for alternative livelihood/ livelihood improvement	
Socio-economic status after 5 years	

Source: JICA Study Team

Table 6-80: Compensatory Afforestation

No.	Location of the Afforestation Area (Name of the Village)	Afforestation Area (ha)	No. of Saplings	Species of Trees
1				
2				
3				
4				
5				
6				
7				

Source: JICA Study Team

Compensatory Afforestation is probably the most important activity within the framework of the Project. As described above, approximately 123 ha of the existing forest is lost to the road project. While at the same time implementation of the road project itself emit greenhouse gas and this is compensated by planting trees over 130 ha of area as a measures for reducing the global warming based on the "Paris Agreement" of COP 21. Thus the above monitoring form is suggested to add to JICA Pro forma system of monitoring forms.

6.9.6 Budget for Environmental Management and Monitoring Plan

Based on the above EMP, the annual cost for implementation including the cost of monitoring is estimated as per Table 6-81. Because of the damages made to the forest areas, the cost of tree planting amounts to 79% of the total cost of the management and monitoring plan.

Based on the concept of "REDD+(http://www.wwf.or.jp/activities/nature/cat1248/redd/)", donors are encouraged to bear the cost of afforestation in order to safeguards forest areas as well as to increase forested areas in order to compensate for the GHG emissions released as a result of project implementation. Thus, afforestation should be considered as a sub-project of the NH40 2-lane widening project.

Table 6-81: Budget for EMP

Item of EMP/Monitoring	Contents of EMP/Monitoring	Unit	Unit Price (Rs)	Total (Rs)	Notes
1. Monitoring					
Air Quality	The area in the vicinity of the construction plant	No. of Places	33,750	1,215,000	Assumption is made: one section stretches over 10km and monitoring is carried out at 5 locations.
Water Quality	Carried out as per IS 10500 and IS 2296	No. of Places	5,000	270,000	Based on the monitoring plan, 9 monitoring locations for the construction period as well as for 3 years after the completion of construction.
Noise	Carry out as per CPCB Guideline 1989 at the construction area	No. of Places	89,000	2,403,000	Based on the monitoring plan, 9 monitoring locations for the construction period as well as for 3 years after the completion of construction.
Rare plant and wildlife species	Carry out for bio-diversity	No.	150,000	4,050,000	Once every 6 months during the construction period, and once a year for 3 years during the operation and maintenance period.
Sub-total (I)				7,938,000	
2. Afforestation					
Afforestation for 123 ha of what was lost for the project	Based on the Forest Conservation Act (1980)	No.	200	29,520,000	Sapling for 1,200 pieces/ha
Afforestation for carbon sequestration of the project	Based on the Paris Agreement of COP 21	No.	200	31,200,000	Sapling for 1,200 pieces/ha
Sub-total (II)				60,720,000	
3. Personnel/Institutional Cost					
Monitoring Team	-	Lump Sum	-	18,000,000	-
Staff training for NHIDCL	-	Lump Sum	-	500,000	-
Laboratory Fee	-	Lump Sum	-	1,000,000	-

Item of EMP/Monitoring	**Contents of EMP/Monitoring**	**Unit**	**Unit Price (Rs)**	**Total (Rs)**	**Notes**
Stakeholder Meeting	-	Lump Sum	-	300,000	-
Sub-total (III)				19,800,000	
Sub-total (I+II+III)				88,458,000	
Contingency (10%)				8,845,800	
Grand Total				**977,303,400**	

Source: JICA Study Team

6.10 Stakeholder Consultation

The involvement of the communities in the project area is significant for project implementation in terms of achieving transparency and democratic decision-making. People's participation from the planning stage is a vital ingredient for a project to be efficient and effective. This project has ensured that communities along the project area are involved from the beginning; stakeholders meetings were held at key venues of the project road.

The purpose of the stakeholder consultation was to inform people about the project, listen and consider their issues and suggestions. Potential project-affected persons, local community, relevant departments attended these consultations.

The details will be shown in "7.12 Stakeholders Consultation."

(1) 1st Round Consultation with Communities

The consultations were informed through NGO and villages heads and followings are explained.
1) Outline and Purpose of the Project
2) Alignment, alternatives and reason of recommended alignment
3) Result of the scoping (anticipated positive and negative impact)

The summary of all the meetings are shown in Table 6-82.

Table 6-82: Summary of the 1st Round Meetings

Block	Date	Locatoin	Method	Attendees
Mylliem	11/6/16	Sanmer secondary School	Meeting with Government Official, Village council	34
Khatarshnong Laitkroh	16/6/16	PWD IB Laitlyngkot	Meeting with Government Official, Village council	21
Khatarshnong Laitkroh (2nd)	25/6/16	Community hall	Public Consultation	65
Pynursla (BP5) (1st)	10/6/16	PWD IB, Pynursla	Meeting with Government Official, Village council	7
Pynursla (north, BP5) (2nd)	9/7/16	Community hall	Public Consultation	23
Pynursla (North) (3rd)	12/8/16	Urksew Community Hall	Meeting with Government Official, Village council	26
Pynursla (North) (4th)	19/8/16	PWD IB Pynursla	Meeting with Government Official, Village council	37
Pynursla (Middle) (1st)	9/7/16	Community Hall	Public Consultation	50
Pynursla (Middle) (2nd)	13/7/16	Community Hall	Public Consultation	23
Pynursla (South)	15/7/16	Community Hall	Meeting with Government Official, Village council	45

Block	Date	Locatoin	Method	Attendees
Pynursla (South ・ BP6) / Amlarem	19/8/16	Wahkdait Community Hall	Public Consultation	45

Source: JICA Study Team

For the purposes of promoting information dissemination and community participation, several community meetings were held after block-level consultations. A brief description about the project highlighting the importance of consultations with likely project-affected persons, local community, and other stakeholders was given. Design concepts (e.g. minimize surplus soil, install proper slope protection) with preliminary alignments were also provided and explained. Expected benefits and anticipated adverse impacts as well as the resettlement policy framework as per JICA Guidelines for Environmental and Social Considerations were conveyed. The consultations were held in the local language (Khasi) with assistance from a local person who helped in interpretation as well as prepared transcripts. The proceedings of the consultations were audio recorded as part of the documentation process.

(2) 2nd Round Consultation with Communities

The second round stakeholder meeting was informed through NGO, village heads and local newspaper and held at 5th of November and 5th of December, 2016 to share the follows;

1) Outline and Purpose of the Project
2) Reason of recommended alignment
3) Result of Environmental Assessment (anticipated positive and negative impact, their analysis and mitigation)

Table 6-83: Summary of 2nd round consultations

Block	Date	Locatoin	Method	Attendees
Mylliem, Khatarshnong Laitkroh, Pynursla, Amlarem	5/11/16	Sanmer secondary School	Meeting/ Consultation with Government Official, Village council and PAHs	180
Pynursla/ Amlarem	5/12/16	Wahkdait Community Hall	Meeting/ Consultation with Government Official, Village council and PAHs	150

6.11 Land Acquisition and Resettlement

6.11.1 Requirement for Land Acquisition and Resettlement

The Project is through 28 villages in East Khasi Hills District and West Jaintia Hills District of Meghalaya State, and house structure of 299 households, 48 shops and land will be directly affected by the project. The resettlement required for the project is necessary to be implemented by the participation of Autonomous District Councils and the traditional village leaders in accordance with Indian Laws and JICA Guideline. Resettlement Action Plan has been prepared in accordance with JICA Guideline. Information disclosure was made through NGO and village heads, as well as NHIDCL's website and local newspapers. Considering the fact that 1/4 of affected persons are without education, it was decided to translate RAP into Khasi language though official language in Meghalaya is English.

The project is located entirely in East Khasi Hills District and West Jaintia Hills District of Meghalaya State, inhabited by Khasi and Jaintia with a few Garo, deemed to be STs in the Constitution of India. With reference to the World Bank's Operational Policy 4.10, they are not necessarily considered to be indigenous peoples; however, elements of an Indigenous People Plan (IPP) are considered in RAP. Accordingly, a social assessment was undertaken to evaluate the project's potential positive and adverse effects on the Scheduled Tribes, and to examine project alternatives where adverse effects may be significant.

(1) Project Component and Area

Project components which cause land acquisition and resettlement is as shown below.

Table 6-84: Project Component and Area

Project Name	Road Network Improvement in North-East States of India (Phase 2) (hereinafter referred to as "the project")
Project Overview	Improvement of the National Highway 40 (approx. 80 km) between Shillong and Dawki in Meghalaya (excluding KM7+700 - KM9+100 section overlapping with another project)
ROW	30 m (built-up area: 20 m)
Affected Area	Widening and bypass section for the improvement

Source: JICA Study Team

(2) Alternatives of Initial Design

The following four options were analyzed in section "7.4.4 Analysis of Alternatives".

Table 6-85: Alternatives of Initial Design

Option	Outline	HHs number with their house affected
a. No-project Implemented Option	There is no project intervention, i.e. present road continues to be used	0
b. Widening Option	Narrow space of existing road is subject to Road Widening and is to be high-standard two-way highway with bus stops, ditch, drainage ditch and pavement, etc.	Approx. 850
c. Bypass Inserting Option – DPR Design	In DPR design by Indian government, seven bypasses are inserted while widening of no bypass sections are implemented.	Approx. 350
d. Bypass Inserting Option – JICA Study Team's Design <recommended>	JICA Study Team reviewed DPR design and concluded that Bypass No.6 and No.7 are integrated to be six Bypass insertion options, and made alignment less curves.	299

Source: JICA Study Team

(3) Method for Minimizing Resettlement

The Study Team reduced the Project Affected Households by half of those at option b. by 1) reduction of ROW and 2) Bypasses.

1) Reduction of ROW

To minimize resettlement, ROW was reduced (option d.) from standard ROW in India (option b.).

Table 6-86: Comparison between Initial Design and Bypass Inserting Option

b. Initial Widening Option	d. Bypass Inserting Option after Minimizing PAPs
The IRC standards and specifications (IRC:SP:73-2015) stipulates "Two laning shall be accommodated within the existing ROW to the extent possible. However, additional land, if required for accommodating the two laning cross sections, improvement of geometrics, realignment, junctions, bypasses etc., shall be acquired by the Authority. For bypasses, **ROW shall be 60 m**."	NHIDCL has set out a policy about land acquisition as that ROW for two laning of NH40 including the bypass sections shall be **30 m in principle**. When acquiring ROW encounters difficulties with social environmental impacts and other various reasons, the width shall be flexible and adopt the options of **24 m for hilly sections** with sharp curves, **20 m for built-up sections**, and **as much width as required for high slope sections**.

Source: JICA Study Team

Table 6-87: Width of ROW in option d.

Two-laning including bypasses	ROW (m)
General sections	30
Hilly sections with sharp curves	24
Built-up sections	20
High slope sections	As much as required

Source: JICA Study Team

2) Reduction by Bypasses

"d) Bypass Inserting Option – JICA Study Team's Review of DPR" detoured densely-populated villages like Ritmawniew, Mylliem, Laitlingkot and Pynursla by Bypass No. 2 - 5 , so that affected houses is reduced approximately.

The IRC standards and specifications (IRC:SP:73-2015) stipulates "Two laning shall be accommodated within the existing ROW to the extent possible. However, additional land, if required for accommodating the two laning cross sections, improvement of geometrics, realignment, junctions, bypasses etc., shall be acquired by the Authority. For bypasses, ROW shall be 60 m."

NHIDCL has set out a policy about land acquisition as below. ROW for of NH40 including the bypass sections shall be 30 m in principle. When acquiring ROW encounters difficulties with social environmental impacts and other various reasons, the width shall be flexible and adopt the options of 24 m for hilly sections with sharp curves, 20 m for built-up sections, and as much width as required for high slope sections.

Table 6-88: Width of ROW

Two-laning including bypasses	ROW (m)
General sections	30
Hilly sections with sharp curves	24
Built-up sections	20
High slope sections	As much as required

Source: JICA Study Team

"c) Bypass Inserting Option - DPR" "d) Bypass Inserting Option – JICA Study Team's Design" of Table 6-85 detoured large scale villages of Ritmawniew, Mylliem, Laitlingkot and Pynursla by Bypass 2 – 5 and reduced ROW to 20m in densely-populated area. This reduced affected houses approximately by half, comparing with "b. Widening Option".

6.11.2 Legal Framework for Land Acquisition and Resettlement

(1) Acts / Policies / Notifications for Land Acquisition and Resettlement

Development projects, such as those related to road improvement and widening are mandated to be consistent with the existing Acts and policies of the respective national, state, local governments and also the guidelines and policies of JICA. An outline of the various Acts and policies that are in place in the country are as follows:

Table 6-89: Acts / Policies / Notifications & their relevance to the project

	Acts/Policies/Notifications	Relevance to the project
1	The Right to Fair Compensation and Transparency in Land Acquisition Rehabilitation and Resettlement Act 2013 (LARR 2013)	This Act came into force on 1st January 2014 and extends to the whole of India except the state of Jammu and Kashmir. The provisions of this Act relating to land acquisition, compensation, rehabilitation and resettlement, shall apply when the appropriate government acquires land for its own use, hold and control, including for public sector undertakings and for public purposes.

2	Meghalaya Transfer of Land (Regulation) Act, 1971.	It extends to the tribal areas within the state of Meghalaya. The Act states that no land in Meghalaya shall be transferred by a tribal to a non-tribal or by a non-land tribal to another non-tribal except with the prior sanction of the competent authority: Provided that the government of Meghalaya may, from time to time, by notification, prohibit any transfer of land within such area or areas as may be specified in the notification and there upon, the competent authority shall not sanction any such transfer of land under the provision of this Act, within such area or areas. This act is only applicable for land transfer mainly from government to private companies, or between private individuals and not applicable for land acquisition by public sectors.
3	The United Khasi-Jaintia Hills Autonomous District Council (Management and Control of Forests) Act 1958.	This act extends to the whole of the Khasi-Jaintia autonomous districts.[24] The Act describes the type of forests that exist in Meghalaya, in terms of ownership and management. The Act provides for the maintenance, management and preservation of such forests. No Objection Certificate from the appropriate Autonomous District Council is required for acquisition of community land/forest in Khasi and Jaintia Hills Districts in accordance with this Act.
4	The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006.	This Right recognizes and vests the forest rights and occupation in forest lands in forest dwelling STs who have been residing in such forests for generations but whose rights cannot be recorded, and other traditional forest dwellers who have been occupying the forest land. Since most of lands belong to private individuals or communities in Meghalaya, the role of this act applicable for government land is limited.
5	The National Tribal Policy 2006	Provides an environment conducive to the preservation of traditional and customary systems and regime of rights and concessions enjoyed by different ST communities.
6	Right to Information Act 2005	Provides for citizens to have access to information under the control of the public authorities, in order to promote transparency and accountability in every

[24] Sub-paragraph 20 of the Sixth Schedule to the Constitution of India.

		public authority.

Source: JICA Study Team

1) Right to fair compensation and Transparency in Land Acquisition, Rehabilitation, and Resettlement Act (LARR), 2013

The RFCTLARR 2013 was passed by the Parliament on September 5, 2013 and came into force on January 1, 2014.

