GOVERNMENT OF INDIA

MINISTRY OF ROAD TRANSPORTATION AND HIGHWAYS

NATIONAL HIGHWAYS AND INFRASTRUCTURE DEVELOPMENT CORPORATION LTD. (NHIDCL)

PREPARATORY STUDY FOR NORTH EAST CONNECTIVITY IMPROVEMENT PROJECT IN INDIA

NH54 BYPASSES

ENVIRONMENTAL IMPACT ASSESSMENT REPORT

JUNE 2017

NIPPON KOEI CO.,LTD.
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TABLE OF CONTENTS

List of Tables

List of Figures

ABBREVIATIONS

BRDB	Border Roads Development Board
BRO	Border Roads Organization
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
DOEF	Departments of Environment and Forests
DOF	Department of Forest
DPR	Detailed Project Report
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
GHG	Green House Gas
GOI	Government of India
IRC	Indian Road Congress
MLCU	Martin Luther Christian University
MOEF	Ministry of Environment & Forest
MORTH	Ministry of Road Transport & Highways
MSPCB	Mizoram State Pollution Control Board
NHAI	National Highway Authority of India
NHIDCL	National Highways and Infrastructure Development Corporation
NOC	No-objection Certificates
PAPs	Project Affected Persons
PIU	Project Implementation Unit
PUC	Pollution under Control Certificate
PWD	Public Works Department
RAP	Resettlement Action Plan
RO	Regional Offices
ROB	Road over Bridge
ROW	Right of Way
SC	Supervision consultants
SPCBs	State Pollution Control Boards

CHAPTER 1 INTRODUCTION

1.1 Background

India has achieved remarkable economic growth in the past decades. Rapid development of in transport infrastructures strengthened the linkage between major cities and thus contributed to the economic growth. In particular, road is one of most important modes of transportation given that road transportation constitutes 85% of passenger and 60% of freight transport in India. However, development of transport infrastructure is lagging in mountainous regions of India due to financial and technical reasons, leading to greater economic disparity between mountainous regions and plain areas of the country which have been fully benefited from improved transport network.

Only 28.5% (63.4% is average in whole country) of the road in North-East states is paved and only 53% of national highway has more than 2-lane road. This is because the North-East states are located far from mainland of India and access road to neighboring countries are underdeveloped due to security concern. Severe natural conditions such as steep mountainous geography (most of the state is located in hilly area) and prolonged monsoon season also complicates the challenge. To accelerate economic growth in this part of the country, therefore, improvement in the road network is of great importance. To this end, Government of India (GOI) launched "Special Accelerated Road Development Program for North-East" committed in "Twelfth Five Years Plan (from April, 2012 to March, 2017)" to cope with above mentioned problems by improvement of national highways that connect major cities within the North-East states, and requested Government of Japan to provide loan assistance in carrying out the improvement. Aizawl – Tuipang section of NH54 stretching over five districts of Mizoram State has been selected as one of the priority projects for this assistance and the feasibility study was carried out in 2015.

During the feasibility study for NH54 improvement, construction of four new bypasses has been proposed, mainly to avoid densely populated sections of NH54. This leads to the undertaking of additional feasibility study for four bypasses in Chhiahtlang, Serchhip, Hnathial and Lawngtlai.

1.2 Project Location

The locations for four proposed bypasses are shown below. The total stretch of four bypasses is about 24 km but the length of each bypass differs considerably, ranging from minimum 2.6 km (BP1 and BP4) from maximum 11.8 km (BP2). BP1 and 2 are located in Serchhip district while BP3 and BP4 are located in Lunglei and Lawngtlai district respectively.

Site	Coordinates at B.P./ E.P. side		Alignment Length
	Lat.	Long.	
1. Chhiahtlang bypass	23°23'31.36"N 23°22'53.20"N	92°50'30.11"E 92°50'22.22"E	2.6km
2. Serchhip bypass	23°20'50.76"N 23°17'24.04"N	92°50'57.17"E 92°51'41.78"E	11.8km
3. Hnathial bypass	22°59'06.90"N 22°56'00.06"N	92°55'29.90"E 92°55'29.28"E	7.0km
4. Lawngtlai bypass	22°31'04.79"N 22°30'29.10"N	92°53'14.90"E 92°53'23.29"E	2.6km
Total			24.0km

Figure 1.1 Location of Four Proposed Bypasses

1.3 Requirement and Objective of EIA Report

As per MOEF EIA Notification dated 14.09.2006 (as amended in August 2013), any highway project falls under Category A if the project entails *i) New National Highways; and ii) Expansion of National Highways greater than 100km involving additional right of way or land acquisition greater than 40m on existing alignments and 60m on re-alignments and bypasses*. The proposed bypasses do not trigger these requirements and therefore, the project does not require environmental clearance from MOEF[1].