The objective of this Act is;

- to ensure, in consultation with institutions of local self-Governments and Gram Sabhas established under the Constitution, a humane, participative, informed and transparent process for land acquisition for industrialization, development of essential infrastructural facilities and urbanization with the least disturbance to the owners of the land and other affected families.
- To provide just and fair compensation to the families whose land has been acquired or affected by such acquisition.
- To make adequate provision for such affected persons and their rehabilitation and resettlement.
- To ensure that the cumulative outcome of compulsory acquisition should be that affected persons become partners in development leading to an improvement in their post-acquisition social and economic status and for matters connected therewith or incidental thereto.

The LARR Act 2013 was tried to be amended by the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (Amendment) Ordinance Bills three times - once in 2014 and then twice subsequently in 2015.

MORD order dated 28 August 2015 named as “Removal of Difficulties”, extended the provisions of compensation and rehabilitation & resettlement to the 13 enactments under Schedule IV.

The LARR Act 2013 provision will apply when:

i. Government acquires land for its own use, hold and control for strategic purposes and infrastructure development
ii. Government acquires land with the ultimate purpose to transfer it for the use of private companies for stated public purpose (including PPP projects but other than state or national highway projects)
iii. Government acquires land for immediate and declared use by private companies for public purpose

In Meghalaya this Act was challenged on grounds that the State falls under the Sixth Schedule of the Constitution, hence Land in the State belongs to individuals and not the Government. Nevertheless, the provisions of this Act relating to land acquisition, compensation, rehabilitation and resettlement, shall apply when the appropriate Government acquire land for its own use, hold and control, including for public sector undertakings and for public purposes.

2) The United Khasi- Jaintia Hills Autonomous District Council (Management and Control of Forests) Act 1958.

The Act applies to the Khasi-Jaintia Autonomous Districts and provides for the preservation and management of the forests in the State based on the type of ownership, tradition/culture, and history attached to it. The forests under this Act are classified into 8 types and each type of forest is described for purpose of management and control. The Act also declares certain tress to be reserved trees and restriction of felling of certain trees without the previous sanction of Chief Forest Officer of the District Council or any Officer duly authorized by him in writing.

3) Meghalaya Transfer of Land (Regulation) Act, 1971

The main purpose of this Act is to retain and preserve the land belonging to the tribal people in the State. This Act helps the people in Meghalaya to be in control of their land.

The Act provides that no land in Meghalaya shall be transferred by a tribal to a non-tribal or by a non- tribal to another non-tribal except with the previous sanction of the competent authority: Provided that the Government of Meghalaya may, from time to time, by notification, prohibit any transfer of land with in such area or areas as may be specified in the notification and there upon, the competent authority shall not sanction any such transfer of land under the provision of this Act, within such area or areas.
For others, though there is no specific provision in the Act, traditional laws below exists in Meghalaya state.

- Periodic Patta : Patta issued by State government for land acquisition with limited period. Originally "The Assam Land and Revenue Regulation, 1886", before separation of Meghalaya from Assam
- Village Council Pass : Issued within the field of village council, function as right to use the land conventionally

The owner of them is assessed for compensation as well as land owner regulated in LARR2013 in Meghalaya.

4)The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006

This Right recognizes and vests the forest rights and occupation in forest lands in forest dwelling Scheduled Tribes who have been residing in such forests prior to13/12/2005 for generations but whose rights cannot be recorded, and other traditional forest dwellers who are in occupation of the forest land for at least 3 generations (i.e. 75 years), and up to a maximum of 4 hectares. Such lands are mostly inherited and are not transferable.
Since most of lands belong to private individuals or communities in Meghalaya, the role of this act applicable for government land is limited.

5) National Tribal Policy 2006

The National Tribal Policy has the following objectives: Regulatory Protection:

- Providing an environment conducive to the preservation of traditional and customary systems and regime of rights and concessions enjoyed by different ST communities, and reconciliation of modes of socio-economic development with these;

- Preventing alienation of land owned by STs and restoring possession of wrongfully alienated lands;

- Protection and vesting of rights of STs on forest lands and other forest rights including ownership over minor forest produce (MFP), minerals and water bodies through appropriate legislations and conversion of all forest villages into revenue villages;

- Providing a legislative frame for rehabilitation and resettlement in order to minimize displacement, ensure that affected persons are partners in the growth in the zone of influence, provide for compensation of social and opportunity cost in addition to market value of the land and rights over common property resources - the concept of net present value (NPV);

- Empowerment of tribal communities to promote self-governance and self-rule as per the provisions and spirit of the Panchayats (Extension to the Scheduled Areas) Act, 1996.

- Protection of political right to ensure greater and active participation of tribals in political bodies at all levels.

The National Tribal Policy 2006 outlines several new and continuing initiatives for accelerating the pace of welfare and development of tribal areas in the country.

6) Right to Information Act 2005

The basic objective of the Right to Information Act is to empower the citizens, promote transparency and accountability in the working of the Government. Right to Information Act 2005 mandates timely response to citizen requests for government information. It was enacted on 15th June 2005 and came into force on 12th October 2005. The Act extends to the whole of India except Jammu and Kashmir and is non-applicable to Intelligence and Security organizations.

(2) JICA Guidelines for Environmental and Social Considerations

JICA's Involuntary Resettlement Policy is as follows;

The key principle of JICA policies on involuntary resettlement is summarized below.

I. Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives.

II. When, population displacement is unavoidable, effective measures to minimize the impact and to compensate for losses should be taken.

III. People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.

IV. Compensation must be based on the full replacement cost as much as possible.

V. Compensation and other kinds of assistance must be provided prior to displacement.

VI. For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. It is desirable that the resettlement action plan include elements laid out in the World Bank Safeguard Policy, OP 4.12, Annex A.

VII. In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.

VIII. Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans.

IX. Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.

Above principles are complemented by World Bank OP 4.12, since it is stated in JICA Guideline that "JICA confirms that projects do not deviate significantly from the World Bank's Safeguard Policies". Additional key principle based on World Bank OP 4.12 is as follows.

X. Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers or others who wish to take advantage of such benefits.

XI. Eligibility of Benefits include, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who do not have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying.

XII. Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based.

XIII. Provide support for the transition period between displacement and livelihood restoration.

XIV. Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc.

In addition to the above core principles in the JICA policy, it also laid emphasis on a detailed resettlement policy inclusive of all the above points; project specific resettlement plan; institutional framework for implementation; monitoring and evaluation mechanism; time schedule for implementation; and, detailed financial plan etc.

Key Gap between LARR 2013 and JICA Guidelines, Resettlement and Land Acquisition Policy Applied to this Project

Table 6-90 summarizes key differences between the two sets of legal and policy frameworks i.e. JICA policies and the existing Indian policies relevant to this project. The recommendations for measures to plug the gaps and policy applied for this project are also given in the Table.

Table 6-90: Key gap between JICA and Indian Regulations

SL. No.	JICA Guidelines (2010)	Applicable Policy/Act (LARR2013)	Gaps Between JICA's Guidelines and LARR 2013	Proposed Gap Filling Measures
1	Involuntary resettlement should be avoided wherever possible.	Ensure minimum displacement of people, minimum disturbance to the infrastructure, ecology and minimum adverse impact on the individuals affected. (Chapter II, 8 (2))	No	
2	When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken.	Whenever the appropriate Government intends to acquire land for a public purpose, it will carry out a Social Impact Assessment study in consultation with affected people. (Chapter II, 4 (1)) A Rehabilitation and Resettlement Scheme shall be prepared including the particulars of the rehabilitation and resettlement entitlements of each landowner and landless whose livelihoods are primarily dependent on the lands being acquired and where resettlement of affected families is involved. (Chapter IV, 16 (2))	No	
3	People who must be settled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living,	Adequate provisions for affected persons for their rehabilitation and resettlement and for ensuring that the cumulative outcome of compulsory acquisition should be that affected persons become partners in development leading to an improvement in their post-acquisition social and economic status and for matters connected therewith or incidental thereto. (Preface)	LARR silent on compensation rights of non-titleholders for loss of land (illegally occupied) and structures. R&R benefits such as housing improvement, development benefits, loss of crops, trees transitional support, etc., to be provided only if residing / drawing livelihood for a continuous 3 year period in the area, preceding the declaration of the 'affected area'.	Assistance to be provided for non-titleholders regardless of residing period status.

SL. No.	JICA Guidelines (2010)	Applicable Policy/Act (LARR2013)	Gaps Between JICA's Guidelines and LARR 2013	Proposed Gap Filling Measures
	income opportunities and production levels to pre-project levels.			
4	Compensation must be based on the full replacement cost as much as possible	[Land] The Collector having determined the market value of the land to be acquired shall calculate the total amount of compensation to be paid to the land owner by including all assets attached to the land. (Chapter IV, 27) The market value calculated shall be multiplied by a factor to be specified in the First Schedule. (Chapter IV, 26 (2)) Factor by which the market value is to be multiplied in the case of rural areas is 1.00 (One) to 2.00 (Two) based on the distance of project from urban area (First Schedule, Serial No. 2) In addition to the market value of the land as above provided, the Authority shall in every case award a solatium of one hundred per cent. over the total compensation amount. (Chapter VIII, 69(3)) [Property] The Collector in determining the market value of the building and other immovable property or assets attached to the land or building which are to be acquired. (Chapter IV, 29 (1)) Solatium is equivalent to one hundred percent of	[Land] Solatium for land regulated in LARR2013 is 2 – 4times that of market land value set by district officer. It meets the replacement cost of World Bank op.4.12 (market value of the land + the cost of preparing the land to levels similar to those of the affected land +tax). [Property] Twice as the market value of property. Though this meets the replacement cost of World Bank op.4.12(the market cost of the materials to build a replacement structure + the cost of transporting building materials to the construction site + the cost of any labor and contractors' fees + tax), price after depreciation is usually applied in LARR 2013.	Compensation to be provided at full replacement cost based on prevailing market rates and additional allowance

SL. No.	JICA Guidelines (2010)	Applicable Policy/Act (LARR2013)	Gaps Between JICA's Guidelines and LARR 2013	Proposed Gap Filling Measures
		value of assets attached to land or building. (First Schedule, Serial No. 5)		
5	Compensation and other kinds of assistance must be provided prior to displacement	Take possession of land after ensuring that full payment of compensation as well as rehabilitation and resettlement entitlements are paid or tendered to the entitled persons. (Chapter V, 28(1))	No	
6	For projects that entails large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public.	Whenever the appropriate Government intends to acquire land for a public purpose, it shall consult the concerned panchayat. Municipality or Municipal Corporation, as the case may be, at village level or ward level, in the affected area and carry out a Social Impact Assessment study in consultation with them. (Chapter II, 4(1))	No	RAP to be prepared for this project.
7	In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance.	The appropriate Government shall ensure that a public hearing is held at the affected area, after giving adequate publicity about the date, time and venue for the public hearing, to ascertain the views of the affected families to be recorded and included in the Social Impact Assessment Report. (LARR 2013 chapter II, 5(1)) The appropriate Government shall ensure that the Social Impact Assessment study report and the Social Impact Management Plan are prepared and made available in the local language to the Panchayat,	No	

SL. No.	JICA Guidelines (2010)	Applicable Policy/Act (LARR2013)	Gaps Between JICA's Guidelines and LARR 2013	Proposed Gap Filling Measures
		Municipality or Municipal Corporation, as the case may be, and the offices of the District Collector, the Sub-Divisional Magistrate and the Tehsil, and shall be published in the affected areas' in such manner as may be prescribed, and uploaded on the website of the appropriate Government. (chapter II, 6 (1))		
7-2	When consultation are held, explanations must be given in a form, manner, and language that are understandable to the affected people	Same as above	No	
8	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans	Same as above	No	
9	Appropriate and accessible grievance mechanism must be established for the affected people and their communities	Any person interested in any land which has been notified, as being required or likely to be required for a public purpose, may within sixty days from the date of the publication of the preliminary notification, object to- (a) the area and suitability of land proposed to be	No	INSERT LONG FORM OF GRM (GRM) to be set up. Should be accessible to PAHs to be constituted at district level for issues around land acquisition and R&R benefits. Similar body to exist at state level

SL. No.	JICA Guidelines (2010)	Applicable Policy/Act (LARR2013)	Gaps Between JICA's Guidelines and LARR 2013	Proposed Gap Filling Measures
		acquired; (b) justification offered for public purpose; (c) the findings of the Social Impact Assessment response. (chapter IV, 15)		for monitoring and supervision R&R implementing NGO / consultant to have presence in each project-affected district and facilitate and inform PAHs about GRM and its processes.
10	Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socio-economic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers or others who wish to take advantage of such benefits.	The Social Impact Assessment study shall, amongst other matters, include all the following, namely: (a) assessment as to whether the proposed acquisition serves public purpose; (b) estimation of affected families and the number of families among them likely to be displaced; (c) extent of lands, public and private, houses, settlements and other common properties likely to be affected by the proposed acquisition; (d) whether the extent of land proposed for acquisition is the absolute bare minimum extent needed for the project (e).whether land acquisition at an alternate place has been considered and found not feasible; (f) study of social impacts of the project, and the nature and cost of addressing them and the impact of these costs on the overall costs of the project vis-a-vis	No	

SL. No.	JICA Guidelines (2010)	Applicable Policy/Act (LARR2013)	Gaps Between JICA's Guidelines and LARR 2013	Proposed Gap Filling Measures
		the benefits of the project. (chapter II, 4 (2))		
11	Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who do not have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying	'affected family" includes (i) a family whose land or other immovable property has been acquired; (ii) a family which does not own any land but a member or members of such family may be agricultural labours, tenants including any form of tenancy or holding of usufruct right, sharecroppers or artisans or who may be working in the affected area for three years prior to the acquisition of the land, whose primary source of livelihood stand affected by the acquisition of land; (iii) the Scheduled Tribes and other traditional forest dwellers who have lost any of their forest rights recognized under the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Right) Act, 2006 due to acquisition of land, (iv) family whose primary source of livelihood for three years prior to the acquisition of the land is dependent on forests or water bodies and includes gatherers of forest produce, hunters, fisher-folk and boatmen and such livelihood is. affected due to acquisition of land; (v) a member of the family who has been assigned	Yes, non-titleholders if residing or drawing livelihood for a period less than 3 years are not eligible for R&R benefits	All non-titleholders (as identified on date of census survey) will also be eligible for R&R benefits

SL. No.	JICA Guidelines (2010)	Applicable Policy/Act (LARR2013)	Gaps Between JICA's Guidelines and LARR 2013	Proposed Gap Filling Measures
		land by the State Government or the Central Government under any of its schemes and such land is under acquisition; (vi) a family residing on any land in the urban areas for preceding three years or more prior to the acquisition of the land or whose primary source of livelihood for three years prior to the acquisition of the land is affected by the acquisition of such land. (Chapter I, 3 (c))		
12	Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based.	Land for Land - In the case of irrigation project, as far as possible and in lieu of compensation to be paid for land acquired, each affected family owning agricultural land in the affected area and whose land has been acquired or lost. (The second schedule, 2)	No	
13	Provide support for the transition period (between displacement and livelihood restoration)	Offer for Developed Land - In case the land is acquired for urbanization purposes, twenty per cent. of the developed land will be reserved and offered to land owning project affected families, in proportion to the area of their land acquired and at a price equal to the cost of acquisition and the cost of development. (The second schedule, 3)	Yes, no such benefits provision for non-titleholder residing / drawing livelihood for a period less than 3 years	Transition benefits to be provided to non-titleholders (displaced and livelihoods impacted) who have been identified as per census survey

SL. No.	JICA Guidelines (2010)	Applicable Policy/Act (LARR2013)	Gaps Between JICA's Guidelines and LARR 2013	Proposed Gap Filling Measures
14	Particular attention must be paid to the needs of vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities, etc.	In case of a project involving land acquisition on behalf of a Requiring Body which involves involuntary displacement of the Scheduled Castes or the Scheduled Tribes families, a Development Plan shall be prepared (chapter V section 41 (4)) In case of land being acquired from the members of the Scheduled Castes or the Scheduled Tribes, at least one-third of the compensation amount due shall be paid to the affected families initially as first installment and the rest shall be paid after taking over of the possession of the land. (chapter V section 41 (6)) The affected families of the Scheduled Tribes shall be resettled preferably in the same Scheduled Area in a compact block so that they can retain their ethnic, linguistic and cultural identity. (chapter V section 41 (7))	No	Special R&R assistance to the SC/ST community. Special attention to be made by the R&R implementing NGO, the vulnerable PAH / persons receive R&R support as outlined for them in the RAP.

Source: JICA study team

6.11.3 Scale and Scope of Land Acquisition and Resettlement

The socio-economic profile of the PAH along the project road was examined to better understand the prevailing living conditions - social, economic and health. The survey was conducted to help understand the likely impact that the project may have on the people / community living in the affected area. An asset survey was also conducted for the purpose of calculating the resettlement cost.

(1) Methodology

420 Households whose structures and/or lands would be affected were interviewed by the surveyors using questioners.
Population census, asset inventory survey and livelihood survey were conducted.

- Duration: June – November 2016
- Subjects: Households whose structures, stops, workshops and/or lands would be affected by the Project
- Cut-off date: the end of November, 2016

There are some unfinished section to survey by the reasons below;
- 2.101 Area: Military reservation, takes some time to get permission to survey from Ministry of Defense. After acquisition of permission, implement the survey.
- 18. Langkawet～20. Urksew wahpathaw: There is uncertain community boundary and under discussion, so that examine the survey after achieving mutual agreement of communities.

Table 6-91: Details of PAHs

Villages Name		Surveyed HHs /PAHs	Villages Name		Surveyed HHs /PAHs	Villages Name		Surveyed HHs /PAHs
1	Umshyrpi bridge	11/11	11	Madan Panpoh	1/1	21	Siatbakon	35/35
2	101 Area	0/2	12	Lumshalla	1/1	22	Risawkur	7/7
3	5th mile	7/7	13	Laitlyngkot	3/3	23	Nongshyrngan Pynursla	22/22
4	Mylliem Marbaniang	18/18	14	Pomlum (Pynursla)	9/9	24	Pongtung	36/36
5	Mylliem mawrie	1/1	15	Mawkajem	6/6	25	Pomshutia	24/24
6	Madan ing Syiem	22/22	16	Rngain	4/4	26	Wahkdait	53/53
7	Kyndong Nongkyntir	40/40	17	Langkyrdem	4/4	27	Umsyiem	16/16
8	Umlympung 12 mile	20/20	18	Langkawet	0/1	28	Bakur	44/44
9	Umtyngngar	14/14	19	Nongmadan Shadsngi	0/1			
10	Beh Syiem 15 mile	7/7	20	Urksew wahpathaw	0/14		Total =	402/420

1) Duration: June – November 2016
Source: JICA Study Team

(2) Population Census

Through population census, age, gender, composition of HHs, social category, ethnicity and religion were surveyed.

A summary of the population census is shown below.

1) Summary of HHs

In 420 HHs, 309 HHs are with their structures affected, while 135 HHs are with their land affected

Table 6-92: Summary of the Survey

Villages	**Type of Affected Components**		Number of HHs
Villages under the Project: 27 villages	**Total HH with their Structures Affected**	Houses	299
		Shops	48
		Workshops	5
		Structures	1
		Total*1	309
	Other land/ businesses	Agricultural/open field	46
		Stone and sand quarry	14
		Betel nut Plantation owners	75
		Total s	135
Total of PAHs *2			420

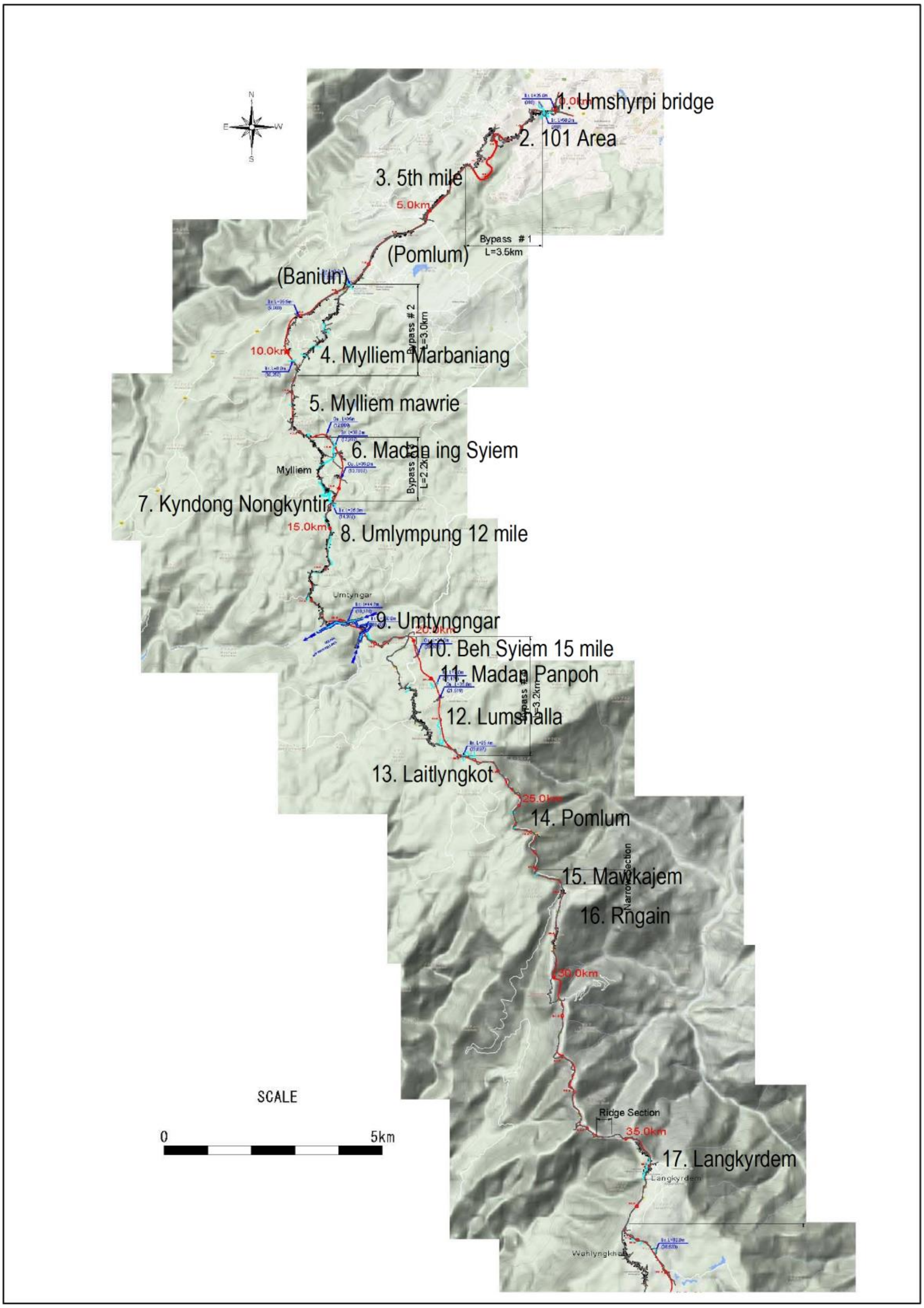
*1 44 HHs are with both houses and shops affected.
*2 24 HHs are with both structures and agricultural lands
Source: JICA Study Team

Table 6-93: Details of PAHs

District	Block	Section	Sl no	Villages Name	PAHs: Structure affected: HHs with house affected (number of house structure)	Shop	Work-shop	Other Structure	Sub-total	(both house/ shop affected)	Land affected: Agri-culture fields	Stone quarry	Betel nut Plantations	Sub-total	Total PAHs	(both structure /land affected)	**Sub-total (Census conducted)**
East Khasi Hills	Mylliem	Widening 1	1	Umshyrpi bridge	11 (3)	-	-	-	**11**		-	-	-	-	**11**		**11**
			2	101 Area	2	-	-	-	**2**		-	-	-	-	**2**		
		Widening 2	3	5th mile	7	7	-	-	**7**	(7)	-	-	-	-	**7**		**7**
		BP 2	-	Pomlum					**-**					-	**-**		
			-	Baniun					**-**					-	**-**		
		(BP2 -Widening 3)	4	Mylliem Marbaniang	1	2	1		**4**		8	6		14	**18**		**18**
		Widening 3	5	Mylliem mawrie	1	-	-	-	**1**		1	-	-	1	**1**	**(1)**	**1**
		BP 3	6	Madan ing Syiem	22 (19)	3	1	-	**22**	(4)	3	-	-	3	**22**	**(3)**	**22**
		(BP3 -Widening 4)	7	Kyndong Nongkyntir	31	3	2	-	**31**	(5)	2	8	-	10	**40**	**(1)**	**40**
	Khatarshnong Laitkroh	Widening 4	8	Umlympung 12 mile	17	3	1	-	**20**	(1)	-	-	-	-	**20**		**20**
			9	Umtyngngar	14	9	-	-	**14**	(9)	2	-	-	2	**14**	**(2)**	**14**
		BP 4	10	Beh Syiem 15 mile	5	2	-	-	**7**		6	-	-	6	**7**	**(6)**	**7**
			11	Madan Panpoh	1	-	-	-	**1**		1	-	-	1	**1**	**(1)**	**1**
			12	Lumshalla	1	-	-	-	**1**		1	-	-	1	**1**	**(1)**	**1**
			13	Laitlyngkot	3	1	-	-	**3**	(1)	-	-	-	-	**3**		**3**
	Pynursla	Widening 5	14	Pomlum (Pynursla)	8	3	-	-	**8**	(3)	-	-	-	-	**8**		**8**
			15	Mawkajem	6	2	-	-	**6**	(2)	-	-	-	-	**6**		**6**
			16	Rngain	-	2	-		**2**					-	**2**		**2**
			17	Langkyrdem	4	-	-	-	**4**		-	-	-	-	**4**		**4**
		BP 5	18	Langkawet	1	-	-	-	**1**		-	-	-	-	**1**		
			19	Nongmadan Shadsngi	1	-	-	-	**1**		-	-	-	-	**1**		
			20	Urksew wahpathaw	14	-	-	-	**14**		-	-	-	-	**14**		
		Widening 6	21	Siatbakon	35 (33)	5	-	-	**35**	(5)	5	-	-	5	**35**	**(5)**	**35 -**
			22	Risawkur	4	-	-	-	**4**		3	-	-	3	**7**		**7**
			23	Nongshyrngan Pynursla	22	-	-	-	**22**		2	-	-	2	**22**	**(2)**	**22**
			24	Pongtung	36	6	-	-	**36**	(6)	2	-	-	2	**36**	**(2)**	**36**
			25	Pomshutia	24	-	-	1	**24**	(1)	-	-	-	-	**24**		**24**
		BP 6&7	26	Wahkdait					**-**				53	53	**53**		**53**
			27	Umsyiem	-	-	-	-	**-**		-	-	16	16	**16**		**16**
West Jaintia Hills	Amlarem	after BP 6&7	28	Bakur	28	-	-		**28**		10	-	6	16	**44**		**44**
				TOTAL	**299** (286)	**48**	**5**	**1**	**309**	**44**	**46**	**14**	**75**	**135**	**420**	**24**	**402**

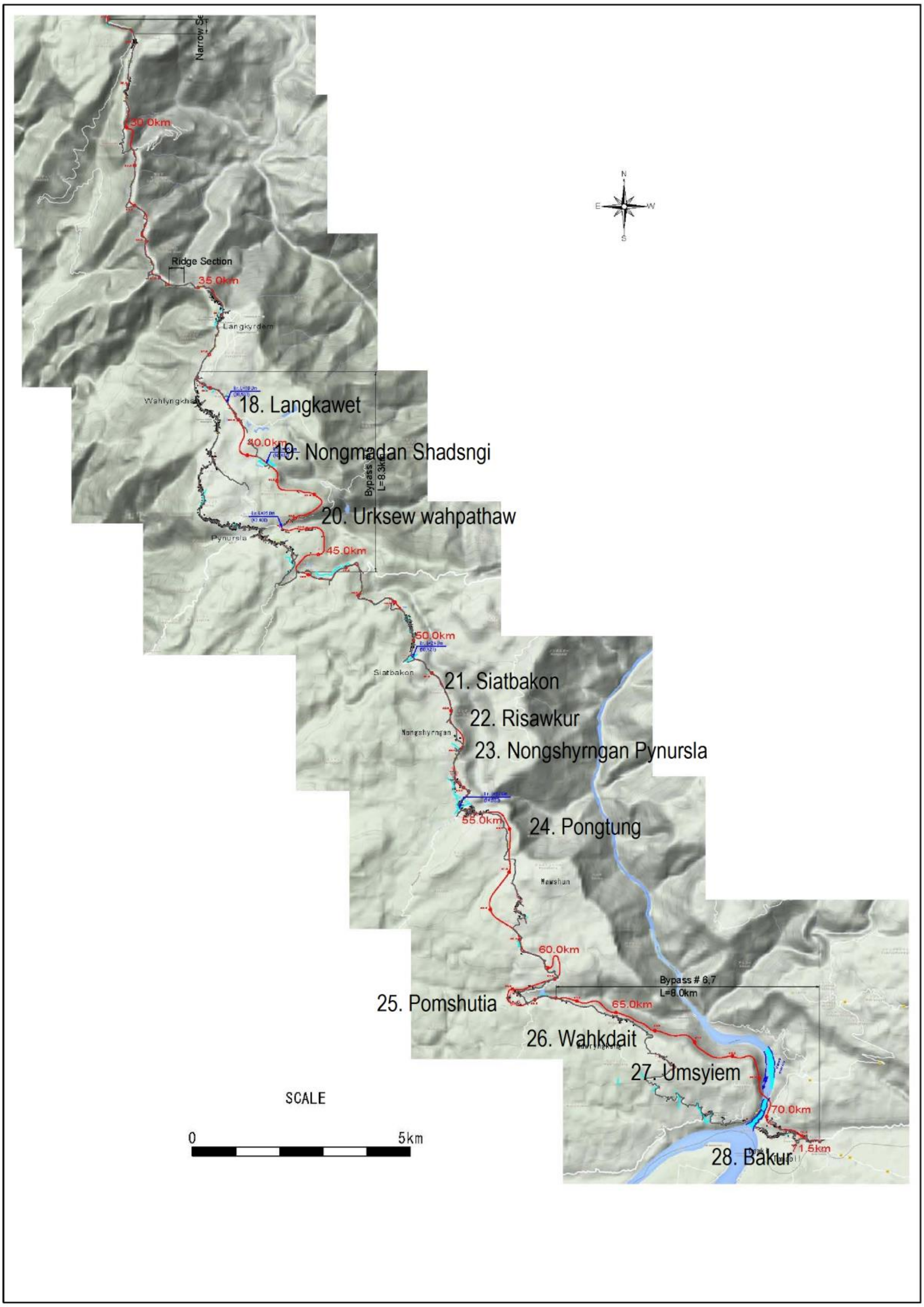
1) Number in ( ) under HHs with house affected presents 2 households living in same building (presents number of house).