On the other hand, the project has been classified as Category A as per JICA's Environmental and Social Guidelines, for which a full EIA study is required. Based on this backdrop, an EIA study has been carried out as per JICA's guidelines. The EIA builds on an already completed EIA study on widening and improvement of existing NH54, which was also carried out as per JICA's guidelines. The Environmental Checklist for road projects is attached in Appendix A. The EIA aims to:

[1] The project requires NOC (Consent-for-Establishment and Consent-for-Operation) from the respective State Pollution Control Board, which will be discussed in more detail Chapter 3.

- Review environmental assessment undertaken as part of DPR study and identify gaps to satisfy requirements under JICA Guidelines for Environmental and Social Considerations
- Study baseline conditions (physical, social and environmental) along the targeted section and influence area of new bypasses
- Carry out environmental analysis with respect to proposed project vis-à-vis existing condition; identify environmental impacts that may be expected to occur during design, construction and operation; and identify environmental issue/challenges that require further studies
- Carry out alternative analysis including comparison with "no project' scenario
- Assess environmental impacts of the proposed project components on natural, physical and socio-economic environments
- Develop cost effective and implementable measures for mitigating adverse environmental and social impacts and enhancing positive aspects
- Develop a practical and implementable Environmental Management Plan (EMP) for mitigation of impacts and monitoring of implementation of mitigation measures during design, construction and operation stages
- Consult and inform the project affected people (PAP) and other stakeholders, and ensure their active participation

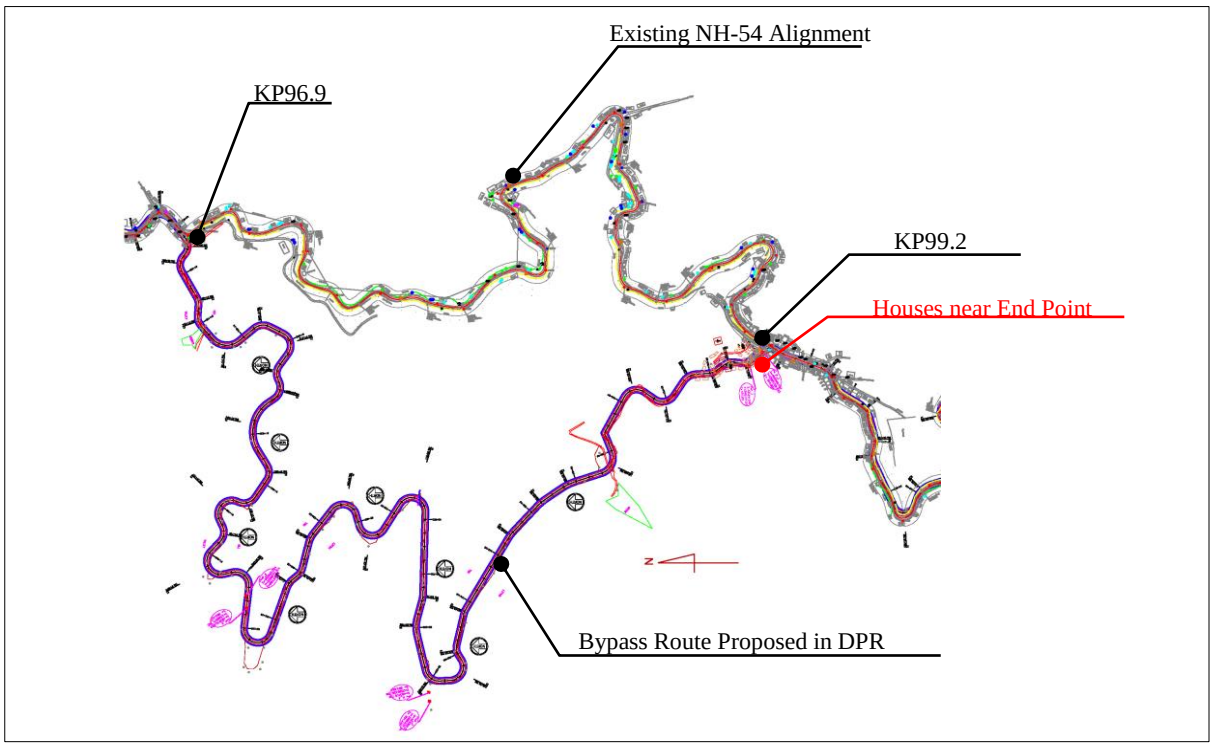
CHAPTER 2 DESCRIPTION OF PROJECT

2.1 Bypass Designs as in DPR and Proposed Adjustments

This sections presents the brief review of preliminary designs of four bypasses proposed in DPR.