Source: JICA Study Team



Source- JICA study team

Figure 6-40: Affected Villages (1)



Source- JICA study team

Figure 6-41: Affected Villages (2)

2) Population

Population of surveyed 402 HHs as of 30/11/2016 is 2,186 of which males are 48.4% and females are 51.6%.

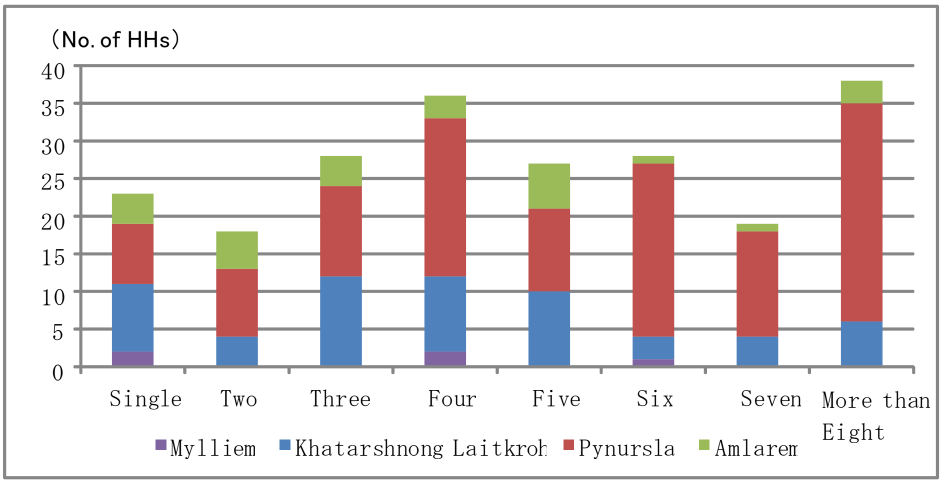
3) Composition of HHs

Average number of HHs member of surveyed 402 HHs as of 30/11/2016 is approximate 5.4 and HHs over 8 member are 86 HHs, most numerous.

Table 6-94: Composition of Affected HHs

District	Block	single	two	three	four	five	six	seven	More than eight	Total
East Khasi Hills	Mylliem	12	5	11	21	23	8	9	9	99
	Khatarshnong Laitkroh	1	2	3	10	8	8	6	8	46
	Pynursla	12	6	16	24	39	33	13	66	213
West Jaintia Hills	Amlarem	3	3	5	4	10	12	2	3	44
Total		**28**	**16**	**35**	**59**	**80**	**61**	**30**	**86**	**402**
		(6.9%)	(4.0%)	(8.7%)	(14.7%)	(19.9%)	(15.2%)	(7.5%)	(21.4%)	

Source: JICA Study Team



Source: JICA Study Team

Figure 6-42: Composition of Affected HHs

3) Social category

The social category of the surveyed 402 HHs is shown for each block in Table 6-95. As aforementioned in the district background, the majority of the PAPs belong to the ST (96.52%), 1.00% belong to the SC.

*For 402HHs surveyed as of 30/11/2016.

Table 6-95: Social category

District	Block	ST	SC	OBC	Others	Total
East Khasi Hills	Mylliem	89	1	0	9	99
	Khatarshnong Laitkroh	44	2	0	0	46
	Pynursla	211	1	0	1	213
West Jaintia Hills	Amlarem	44	0	0	0	44
Total		**388 (96.52%)**	**4 (1.00%)**	**0 (0.00%)**	**10 (2.49%)**	**402**

※ST：Scheduled Tribe SC：Scheduled Caste
OBC：Other Backward Class Others：Other
Source: JICA Study Team

4) Ethnicity background

The ethnic background of the surveyed 402 HHs is shown for each block in Table 6-96. The graph below indicates that the PAHs along the project road are mostly Khasi at 85.07%, and 10.95% are from the Jaintia Tribe, 1.74 % are Nepalese, 0.50% are Garo and 0.25% are Bengalis.
*For 402 HHs surveyed as of 30/11/2016

Table 6-96: Ethnic background

District	Block	Khasi	Jaintia	Garo	Nepali	Bengali	Others	Total
East Khasi Hills	Mylliem	87	0	0	6	0	6	99
	Khatarshnong Laitkroh	44	0	1	1	0	0	46
	Pynursla	211	0	1	0	1	0	213
West Jaintia Hills	Amlarem	0	44	0	0	0	0	44
Total		**342 (85.07%)**	**44 (10.95%)**	**2 (0.50%)**	**7 (1.74%)**	**1 (0.25%)**	**6 (1.49%)**	**402**

Source: JICA Study Team

5) Religion

The religious breakdown of the surveyed 402 HHs is shown block-wise in Table 6-97. The majority of the PAPs are Christians at 74.63%, followed by 20.15% of the PAPs who follow the indigenous religion known as the *Niam Khasi*. Finally, 2.99% are Hindus and 2.24 % are Buddhists.
*For 402 HHs surveyed at 30/11/2016

Table 6-97: Religious Breakdown

District	Block	Christian	Buddhist	Hindu	Muslim	Others	Total
East Khasi Hills	Mylliem	83	0	12	0	4	99
	Khatarshnong Laitkroh	13	6	0	0	27	46
	Pynursla	160	3	0	0	50	213
West Jaintia Hills	Amlarem	44	0	0	0	0	44
Total		**300 (74.63%)**	**9 (2.24%)**	**12 (2.99%)**	**0 (0.00%)**	**81 (20.15%)**	**402**

Source: JICA Study Team

6) Cut-off Date

Cut-off date regarding resettlement of the Project is as follows.
- Cut-off date of the RAP: Completion date of census (30 November, 2016)

- SIA based on LARR 2013: Date of SIA notification from Revenue Department after approval of DPR (the beginning of 2017)

7) Prevention of Influx after the Cut-off Date

For the purpose of preventing an influx of people into the project area after cut-off date, a list of land owners will be prepared under the responsibility of the deputy commissioner of each district before SIA.

8) Update of Census

The census will be updated by the SIA Unit appointed by the Revenue and Disaster Management Department after approval of the DPR.

(3) Asset and Land Survey

1) Impact of Affected Households and Structures

Ownership of affected structure is as shown Table 6-98. The project will impact 298 households. Of the 291 households that have completed the asset survey, 235 own their houses and 41 live in rented houses.

Table 6-98: Ownership of Structure

（No. of House）

District	Block	Owned	Rented	No response	Total
East Khasi Hills	Mylliem	47	27	2	76
	Khatarshnong Laitkroh	40	5	1	46
	Pynursla	124	5	12	141
West Jaintia Hills	Amlarem	24	4	0	28
Total		**235 (80.1%)**	**41 (14.1%)**	**15 (5.2%)**	**291**

Source：JICA Study Team

Affected Structure Level is shown as in Table 6-99. Wooden Single storey is 77.37% and Tin is 11.68%.

Table 6-99: Affected Structure Level

（No. of HH）

District	Block	Single storey	Single storey RCC	Two storey RCC	Tin	Total
East Khasi Hills	Mylliem	51	8	0	7	66
	Khatarshnong Laitkroh	42	1	2	0	45
	Pynursla	112	10	0	13	135
West Jaintia Hills	Amlarem	7	7	2	12	28
Total		**212 (77.37%)**	**26 (9.49%)**	**4 (1.46%)**	**32 (11.68%)**	**274**

Source：JICA Study Team

2) Impact on Land

Land use of the site of this project is as shown below;

Table 6-100: Affected Land

	Village name	Type of land	Number of structure	Affected land Unit (m2)
1	Umshyrpi bridge	Residential Area	3	700
2	101 Area	Under Survey		
3	5th mile	Residential/ commercial Area	7	315
4	Mylliem Marbaniang	Stone quarry Residential/ commercial Area Agriculture field Fruits Garden	6 4 - -	1,250 1,200 1,800 250
5	Mylliem mawrie	Residential Area	-	800
6	Madan ing Syiem	Residential/ commercial Area	19	1,140
7	Kyndong Nongkyntir	Agriculture field Sand quarry Forest Residential/ commercial Area Petrol Pump	- 5 1 28 1	1,800 8,750 50 13,930 100
8	Umlympung 12 mile	Residential Area	20	3,910
9	Umtyngngar	Residential Area	14	5,250
10	Beh Syiem 15 mile	Residential Area	7	30,250
11	Madan Panpoh	Residential Area	1	2,200
12	Lumshalla	Residential Area	-	-
13	Laitlyngkot	Residential Area	3	123,000
14	Pomlum (Pynursla)	Residential Area	8	650
15	Mawkajem	Residential Area	6	430
16	Rngain	Commercial Area	2	270
17	Langkyrdem	Residential Area	4	500
18	Langkawet	Under Survey		
19	Nongmadan Shadsngi	Under Survey		
20	Urksew wahpathaw	Under Survey		
21	Siatbakon	Residential/ commercial Area	32	4,840
22	Risawkur	Residential Area Open space	4 -	6,050 8,650
23	Nongshyrngan Pynursla	Residential Area Open space	4 -	3,120 400
24	Pongtung	Forest Residential/ commercial Area	1 31	600 3,270
25	Pomshutia	Forest Agriculture field Residential/ commercial Area	1 1 21	175 175 370
26	Whakdait	Plantation	-	180,330
27	Umsyiem	Plantation	-	148,530
28	Bakur	Residential Area Plantation Agricultural Land	21	5,710 19,500 11,700

Source: JICA Study Team

Survey aforementioned does not provide enough information of community land. Trough site survey, satellite photograph, and map of "Forest Flora" shown in Figure 7-24 and 7-25, composition of 234.4ha of land affected by this project was estimated. The area consists of approximate 52.48% of forest, 27.45% of agricultural land, 11.18% of residential area, 1.92% of military area and 1.86% of sand and quarry site.

Table 6-101: Utilization of Affected Land

(m^2)

District	Block	Forest Area	Agricultural Area	Residential Area	Defense Area	Quarry	Other Area	Total
East Khasi Hills	Mylliem	207,040	48,726	40,840	45,120	1,500	38,900	382,126
	Khatarshnong Laitkroh	42,103	155,337	32,450	0	30,000	0	259,890
	Pynursla	974,631	430,580	170,945	0	12,000	80,984	1,669,140
West Jaintia Hills	Amlarem	6,810	9,000	17,930	0	0	0	33,740
Total		**1,230,584** (52.48%)	**643,643** (27.45%)	**262,165** (11.18%)	**45,120** (1.92%)	**43,500** (1.86%)	**119,884** (5.11%)	**2,344,896**

※Except first half of Bypass 2 which is outside of project section
Source: JICA Study Team

3) Impact on Trees and Crops

The entire stretch of the project road has a large number of trees, vegetable and paddy fields. The State Government Agriculture Department, Horticulture Department with their fields of vegetables, flowers and fruits and tea, are all located along the project road. Towards the end of the project road, starting from Wahlynkhat to Dawki, a series of Betel Nut plantation is seen along the project area. Betel Nut trees are a major source of income for the people in this area. The widening and improvement plan will be affecting these trees and the land. Approaches to restore the loss of the trees is vital to reduce the adverse impact of the project.

Affected Trees is as shown in Table 6-102 while this does not provide enough information of trees in community forest. Estimated tree number calculated by total square measure of affected forest is as shown in Table 6-103.

Table 6-102: Affected Trees (1)

Village name		Type	Number
1	Umshyrpi bridge	-	0
2	101 Area	Under Survey	
3	5th mile	-	0
4	Mylliem Marbaniang	Small tree Medium tree Fruit	1,475 15 5
5	Mylliem mawrie	Plum tree	6
6	Madan ing Syiem	-	0
7	Kyndong Nongkyntir	Small tree Fruit	16 48
8	Umlympung 12 mile	-	0
9	Umtyngngar	Plum tree Fruit	7 4
10	Beh Syiem 15 mile	-	0
11	Madan Panpoh	-	0
12	Lumshalla	Fruit	20
13	Laitlyngkot	-	0
14	Pomlum (Pynursla)	-	0
15	Mawkajem	-	0
16	Rngain	-	0
17	Langkyrdem	-	0
18	Langkawet	Under Survey	
19	Nongmadan Shadsngi	Under Survey	

	Village name	Type	Number
20	Urksew wahpathaw	Under Survey	
21	Siatbakon	Small tree	10
22	Risawkur	Pine tree	3
23	Nongshyrngan Pynursla	Small tree	10
24	Pongtung	Fruit	10
25	Pomshutia	N/A	
26	Wahkdait	Small tree Medium tree	17,401 4,406
27	Umsyiem	Small tree Medium tree	8,334 1,361
28	Bakur	Betel nut	700

Source: JICA Study Team

Table 6-103: Affected Trees (2)

	Type	Number
1.	Khasi Pine	6,400
2.	Broad Leave Tree (Such as Teak etc.)	113,600
3.	Betel Nut	23,500
4.	Other Fruit bearing tree/Bamboos/Jack Fruit etc.	4,100
	Total	147,600

Source: JICA Study Team

Affected Crops is as shown in Table 7-104.

Table 6-104: Affected Crops

	Village name	Type	Number
1	Umshyrpi bridge	-	0
2	101 Area	Under Survey	
3	5th mile	-	0
4	Mylliem Marbaniang	-	0
5	Mylliem mawrie	-	0
6	Madan ing Syiem	-	0
7	Kyndong Nongkyntir	Paddy Vegetable	50,000 120,000
8	Umlympung 12 mile	N/A	
9	Umtyngngar	Crop	20,000
10	Beh Syiem 15 mile	-	0
11	Madan Panpoh	-	0
12	Lumshalla	Crop	20,000
13	Laitlyngkot	-	0
14	Pomlum (Pynursla)	-	0
15	Mawkajem	-	0
16	Rngain	-	0
17	Langkyrdem	-	0
18	Langkawet	Under Survey	
19	Nongmadan Shadsngi	Under Survey	
20	Urksew wahpathaw	Under Survey	
21	Siatbakon	Pumpkin Vegetable	20,000 120,000
22	Risawkur	Crop	108,000
23	Nongshyrngan Pynursla	Crop	20,000

	Village name	Type	Number
24	Pongtung	Crop	120,000
25	Pomshutia	Crop	-
26	Wahkdait	Betel nut	6,370,000
27	Umsyiem	Betel nut	4,050,000
28	Bakur	Betel nut	1,982,000

Source: JICA Study Team

(4) Livelihood Survey

1) Education Level of PAPs

Education Level of PAPs is as shown in below.

Of the PAPs, 23.63% have had no education at all. About a quarter, 35.08%, have completed elementary education, 25.27% have completed high elementary school, and only 6.22% have completed high school. Only 1.49% of the PAPs have completed college or graduate school.

Table 6-105: Education Level of PAPs

District	Block	No Education	Completed Primary	Completed Upper Primary	Complete High School	Not complet-ed college	Graduate or Higher	No response	Total
East Khasi Hills	Mylliem	16	15	41	13	3	4	7	99
	Khatarshnong Laitkroh	21	16	8	1	0	0	0	46
	Pynursla	51	93	43	11	3	2	10	213
West Jaintia Hills	Amlarem	7	17	19	0	0	0	1	44
Total		**95** (23.63%)	**141** (35.08%)	**111** (25.27%)	**25** (6.22%)	**6** (1.49%)	**6** (1.49%)	**18** (4.48%)	**402**

Source: JICA Study Team

2) Literacy

Table 6-106 below indicates Average Literacy of PAPs. As mentioned in 7.6.5 Baseline Data of the Natural and Socio-economic Environment, average literacy of East Khasi Hills district is 84.15%, and that of West Jaintia Hills district is 63.12%, therefore Literacy of affected villages indicate slightly higher than standard.

Table 6-106: Literacy

District	Block	Literacy Rate		
		Total	Male	Female
East Khasi Hills	Mylliem	86.52%	88.30%	84.30%
	Khatarshnong Laitkroh	80.73%	78.87%	82.48%
	Pynursla	85.06%	85.05%	85.06%
West Jaintia Hills	Amlarem	83.25%	89.38%	76.26%
Total		**85.24%**	**86.30%**	**84.05%**

Source: Census2011by JICA Study Team

2) Occupation

Table 6-107 below indicates that the majority (53.23%) of the PAPs are self-employed. Men and women in the project area are more inclined to earn their livelihood through self-employment such as running a shop (tea, groceries, vegetables etc), manage a sand or stone quarry, or provide private transport for tourists, etc. There are 26.87% that earn their livelihood through agriculture, growing vegetables in their own garden or a bigger land attached to their homes, 3.73% are in government services and 1.49% are unskilled laborers.

Table 6-107: Occupation

Dist.	Block	Agriculture / Allied Agriculture	Dairy	Household /Cottage Industry	Self Employed	Skilled Profession	Unskilled Labor	Private Service	Gov. Service	Other/ No response	Total
East Khasi Hills	Mylliem	9	0	0	65	2	0	0	11	12	99
	Khatarshnong Laitkroh	11	1	2	22	1	0	0	1	8	46
	Pynursla	69	1	2	103	0	6	3	3	26	213
West Jaintia Hills	Amlarem	19	0	0	24	0	0	0	0	1	44
Total		**103** (26.87%)	**2** (0.50%)	**4** (1.00%)	**214** (53.23%)	**3** (0.75%)	**6** (1.49%)	**3** (0.75%)	**15** (3.73%)	**47** (11.69%)	**402**

Source: JICA Study Team

4) Number of employed members in PAHs

Table 6-108 below indicates that number of employed members in a PAPs. Out of the total 402 PAHs surveyed, the total number of adults is 2,148, out of which 39.2% are employed and 16.5% are unemployed, while 8.5% are involved in housework.

Table 6-108: Number of employed members in PAHs

District	Block	Employed	Unemployed	Housework	Students	Total
East Khasi Hills	Mylliem	128	48	41	127	344
	Khatarshnong Laitkroh	88	37	10	88	223
	Pynursla	299	145	62	271	777
West Jaintia Hills	Amlarem	40	4	8	21	73
Total		**555** (39.2%)	**234** (16.5%)	**121** (8.5%)	**507** (35.8%)	**2,148**

Source: JICA Study Team

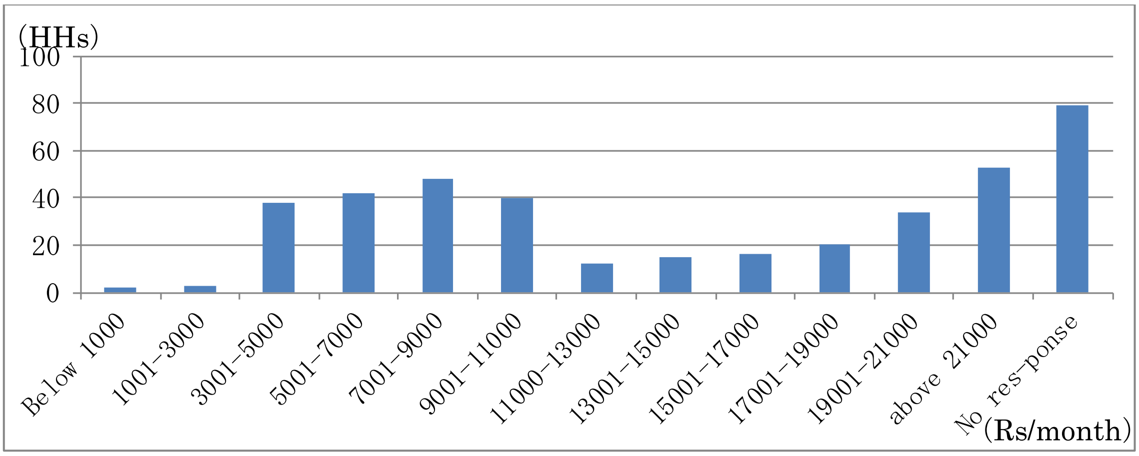
3) Total monthly household income of HHs from all sources:

Table 6-109 below indicates the total monthly income of the PAH; Approximate 40% of the PAPs have a monthly income that falls within Rs 3000/-11000. Majority is 11.94% within Rs 7000/- 9000 followed by 10.45% those earning between Rs 5000 to 7000. HHs below Poverty line is 10.7% earning below Rs 5000/-. As shown in Table 6-110, average monthly income is Rs 12,400.

Table 6-109: Total monthly household income of H/H from all sources (INR/month)

Dist.t	Block	Below 1000	1001 - 3000	3001 - 5000	5001 - 7000	7001 - 9000	9001 - 11000	11000 - 13000	13001 - 15000	15001 - 17000	17001 - 19000	19001 - 21000	above 21000	No res-ponse	Total
East Khasi Hills	Mylliem	0	0	4	10	13	8	2	1	3	0	7	21	30	99
	Khatarshnong Laitkroh	0	1	11	8	9	4	2	2	1	0	1	3	4	46
	Pynursla	2	2	18	20	22	19	3	7	11	19	26	29	35	213
West Jaintia Hills	Amlarem	0	0	5	4	4	9	5	5	1	1	0	0	10	44
Total		**2** (0.50)	**3** (0.75)	**38** (9.45)	**42** (10.45)	**48** (11.94)	**40** (9.95)	**12** (2.99)	**15** (3.73)	**16** (3.98)	**20** (4.98)	**34** (8.46)	**53** (13.18)	**79** (19.65)	**402** **(100)**

Source: JICA Study Team



Source: JICA Study Team

Table6-1: Total monthly household income of H/H from all source

Table 6-110: Average income of HHs (Rs/month)

District	Block	Average (Rs. / month)
East Khasi Hills	Mylliem	13,700
	Khatarshnong Laitkroh	8,600
	Pynursla	13,300
West Jaintia Hills	Amlarem	9,700
Total Average		**12,400**

Source: JICA Study Team

(5) Land System

Land system is as shown in Table below.
Majority is 37.81% HHs of private land out of 402 HHs, followed by 34.33% of village council pass 60HHs.

Table 6-111: Land System

District	Block	Private Land with Land Settlement Certificates	Periodic Patta	Home Site	Village Council Pass	Others	No response	Total
East Khasi Hills	Mylliem	48	15	1	5	1	29	99
	Khatarshnong Laitkroh	24	2	14	0	5	1	46
	Pynursla	56	14	7	118	7	11	213
West Jaintia Hills	Amlarem	24	2	0	15	0	3	44
Total		**152** (37.81%)	**33** (8.21%)	**22** (5.47%)	**138** (34.33%)	**13** (3.23%)	**44** (10.95%)	**402**

Source: JICA Study Team

Table 7-112: Land System with Affected Houses

District	Block	Private Land with Land Settlement Certificates	Periodic Patta	Home Site	Village Council Pass	Others	No response	Total
East Khasi Hills	Mylliem	39	15	1	5	0	16	76
	Khatarshnong Laitkroh	24	2	14	0	5	1	46
	Pynursla	56	2	7	59	7	10	141
West Jaintia Hills	Amlarem	24	1	0	0	0	3	28
Total		**143** (49.14%)	**20** (6.87%)	**22** (7.56%)	**64** (21.99%)	**12** (4.12%)	**30** (10.31%)	**291**

Source: JICA Study Team

- Periodic Patta : Patta issued by State government for land acquisition with limited period.
- Village Council Pass : Issued within the field of village council, function as right to use the land conventionally

(6) Vulnerability

17.7% of HHs are headed by a female. 21.6% of HH are headed by the persons over 55 years old. 13.2% are BPL and 95.48% of the affected HHs are STs.

Table 6-113: Vulnerability

(HHs)

District	Block	Female HH	HH above 55	Minority	Below Poverty Line	Total Vulnerable	Total HHs
East Khasi Hills	Mylliem	36	20	6	5	51	99
	Khatarshnong Laitkroh	3	11	1	15	23	46
	Pynursla	27	42	1	28	78	213
West Jaintia Hills	Amlarem	5	14	0	5	19	44
Total		**71** **(17.7%)**	**87** **(21.6%)**	**8** **(2.0%)**	**53** **(13.2%)**	**171** **(42.5%)**	**402**

* There are HHs doubled in the table, so that total HHs and number of vulnerable do not correspond.
Source: JICA Study Team

6.11.4 Compensation and Assistance Policy

(1) Objective of Policy Framework

The resettlement policy of the project is prepared according to the principles of the R& R policy of the GOI and in line with requirements of JICA guidelines and policies. For ensuring compensation with replacement cost, structure cost shall be compensated without depreciating.

Cut-off date and compensation policy is as shown below.
<Cut-off Date>
Completion date of census of JICA Study: End of November, 2016
SIA based on LARR 2013: Date of SIA notification from Revenue Department after approval of DPR (the beginning of 2017)
<Compensation Policy>
In appreciating this verity, the policy framework for this project can realize the following:

Table 6-114: Compensation Policy

Item	Contents
Fundamental Items	➢ Collate all the successful RAPs of similar projects in Meghalaya – (a).Road upgradation (Shillong- Nongstoin- Tura) Project, 2 laning of Shillong Nongstoin NG 44 and Nongstoin-Tura road under phase A of SARDP-NE. (b). Jorabad-Shillong NH 40 road project (4 laning of Jorabad Shillong section) under the SARDP-NE. and examine Specific measures according latest law and JICA's Guideline. Strengthen the capacity of the various institutions relevant to the project especially those implementing the project from the Government side, in terms of comprehension and practical execution of RAP and livelihood restoration. ➢ Establish a grievance redressal Mechanism that will ensure that the issues of project affected people are heard and addressed, resulting in a fair and justified RAP. ➢ Child labour will not be involved.
Consideration Level	➢ The affected Community is involved from the initial phase; through community and stakeholder meetings, FGDs, that informs the people about the project and their views are noted. The consent of the community, especially the PAPs is compulsory for initiation of the survey and the project at large. ➢ When displacement in inevitable, people affected will be assisted in measures that will better their current status of living without having to bear any cost.
Specific measures	➢ The property and asset (building, land, forest, products etc.) shall be compensated as same or better than before resettlement. ➢ The income of the PAPs must improve after resettlement by supporting agricultural production and compensating income. ➢ In case change of occupation, job training will be provided. ➢ Payment of compensation and assistance to PAPs will be ensured before the civil work of the project starts. ➢ All land acquisition will be carried out after issuance of notifications for harvesting of crops. ➢ Women workers will be provided with gender friendly facilities on project site, and be paid equal wages for equal volume of work. ➢ Health Education focusing on HIV, STIs at the project sites, labour camps, will be compulsory when the civil work starts.

Source: JICA Study Team

(2) Rehabilitation Plan

The rehabilitation plan should consider the present socio-economic status of the PAPs. The survey conducted captures this information and helps in formulating a plan that considers the peoples' current way of life and how a new environment can better their standard of living. A key objective of RAP is to enhance the livelihood of PAPs and ensure that their resettlement is not lowering their quality of life. The rehabilitation plan is to be developed and implemented by the state government; inputs and feedback from relevant stakeholder / communities must be incorporated in the plan through a series of discussions and workshops. The plan should be outlined within the framework of the policies and guidelines of JICA and the state / country policy.

The objectives of Rehabilitation Plan in this project is following;

- Agricultural Land affected by the project, PAPs working at sand and quarrying
- Residents whose occupation affected directly (resettlement) or indirectly (decreasing income by construction of bypass) by the project.

Measure 1. Job Training
Purpose: - Train for earning by new occupation
Countermeasure: -Survey the applicants and their demand for new occupation.
-Based on possibility of project, market and advice from Experts, consider contents of job training.
-Programs of seminar or practice for job training
-Provide the opportunity of job training

Measure 2. Provide and enhance the chance of Employment
Purpose: -Increase the production of existing agriculture and quarrying etc.
Countermeasure: -Based on survey of household livelihood and opinion of PAPs, consider measures to provide and enhance.
-Consider according to expert's advice based on possibility of project and market
-Consider reduction of individual expense, such as leased land or group purchase in case of land expansion

Measure 3. Financial Support
Purpose: -Better economic situation after resettlement
Countermeasure: -Establishment of Microfinance (Low / Non interest)
-Subsidy

Measure 4. Employment in short term
Purpose: -Make opportunity of short term employment in relocated place until getting stable income by the main job.
Countermeasure: -Make opportunity of short term employment

Table 6-115: Entitlement Matrix

Type of loss	Occupant of property	Unit of Entitlement	Entitlement	Details of Entitlement
1. Agricultural Land	Titleholder Periodic Patta Holder/Temporary Village Pass Holder	Household	Compensation at Replacement value and Assistance	a) Land for land, if available. Or cash compensation for the land at replacement cost(*), which will be determined by District Collector. b) If the compensation amount is less than the replacement cost mentioned above, the difference amount will be paid as Assistance. c) If the residual land is unviable for agriculture, PAPs shall have the following three options: • Compensation for affected land and continue on the remaining unaffected plot of land; or • If eligible person surrenders the residual plot, then compensation and assistance given for the entire plot of land; or • Replacement land, if so wished by eligible persons, subject to availability of land that is at least equally productive. d) Resettlement allowance of Rs. 50,000/- will be provided to those who do not get land for land, irrespective of the size of land. e) In case of severance of cultivable land, an additional grant of 10% shall be paid over and above the amount paid for land acquisition.
	Community	Community	Same as above	a) Land for land, if available. Or cash compensation for the land at replacement cost, which will be determined by District Collector. b) If the compensation amount is less than the replacement cost mentioned above, the difference amount will be paid as Assistance. *Distribution of the compensation will be determined through consultation within the community.
2. Non-Agricultural land (Homestead, Commercial and others)	Titleholder Periodic Patta Holder/ Temporary Village pass Holder	Household	Compensation for structure at Replacement Cost plus assistance	a) Land for land, if available. Or cash compensation for the land at replacement cost, which will be determined by District Collector. b) If the compensation amount is less than the replacement cost mentioned above, the difference amount will be paid as Assistance c) Resettlement allowance of Rs. 50,000/- will be provided irrespective of the size of land.