2.1.1 Chhiahtlang Bypass (Bypass 1)

The bypass route stars near existing KP96.9 and ends near KP99.2 with an approximate length of about 3 km. The bypass runs through a residential area near the proposed ending point (where the bypass reconnects with NH54). To avoid involuntary resettlement as much as possible, minor adjustment of alignment is proposed. The layout of Chhiahtlang Bypass proposed in DPR is given in Figure 2.1 below.

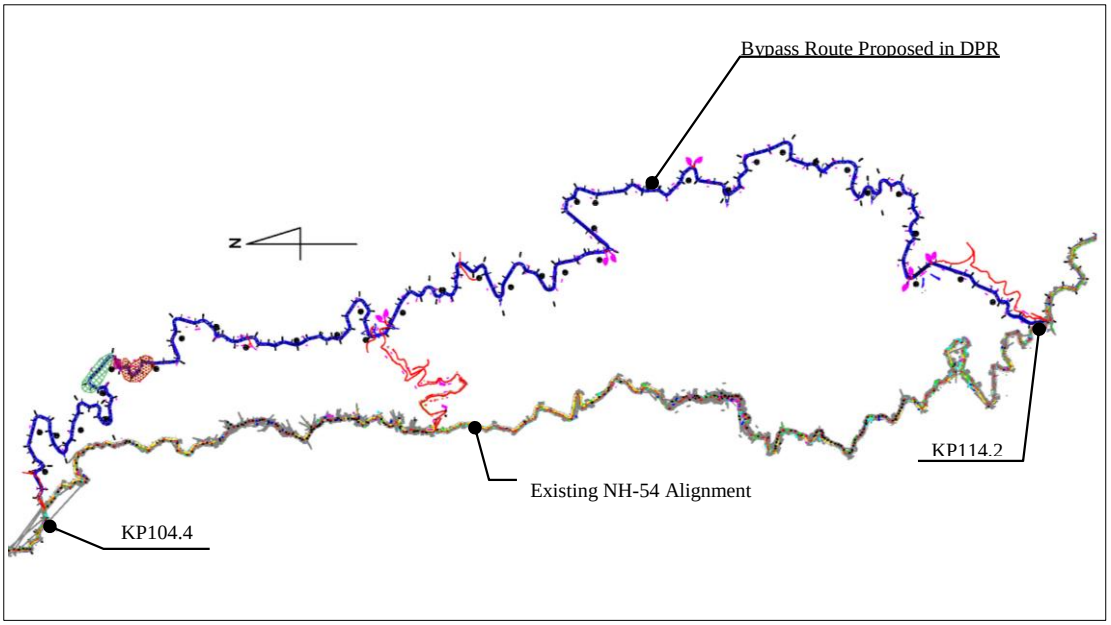


Source: JICA Study Team

Figure 2.1 Chhiahtlang Bypassed Protected in DPR

2.1.2 Serchhip Bypass (Bypass 2)

The layout of Serchhip Bypass proposed in DPR is given in Figure 2.2. The bypass in DPR is proposed from the eastern side since much longer length would be required if western side is selected for bypass construction for Serchhip. Therefore, JST considers the eastern route proposed by DPR is appropriate. However, some residences were observed based on the available map in the area near the endpoint, which needs to be confirmed during site investigation.