Type of loss	**Occupant of property**	**Unit of Entitlement**	**Entitlement**	**Details of Entitlement**
	Community	Community	Same as above	a) Land for land, if available. Or cash compensation for the land at replacement cost, which will be determined by District Collector. b) If the compensation amount is less than the replacement cost mentioned above, the difference amount will be paid as Assistance. *Distribution of the compensation will be determined through consultation within the community.
3. Loss of Crops	Owner/ occupant	Household	Compensation	a) Revenue Department or Special Committee to determine the current cost. b) Four (4) months notice to harvest standing crops shall be given. However, if notice cannot be given then compensation for these crops shall be paid at market value c) Subsistence Grant equivalent to Rs. 3000/- (MAW; Minimum Agriculture Wage) per month for 6 months.
	Community	Community	Same as above	a) Revenue Department or Special Committee to determine the current cost. b) Four (4) months notice to harvest standing crops shall be given. However, if notice cannot be given then compensation for these crops shall be paid at market value *Distribution of the compensation will be determined through consultation within the community.
4. Loss of Plants/trees	Owner/ occupant	Household	Compensation	Revenue Department or Special Committee to determine the current cost. For perennial fruit bearing trees such as pineapples, jackfruits, Arecanutetc, average productivity of such trees will be taken as 20 years.
	Community	Community	Same as above	Revenue Department or Special Committee to determine the current cost. For perennial fruit bearing trees such as pineapples, jackfruits, Arecanutetc, average productivity of such trees will be taken as 20 years. *Distribution of the compensation will be determined through consultation within the community.
5. Loss of Cattle shed, poultry shed or any other shed for domestic animals	Owner/ Occupant	Household	Compensation	Rs.600 per m^2 for thatched roof and Rs. 1000 per m^2 for GCI sheet roof (to be paid as per revised/latest available updated basic schedule of rates for buildings). In case of non-revision, 10%premium per year will be added to the latest rate available.

Type of loss	Occupant of property	Unit of Entitlement	Entitlement	Details of Entitlement
6. Loss of Residence/ Commercial unit	Tenant	Household	Assistance	a) The amount of deposit or advance paid by the tenant to the landlord or the remaining amount at the time of expropriation (this will be deducted from the payment to the landlord) b) Subsistence grant of Rs.3,000/-per month for a period of twelve (12) months from the date of displacement c) Lump sum shifting allowance of Rs. 15000/- d) Resettlement allowance of Rs. 50,000/- will be provided irrespective of the size of land
7. Loss of Kiosk	Owner/ Occupant	Household	Assistance	a) Lump sum shifting allowance of Rs.7500/- b) Right to salvage materials from the existing structure
8. Loss of employment	Wage earner	Household	Assistance	a) Economic Rehabilitation Grant equivalent to twenty-five (25) days of Minimum Agricultural Wages (MAW) per month for a period of three months. b) Priority work opportunities in the project construction work c) Rs.20000/- towards vocational/skill improvement as per choice.
9. Loss of livelihood (losing commercial unit . losing agricultural land and with balance land below MEH)	Titleholder/Periodic Patta holder/ Village Pass holder	Household	Assistance	a) Priority work opportunities in the project construction works. b) Rs. 20,000/- towards vocational skill improvement as per choice. The amount will cover daily stipend equivalent to MAW for the duration of training and shall also cover costs towards boarding, lodging, transportation, etc.
10. Additional support to vulnerable groups	Titleholder/Periodic Patta/Village Pass holder	Household	Assistance	One time additional financial assistance of Rs.25000/- as Economic Rehabilitation Grant towards income generation.

Type of loss	Occupant of property	Unit of Entitlement	Entitlement	Details of Entitlement
11. Loss of common property Resource	Village	Village	Enhancement of community resources	Replacement /Restoration or augmentation of existing infrastructure and provision of additional infrastructure facilities based on identified need
12. Loss of Access	Village	Village	Alternate access	Provision of access path(s), steps, footpaths at identified locations in consultations with community
13. Temporary and unforeseen impacts.	Affected entity	Household	Mitigation measures in line with principles of resettlement policy framework	Unforeseen and temporary impacts during construction will be documented and dealt with on case by case basis through the GRM in accordance with the principles laid down in the resettlement policy framework

Source: JICA Study Team

*Replacement cost

Referring to JICA project (Bengaluru Peripheral Ring Road Project) after implementation of LARR2013, surmised as below;

・**Land price**

1. Market price decided by Deputy Commissioner	2. Annual Interest 12%	3. Rural are Multiplier (x1.0-2.0、Figure x2.0)	4. 100% Solatium (Re-add the total of 1-3)

This meets the replacement cost of World Bank op.4.12 (market price + the cost of preparing the land to levels similar to those of the affected land +tax), so that land price calculated by LARR is applied.

・**Structure Price**

1. Standard price by State Government	2. 100% Solatium

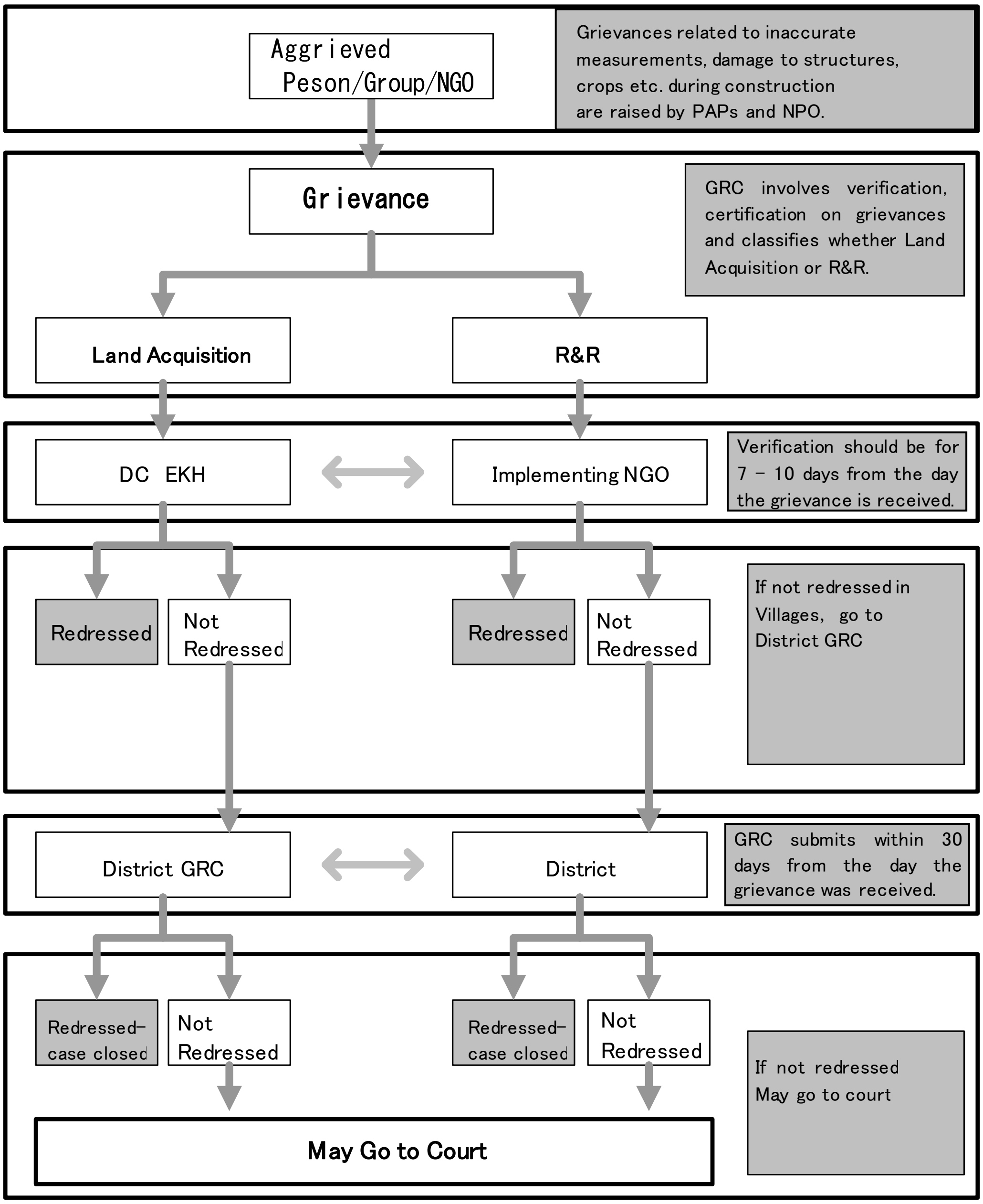
While this meets the replacement cost (market price of the materials to build a replacement structure + the cost of transporting building materials to the construction site + the cost of any labor and contractors' fees +tax) of World Bank op.4.12, LARR2013 usually applies the price of with depreciation. This project demand to apply the price without depreciation.

In project of NH51(Tura-Dalu) of the State, State Revenue and Disaster Management Department issued the Request Letter of resettlement and land acquisition based on RAP to Deputy Commissioner. Procedure like this is confirmed to be implemented for this project.

6.11.5 Grievance Redress Mechanism

In order to provide an accessible mechanism to the affected people, community and any stakeholder(s) to raise their issues and grievances as well as concerns, a Grievance Redress Mechanism (GRM) will be established within the project. The fundamental objectives of the GRM are to resolve any land acquisition disputes in consultation with the aggrieved party to facilitate the smooth implementation of the project.

Procedure and role of GRM is as shown below;



Source: JICA Study Team

Figure 6-43: Grievance Redress Mechanism

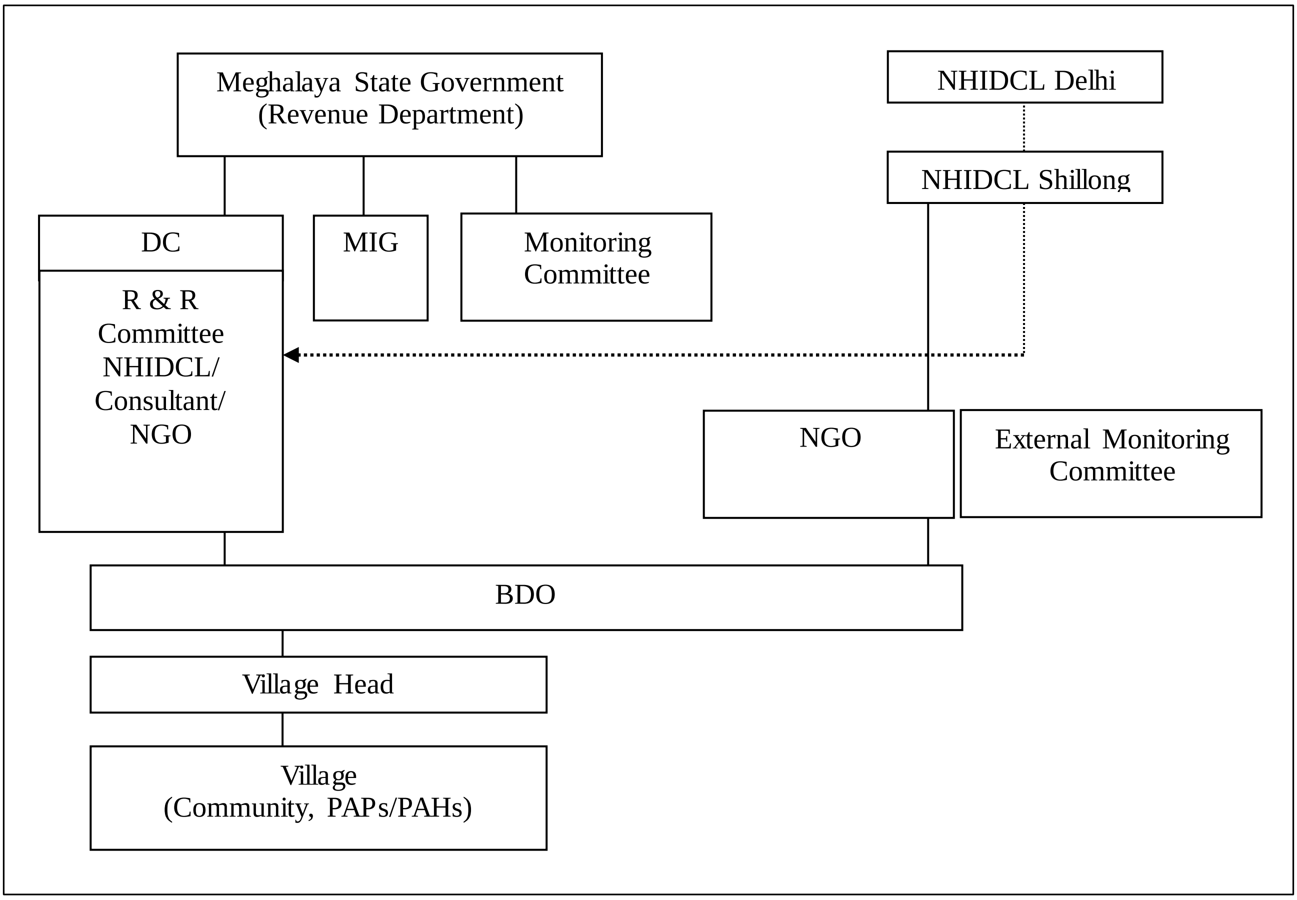
6.11.6 Institutional arrangements

As per Indian regulations, the resettlement and rehabilitation activities must be executed by the state government. Since the state of Meghalaya falls under the 6th Schedule of the Indian Constitution, the Autonomous District Councils (ADC) established in the state play a major role in administration and governance. Hence, it is only expected that the ADC, in this case the Khasi Hills and Jaintia Hills ADC, the traditional heads / headmen are involved in the R&R activities, for they have a major role to play in land acquisition and land management. It is also recommended that a project implementation unit (PIU) be set up in the district, and an expert from NHIDCL with relevant officers at the district and state level ensure that the RAP implementation is moving along in line with JICA Guidelines for Environment and Social Considerations.

Table 6-116: Implementation Institute and their Roles

Name	Members and Roles
Central Level Institution	
National Highways and Infrastructure Development Corporation Limited (NHIDCL)	Project Implementation Institution
State Government	
Revenue and Disaster Management Department	SIA : Notification of procedure for Land Acquisition
Local Government	
KHADC : Khasi Autonomous District Council	Member of GRC Issue No Objection Certificate for Land Acquisition
JHADC : Jaintia Autonomous District Council	
DC.EKH : Deputy Commissioner of East Khashi Hills District	Have the responsibility of Land Acquisition, Resettlement and Rehabilitation
DC.WJH : Deputy Commissioner of West Jhaintia Hills Distict	
Others	
GRC : Grievance Redress Committee	Consist of Deputy of NHIDCL, PWD, East Khasi and West Jaintia for Grievance Redress. Members are not less than 3 from different position.
PAP : project affected persons	Representative of Project affected person, NGO may be included.
Village Community	Verification, Certification of Grievance
MIG : Meghalaya Institute of Governance	Implementation Institute of SIA
NGO : Non Governmental Organization	Support PAPs, Function as a link between Government and District Administration. - Role as PAPs and Spokesperson of project - Support NHIDCL to mitigate adverse impact for project - Interface between local communities and NHIDCL - As a link of NHIDCL, Government, and Autonomous District Councils.

Source：JICA Study Team



NHIDCL:National Highways and Infrastructure Development Corporation Limited
DC:Deputy Commissioner, MIG: Meghalaya Institute of Governance, BDO: Block Development Officer
Source: JICA Study Team

Figure 6-44: Institutional arrangements

6.11.7 Resettlement Schedule

Resettlement Schedule is as shown below, and it is implemented in accordance with principal activities as below.

Table 6-117: Resettlement Schedule

Year	2017				2018				2019				Department	
Quarter	1	2	3	4	1	2	3	4	1	2	3	4	Management	Implementation
Preparation														
Completion of ROW drawings	■	■											DC	DC
Hiring NGO for RAP Preparation	■	■	■	■									NHIDCL	NGO
Verification and update RAP			■	■									PWD	MIG
Preparation of Rehabilitation Plan			■	■									DC	NGO
Submission of revised RAP to JICA				■									DC	NGO
RAP budget approval from Central Government				■									NHIDCL	DC
Disclosure of revised RAP				■	■	■	■	■	■	■	■	■	Revenue Dep.	Revenue Dep.
Establish Grievance Redress Mechanism				■	■	■	■	■	■	■	■	■	DC	ADC, NGO
Declaration of cut-off date (LA notification)				■									Revenue Dep.	Revenue Dep.
Preparation of resettlement sites				■	■	■	■	■					DC	R&R Committee
Implementation														
Rehabilitation				■	■	■	■	■	■	■	■	■	DC	R&R Committee
Disbursement of compensation and assistance				■	■	■	■	■					NHIDCL	DC/ NGO
Physical displacement						■	■	■	■				DC	R&R Committee
Taking possession of acquired land						■	■	■	■	■	■		DC	R&R Committee
Handover of acquired land to contractor						■	■	■	■	■	■		DC	R&R Committee
Monitoring														
Half-yearly report					■		■		■				Revenue Dep.	Monitor.Commit..
Completion report											■		Revenue Dep.	Monitor.Commit..
Road Construction Civil Works									■	■	■	■	NHIDCL	Contractor

NHIDCL:National Highways and Infrastructure Development Corporation Limited
DC: Deputy Commissioner, ADC: Autonomous District Councils, R&R Committee: Rehabilitation and Resettlement Committee
Source: JICA Study Team

Phase of Resettlement and Rehabilitation

To summarize, the proposed R&R activities are divided in to three broad categories based on the stages of work and process of implementation. The following are details of activities involved in these three phases, i.e. Project Preparation Phase, Resettlement Plan (RP) Implementation phase, Monitoring and Evaluation period:

(a) Project Preparation Phase

- The major activities to be performed in this period include the establishment of PMU and PIU at the project level.
- Appointment of NGO and establishment of the GRC, etc.
- The information campaign & community consultation will be a process initiated from this stage and will go on till the end of the project. Information dissemination through consultations, community meetings using brochures / leaflets that inform the community about the resettlement policy, entitlements and any necessary information deemed relevant for project effectiveness. The language of the dissemination must be in the regional language.

(b) RP Implementation Phase

- After the project preparation phase, the next stage is the implementation of RP which includes issuing the compensation by the EA; payment of all eligible assistance; relocation of PAPs; initiation of economic rehabilitation measures; site preparation for delivering the site to contractors for construction, and finally starting civil work.

(c) Monitoring and Evaluation Period

As mentioned earlier, internal monitoring will be the responsibility of the PMU, PIU and the implementing NGO, and will start early during the project when the implementation of the RP starts, and will continue till the complementation of the project. The independent monitoring and evaluation will be the responsibility of an external agency to be hired for the project.

The R&R implementation schedule will follow the key activities below.

i. State government shall by notification appoint an officer not below the rank of joint collector or additional collector or deputy collector or equivalent official of the Revenue Department, to be the administrator for R&R for the project.

ii. The administrator for R&R, to enable him / her to function efficiently, will be provided with such powers, duties and responsibilities as prescribed by the appropriate government. He / she will also be provided with office infrastructure and be assisted by officers and staff who shall be subordinate to him / her as the appropriate government may decide.

iii. The state government shall also appoint an officer of the rank of commissioner or secretary for R&R who will be responsible for supervising the formulation of R&R schemes or plans and the proper implementation of the same. He / She will also be responsible for the post – implementation social audit.

iv. Under the chairmanship of the administrator of R&R, the state government shall constitute a committee called the Rehabilitation and Resettlement Committee. The committee may consist of members as per details provided by the RFCTLARR 2013 section vi clause 45 (2).

v. A notification regarding the project affected land will be published in the official gazette, two daily newspapers, of which one is of the regional language, in the respective village Dorbar office, the office of the district collector and the sub-divisional magistrate, uploaded in the official website of the government and in the affected villages.

vi. Immediately after issuance of the notification, the ADC shall be informed of the notification issued at a meeting called especially for the purpose.

vii. Appraisal of Social Impact Assessment Report by Expert Group. The appropriate government will ensure that the SIA be evaluated by an expert group (consisting of members as prescribed in the RFCTLARR 2013 chapter II Clause 7 (2).

viii. Update the list of PAP through the Detailed Measurement Survey DMC.

ix. Conduct a survey and undertake a census of the affected families - inventory of affected properties and assets estimation.

6.11.8 Resettlement Budget and its Source

The resettlement budget takes account of compensation for affected land, structures, trees, resettlement assistance, institutional cost, hiring of RAP implantation agency, contingency, HIV / STI awareness activities, capacity building, external monitoring and evaluation consultants, documentation and internal monitoring, and institutional costs.

Table 6-118: R&R Budget

Item	Unit	Unit Cost	Quantity	Total (Rs)
I. Compensation				
Land (construction)	ha	1,500,000	234.49	351,734,400
Land (surplus soil)		1,000,000	52.82	52,820,000
Rural area multiplier	*the land price will be double for compensation of rural area land as per LARR 2013			809,108,800
Structure	Sq. m		34,500	81,690,000
Trees	No.			258,900,000
Crops	No.			683,226
Solatium	*100% of compensation as per LARR 2013			1,150,382,026
Sub-Total (I)		**2,300,764,052**		**2,282,258,000**
II. Allowance				
Moving allowance	Household	50,000	307	15,350,000
Subsistence allowance	Household	36,000	307	11,052,000
Assistance to vulnerable	Household	25000	180	4,500,000
Training	Household	20,000	307	6,140,000
Sub-Total (II)				**37,042,000**
III. Implementation				
Expert fees	Lump sum			7,000,000
Staff training	Lump sum			1,000,000
External monitoring	Lump sum			15,000,000
NGO	Lump sum			2,000,000
Information disclosure	Lump sum			1,000,000
Livelihood restoration	Lump sum			10,000,000
Sub-Total (III)				**36,000,000**
Sub-Total (I+II+III)				**2,373,806,052**
Contingency (10%)				**237,380,605**
Total				**2,611,186,657**

Source: JICA Study Team

Funding for the resettlement budget will be secured by MORTH from the national budget based on an application from NHIDCL. The budget will be transferred from MORTH to DC through NHIDCL, and disbursed to entitled households / communities.

6.11.9 Monitoring and Evaluation

Monitoring and evaluation are critical for building a strong, evidence-based documentation surrounding the project. It is also a tool for identifying and documenting successful programmes and approaches and tracking common indicators across related projects. Monitoring and evaluation forms the basis of understanding around the many multi-layered factors underlying a project. Since this is a project which deals with infrastructure development and involuntary resettlement, it must employ strong monitoring mechanisms all the more. RAP implementation issues can be resolved more effectively when the project has a strong system of checks and balances, thereby resulting in good management.

Evaluation allows the project to go through periodic assessments to examine impacts and sustainability; it especially assists the project in attaining its achievement index, and in reviewing its current approach and strategies to better the outcome of the project. Monitoring and evaluation are tools that are indispensable in the RAP implementation, for it ensures the performance and fulfillment of the project objectives.

The project can adopt two types of monitoring; internal monitoring and external monitoring and evaluation.

Internal Monitoring:
Internal monitoring will be carried out by the PIU, PWD with assistance from the RAP implementation agency. The PIU and PWD will also engage an external agency (third party) to undertake monitoring at different stages of the project, preferably biannually and evaluation at the middle and end of the project. The monitoring and evaluation will consist of a desk review of documentation and field-based work with focus group discussions with the community, stakeholders and the implementation team.

The objectives of internal monitoring is:
- (i) To measure progress against the RAP implementation plan.
- (ii) Confirm if all entitlements agreed upon are delivered to PAPs.
- (iii) Identify critical issues that stall the project, or that are hurting the people, and suggest corrective actions.
- (iv) Monitor the efficiency of the GRM.
- (v) Appraise the satisfaction of PAPs over the activities and implantation of the project.

Design of Monitoring Form is as shown below;

Table 6-119: Monitoring Form Design(Summary)

	Major items of action	Specific action steps (sub-items)	Progress in quantity	Progress during the month in %	Cumulative Progress in %
1	Recruitment, training and deployment	Deployment of staff, Training and mobilization (MM)			
2	Adopting the Land Resettlement Plan	Review of RP, Approval of RP with corrections (%)			
3	Socioeconomic Survey	Field Survey and collection of data, Data analysis and report generation (%)			
4	Valuation of affected property	Collection of data (%)			
5	Information campaign	Distribute information brochure(books) Public consultation meetings/FGD(frequency)			
6	Relocation of Project Affected Persons	Payment of Transfer Grant(No.of person)			
7	Identification of Eps	Assigning ID numbers (No. of Person)			
8	Grievance Redress	Receiving complaints / claims from EPs (No.of case)			
9	Information Management/ Technical services	Finalization of resettlement budget, Preparation of information brochure, Designing ID card (%)			
10	Resettlement of Project Affected Persons.	Opening bank account (No.of case) Assist vulnerable EPs in resettlement(No.of case)			
11	Supervision and Management	Supply of manpower (MM)			
12	Performance Reporting	Inception / Monthly progress / Draft final report (books)			

Source:JICA Study Team

External Monitoring:

The fundamental objectives of external monitoring is as follows:

(i) To assess the overall compliance of RAP in the project.

(ii) To assess the extent of the livelihood restoration efforts of affected communities; to assess whether their quality of life is enhanced.

(iii) To authenticate the measures taken for the restoration of livelihoods of affected communities.

Table 6-120: Terms of Reference of the External Monitoring(design)

Scope of Work (1) To review and verify the progress in land acquisition/resettlement implementation of the Project and whether they have been followed as provided in the RAP. (2) Provide a summary of whether involuntary resettlement was implemented (a) in accordance with the RAP, and (b) in accordance with the stated policy. (3) Verify expenditure & adequacy of budget for resettlement activities. (4) Describe any outstanding actions that are required to bring the resettlement activities in line with RAP. Describe further mitigation measures needed to meet the needs of any affected person or families judged and/or perceiving themselves to be worse off as a result of the Project. Provide a timetable and define budget requirements for these supplementary mitigation measures. (5) Describe any lessons learned that might be useful in developing the new national resettlement policy and legal/institutional framework for involuntary resettlement. (6) To Identify, quantify, and qualify the types of conflicts and grievances reported and resolved and assess whether the consultation and participation procedures followed in accordance with the RAP. (7) To identify the strengths and weaknesses of the land acquisition/resettlement objectives and approaches, implementation strategies. (8) Identification of the categories of impacts and evaluation of the quality and timeliness of delivering entitlements (compensation and rehabilitation measures) for each category and how the entitlements were used and their impact and adequacy to meet the specified objectives of the plans. The quality and timeliness of delivering entitlements, and the sufficiency of entitlements as per approved policy. (9) To review the quality and suitability of the relocation sites from the perspective of the both affected and host communities. (10) Review results of internal monitoring and verify claims through sampling check at the field level to assess whether land acquisition/resettlement objectives have been generally met. Involve the affected people and community groups in assessing the impact of land acquisition for monitoring and evaluation purposes. (11) To monitor and assess the adequacy and effectiveness of the consultative process with affected APs, particularly those vulnerable, including the adequacy and effectiveness of grievance procedures and legal redress available to the affected parties, and dissemination of information about these.

Source: JICA Study Team

6.11.10 Stakeholder Consultation

The purpose of the stakeholder consultation was to inform people about the project, listen and consider their issues and suggestions. Details are summarized in “7.12 Stakeholders Consultation”.

6.11.11 Indigenous People

(1) Requirement of IPP survey

With reference to the World Bank’s Operational Policy 4.10, Scheduled Tribes in affected areas, such as Khasi, Jaintia and Garo are not necessarily considered to be indigenous peoples while some of the definition can be relevant.

Table 6-121: Definition of Indigenous People in WB OP.4.10

(a) self-identification as members of a distinct indigenous cultural group and recognition of this identity by others
(b) collective attachment to geographically distinct habitats or ancestral territories in the project area and to the natural resources in these habitats and territories
(c) customary cultural, economic, social, or political institutions that are separate from those of the dominant society and culture; and
(d) an indigenous language, often different from the official language of the country or region.

Source: World Bank OP. 4.10

Scheduled Tribes are majority in project site and besides possible to resettle in the same cultural region, therefore it may not suppose the large impact threatening identity of their culture or ethnicity. However, since this project is implemented by India Government, special consideration must be necessary so as not to causing negative impact for culture and tradition of scheduled tribe. In implementation of project, as well as respecting the right of tribal people for acquisition of land and resource, consensus of the peoples must be secured by advanced free consultation with plenty of information. In this project, level of direct or indirect impact for economy, society, culture (cultural heritage) and environment for tribal people living in project area with collective attachment shall be evaluated.

(2) Scope of Work

The social assessment to be undertaken covers the social structure, value system and their assessment in relation to the potential positive and adverse effects, which will be specifically addressed in the elements of IPP. These are not limited to but include the following:

- Gathering of baseline information on the social structure, value system, demographics, political characteristics including the clan system, the land and territories that they have traditionally owned or customarily used or occupied, and the natural resources on which they depend.

- The customary rights of the tribal people, both individual and collective, pertaining to lands or territories they traditionally owned, or customarily used or occupied, and where access to natural resources is vital to the sustainability of their cultures and livelihoods.

- The need to protect such lands and resources against illegal intrusion or encroachment by others.

- The cultural and spiritual values that the tribal peoples attribute to such lands and resources such as the “Sacred Forest” and “Monolith” and others, if any.

- Tribal peoples’ natural resources management practices and the long-term sustainability of such practices.

- Identification of the key project stakeholders and determination of potential adverse impacts for analysis of the relative vulnerability of, and risks to, the affected Scheduled Tribes’ communities given their distinct circumstances and close ties to Khasi Hills and its natural resources, as well as their lack of access to opportunities relative to other social groups in Meghalaya State of India.

- Assessment, based on free, prior, and informed consultation, of the affected Scheduled Tribes’ communities and each clan within the project area of NH40, in terms of the potential adverse and positive effects imposed on them by the project.

- Identification and evaluation, based on free, prior, and informed consultation with the affected Scheduled Tribes’ communities, of measures necessary to avoid adverse effects, or if such measures are not feasible, identify measures to minimize, mitigate, or compensate for such effects, and to ensure that the peoples receive culturally appropriate benefits under the project.

- Review or identify, on a scale appropriate to the project, the legal and institutional framework applicable to the peoples.

In the project, for the possibility of community or tribe to be affected the negative impact by project shall be evaluated by free, prior and informed consultation. Moreover, countermeasure for avoiding negative impact, if it is difficult, measures to mitigate or alleviate the impact for appropriate cultural benefit shall be formulated by advanced consultation.

(3) Traditional Livelihoods in Meghalaya State and Project Districts

Meghalaya is predominantly an agrarian economy. Agriculture and allied activities engage nearly two-thirds of the total work force in Meghalaya. About 80% of the population depends entirely on agriculture for their livelihood. Shifting cultivation and terrace agriculture are the major farming systems practiced by the people in the state. Rice is the dominant food grain crop accounting for over 80% of the food grain production in the state. Other important food grain crops are maize, wheat and a few other cereals and pulses. Besides these are potato, ginger, turmeric, black pepper, areca nut, bay-leaf, betel vine, mustard and rapeseed etc. that are some of the important cash crops. In Meghalaya, land ownership pattern is followed, which means that the village land is communally owned. Shifting cultivation is practiced in these lands and collection of forest products from the forest for sustenance are the main livelihood activities whereas in privately-owned land, settled agriculture is practiced and cash crop cultivation are the main activities.

The state of Meghalaya is endowed with large deposits of valuable mineral resources such as coal, limestone, granite and clay which is also a source of livelihood for the people in this region. The state of Meghalaya is blessed with abundant stone quarries from which stones of various quality and size can be extracted, hence the process of quarrying which means that rock materials are removed from the ground, either manually or mechanically. Among the different types of rocks are sandstone, limestone, marble, granite and slate. Rocks maybe extracted from the hillocks or ground in the form of solid blocks or slabs. Then these are crushed into pieces or broken by manual work.
Carrying livestock is also identified as one livelihood in Meghalaya which can promote self-sustainability and gainful employment to the people of the state.

In Meghalaya non-timber forest products (NTFPs) and medicinal and aromatic plants (MAPs) have become an important source of cash and subsistence income for poor people living near forests. People in this region have traditionally been collecting different forest products from private forests as well as community conserved forests.

(4) Public Consultation

The NGO - ***Tynrai Foundation*** conducted the first round of extensive consultations at the community / village level in the project area during August and September 2016. Community level consultations (FGDs and interviews) were held with targeted beneficiaries and the primary stakeholders of the project in 6 villages across the 2 districts of project area. These consultation included women, youth, BPL House Holds, Self Help Group members, and farmers. The consultation meetings also involved tribal and other customary village leaders, and members of village councils. The consultations were free, in the local language, and conducted with prior information disseminated through the consultation team.

Table 6-122: Village wise consultation profile

Village	Date/Time	Location	No. of Participant (Male/Female)
MylliemRngi	06/9/2016	Community Hall of the Village	5 Male-1/ Female-4
Umlympung	06/09/2016	Community Hall of the Village	33 Male-11/ Female-22
Siatbakon	07/09/2016	Community Hall of the Village	33 Male-10/ Female-23
Nongshyrngan	07/09/2016	Community Hall of the Village	29 Male-12/ Female-17
Bakur	09/09/2016	Community Hall of the Village	18 Male-8/ Female-10
Mylliem Madan Iing Syiem	10/09/2016	Community Hall of the Village	19 Male-2/ Female-17

Source: JICA Study Team

While consensus for the project was confirmed through the consultation, actual condition of less adequate income by agriculture or self-owned business, malfunction of governmental program or self-help group, and adverse accessibility to social / livelihood service or infrastructure caused by lack of information and of literacy are indicated, and a strong demand and broad community support for livelihood interventions are apparent.

(5) Livelihood Plan

Alternative plans for livelihood after resettlement shall be considered as below;

- Achieving Agricultural Effiiency / Diversity by introducing new technology, diversity of rural livelihood
- Governmental Support for livelihood option
- Temporary livelihood option for daily workers, in particular non-land owner in the region
- Promoting local beekeeper
- Training of Agricultural Products Industry
- Training of embroidery and tailoring

These plans are necessary to be implemented as a part of R&R measure under responsibility of Implementation facility cooperated by Block Developnment Officer and NGO.

6.12 Stakeholders Consultation

The involvement of the communities in the project area is significant for project implementation in terms of achieving transparency and democratic decision-making. People’s participation from the planning stage is a vital ingredient for a project to be efficient and effective. This project has ensured that communities along the project area are involved from the beginning; stakeholders meetings were held at key venues of the project road.

The purpose of the stakeholder consultation was to inform people about the project, listen and consider their issues and suggestions. Potential project-affected persons, local community, relevant departments attended these consultations.

(1) 1st Round Consultation

The consultations were informed through NGO and villages heads and followings are explained.

1) Outline and Purpose of the Project

2) Alignment, alternatives and reason of recommended alignment
3) Result of the scoping (anticipated positive and negative impact)

The details of 1st Round Consultation with Communities are summarized in Table 7-123 エラー! 参照元が見つかりません。 .

Table 6-123: Details of All Meetings

Block	Date	Venue	No of participants	Observations
Mylliem	11/6/16	Sanmer Secondary School	34	Village council members were very receptive and welcomed the project. As they were apprehensive on how the PAP will respond, community meeting and FGD would be held for consensus building.
Khatarshnong Laitkroh(1)	16/6/16	PWD IB, Laitlyngkot	25	The village leaders present in the meeting unanimously agreed and welcomed the project. However, the village authority itself cannot decide on this matter, the opinion of the village people especially those affected is required and a meeting with them is essential. Consultation with PAHs was held on 25 June.
Khatarshnong Laitkroh (2)	25/6/16	Community hall	65	Information about the project was received with many queries which were clarified. PAPs supported the project and the survey to be conducted.
Pynursla (north) (1)	10/6/16	PWD IB, Pynursla	7	A few traditional heads who attended the meeting informed the team that a state study was conducted a few years back indicating a different alignment. They suggested the team organize another meeting wherein potential project affected households can also be invited to discuss the project. Consultations were consciously held after 9 July, 12 and 19 August.
Pynursla (north)(2)	9/7/16	Community hall	30	Issues were raised: >Raid Nongkhlieng and Raid Shabong (community lands that are affected) are the two raids whose boundary remains uncertain to this day. >There was opinion that the people had already agreed to the alignment put forward by the government for a proposed by pass in 2009. Majority of the people present emphasized that the 2009 alignment should be followed. >Community suggested that this issue be resolved and made it clear that they are not against the construction of roads but that the outstanding issues should be resolved first.
Pynursla (north) (3)	12/8/16	Urksew Community Hall	26	>Community must be aware of survey before it starts. >Owners of affected land should be

Block	Date	Venue	No of parti-cipants	Observations
				consulted. >Major part of the affected land belongs to 2 clans, the boundary issue between is yet to be resolved. >Members of Clan Shabong requested for a meeting with their leader who was not present. > Meeting with all the clans in the BP5 affected area set for the 19th of Aug, at PWD IB.
Pynursla (north)(4)	19/8/16	PWD IB Pynursla	37	>Presentation of the project, alignment, affected areas, benefits. > All the clan leaders were present. Except for one clan, all the other clans supported the project and the new alignment. >Resolution - status quo, request for concerned authority to have dialogue with Clan Shabong.
Pynursla (middle) (1)	9/7/16	Community Hall	50	Local elders appreciated the meeting since this was the first time their consent, support and feedback was respected over a project. However a number of issues from previous road projects of the government, related to the nonpayment of compensation, is pending. The people ask that these issues be resolved first, before the current project starts.
Pynursla (middle) (2)	13/7/16	Community Hall	23	PAPs were briefed about the project, presentation on alignments, activities that will take place, affected land and the process of surveys to be conducted. PAPs agreed to the survey and raised questions about the compensation and issues of rehabilitation. They suggest the team sit with them again to discuss in detail. Clarified that FGDs will be held and they are also free to call anytime to clarify doubts.
Pynursla (south)	15/7/16	Community Hall	45	Villagers requested repair and maintenance of the existing road.
Pynursla (BP6) / Amlarem	19/8/16	Wahkdait Community Hall	45	>Traditional leaders and land owners were present. >Questions on compensation, duration of project, workers etc were raised and clarified. >Question on bypass #5 and the neglect of the existing road. >All leaders agreed to the survey to be conducted. Final consensus will depend on 2 criteria- (i) Existing road is improved and maintained, (ii). Compensation package is agreed on with affected persons, both of which would be satisfied.

Source: JICA Study Team

Table 6-124: Participation details of 1st round consultations

CD Block/ Villages	Date	Total no of participants	Representation		
			Govt	Dorbar	PAP
Mylliem	11/6/16	34	3	31	
Khatarshnong Laitkroh(1)	16/6/16	21	3	18	
Khatarshnong Laitkroh (2)	25/6/16	65			65
Pynursla (north) (1)	10/6/16	7	2	5	
Pynursla (north)(2)	9/7/16	23			23
Pynursla (north)(3)	16/8/16	26		26	
Pynursla (north)(4)	19/8/16	37	1	36	
Pynursla (middle) (1)	9/7/16	50		2	48
Pynursla (middle) (2)	13/7/16	23		1	22
Pynursla (south)	15/7/16	45	45		
Pynursla (BP6) / Amlarem	19/8/16	45		5	40

Source: JICA Study Team

For the purposes of promoting information dissemination and community participation, several community meetings were held after block-level consultations. A brief description about the project, highlighting the importance of consultations with likely project-affected persons, local community, and other stakeholders was given. Design concepts (e.g. minimize surplus soil, install proper slope protection) with preliminary alignments were also provided and explained. Expected benefits and anticipated adverse impacts as well as the resettlement policy framework as per JICA Guidelines for Environmental and Social Considerations were conveyed. The consultations were held in the local language (Khasi) with assistance from a local person who helped in interpretation as well as prepared transcripts. The proceedings of the consultations were audio recorded as part of the documentation process.

Table 6-125: Community Meetings and Focus Group Discussions (FGD)

S. No	Meeting	Date	No of attendees	Area Coverage
1.	Dorbar & Village elders	20/06/2016	6	Umlympung Village (12 miles) to Laitlyngkot Village
2.	Soilyna Huts, Mylliem Marbaniang up to the end of Bypass 3, i.e. Mylliem Kyndong Nongkyntir	21/06/2016	6	Expansion 3 to end of Bypass #3
3.	Expansion 2, i.e. 4 miles up to the midpoint of Bypass 2	23/06/2016	7	Expansion 2 TO Banuin
4.	Bypass 2 i.e. Banuin Village	24/06/2016	7	Banuin Village

Source: JICA Study Team

(2) 2nd Round Consultation with Communities

The second round stakeholder meeting was informed through NGO, village heads and local newspaper and held at 5th of November and 5th of December, 2016 to share the follows;

1) Outline and Purpose of the Project
2) Reason of recommended alignment
3) Result of Environmental Assessment (anticipated positive and negative impact, their analysis and mitigation)

As for RAP, the meetings were aiming at sharing the result of the socio economic survey and

discussing with PAPs on the comprehensive composition of resettlement and compensation. The followings are main questions, which was responded in accordance with RAP report.
- compensation policy
- rehabilitation and livelihood improvement policy
- provision of alternative lands

Summary of the meeting is shown in Table 7-126

Table 6-126: Details of All Meetings

Block	Date	Venue	No of parti-cipants	Observations
Mylliem/ Khatarshnong Laitkroh/ Pynursla/ Amlarem	5/11/16	Sanmer Secondary School	180	While there was concern about impact on paddy fields in BP3, it was explained that impact can be minimized by ensuring irrigation channel with box culvert and agreed. A major concern of the people present from BP3 was the impact on the business establishments like restaurants etc located at Mylliem after the realignment of NH-40. NHIDCL officials assured that there will be sufficient space available within proposed RoW for setting up temporary structures and relocate those affected. It was explained that an affected Public Health Center in Dawki will be rebuild before land acquisition, and old structure will be demolished only after operation of new structure of the PHC.
Pynursla/Amlarem	5/12/16	Wahkdait Community Hall	150	Explained existing road will be repaired at the section of BP6&7. Answering to question about compensation policy, it was explained that it will follow LARR 2013 and also JICA guideline in case that the project is funded by JICA. Answering to question about dumping on roadside, it was explained that appropriate locations would be selected not to disturb residents. Answering to determination of PAHs, it was explained that it would be done through joint inspection by Deputy Commissioner and preparation of land owners. The economic benefits to the area was highlighted including tourism potential with a new bridge at Dawki. Attendees expressed their keenness that the project is started at the earliest.

Source: JICA Study Team

Umjapung 12th mile- PAPa | Laitlyngkot- Traditional leaders

Urksew - Traditional leaders | 12th mile PAPs and Traditional leaders

Consultation with Traditional Heads of clans in Pynursla

Source: JICA Study Team

Figure 6-45: Stakeholders/community Meetings

【Note】
The information related to bidding has been deleted.

CHAPTER 7 CONCLUSIONS AND RECOMMENDATIONS

(1) The Project is relevant and effective

As described in the previous chapter, the project has been appropriately modified based on the proposals made by the JICA Study Team to address issues identified. The project also aligns with upper level plans of the GOI and complies with overarching goals. Furthermore, the quantitative and qualitative effectiveness has been adequately demonstrated. Thus the project is relevant and effective.

(2) Necessity of Sustainable Technical Assistance for Mountainous Roads

The design and construction technology for mountainous roads in India is still under development as they gain more expertise through various experiences and trials. Indian engineers including the DPR consultant need to continue to expand their technical capacity. Japan has a wealth of experience in working with mountainous roads and has accumulated significant knowledge and expertise of design / construction / maintenance of mountainous roads. Although the JICA Study Team carried out the preliminary design and guided the DPR consultant this time, it is necessary to continue the technical assistance to have the knowledge transferred to people in India.

(3) Necessity of Technical Transfer in Operation and Maintenance

NHIDCL was established as a new entity under MORTH in February 2014 to take over the responsibility of improving mountainous roads from BRO, NHAI, and state government PWD. The main mission is construction / improvement / expansion of national highways in the regions neighboring other countries and many of these roads are in mountainous areas. NHIDCL is still young and must accumulate technical experience including knowledge regarding operation and maintenance of mountainous roads. It is necessary to transfer technical knowledge of Japan to local parties regarding the operation and maintenance of roads in mountains.