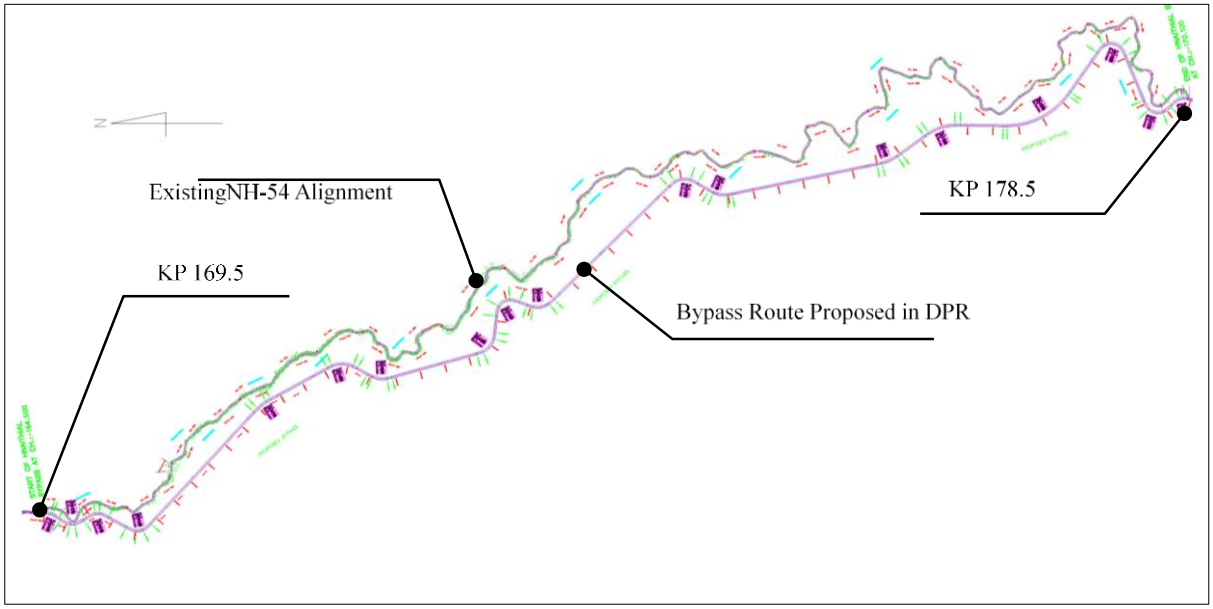


Source: JICA Study Team

Figure 2.2 Serchhip Bypassed Protected in DPR

2.1.3 Hnathial Bypass (Bypass 3)

The layout of Hnathial Bypass proposed in DPR is given in Figure 2.3. The bypass in DPR is proposed from the western side of the existing NH54. In the eastern side of the existing NH54, the terrain is uphill near the end of bypass which makes it difficult to connect back to NH54. Therefore, the eastern side proposed in DPR seems appropriate. The bypass starts at existing KP169.5 and ends at KP178.5.



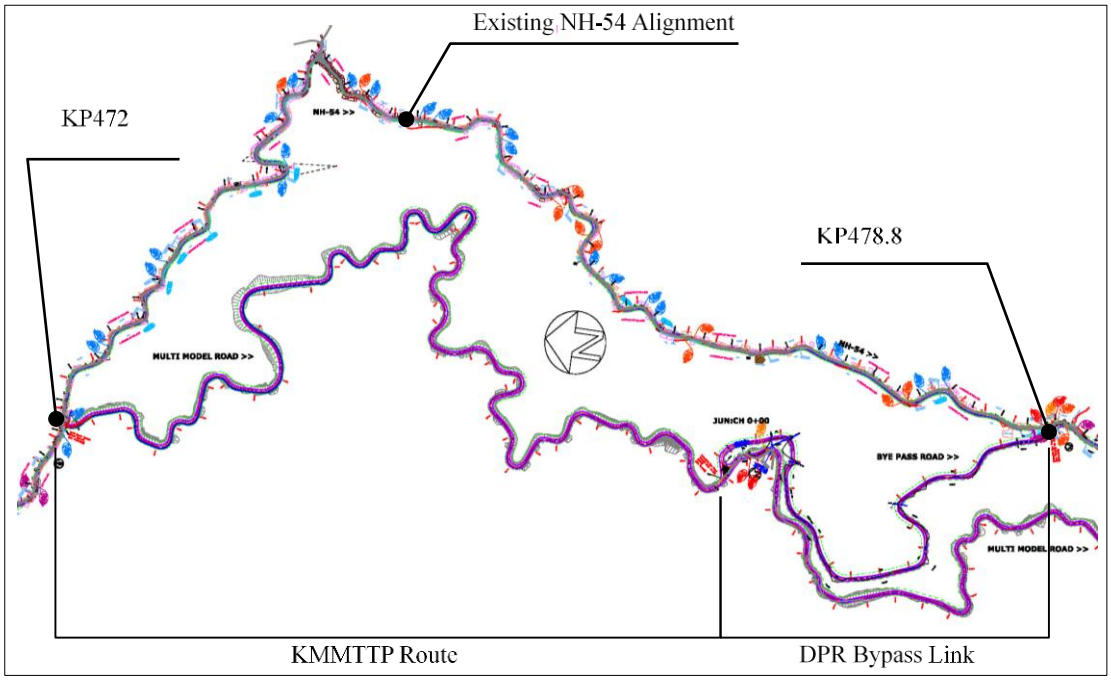
Source: JICA Study Team

Figure 2.3 Hnathial Bypassed Protected in DPR

2.1.4 Lawngtlai Bypass (Bypass 4)

The layout of Lawngtlai Bypass proposed in DPR is given in Figure 2.4. In the Lawngtlai area, there is another road construction project which is the Kaladan Multi-Modal Transit Transport Project (KMMTTP), under construction, avoiding the route of urbanized area of Lawngtlai. Therefore, the beginning section of the bypass for Lawngtlai actually belongs to the KMMTTP project. However, the road under this project does not meet back to the NH54 at the other end. Therefore, a link road is

proposed under the scope of this Project such that it connects back to NH54.



Source: JICA Study Team

Figure 2.4 Lawngtlai Bypassed Protected in DPR

Key components of bypass construction works are summarized below.

2.2 Key Design Concepts for Bypass Construction Works

2.2.1 Road Geometric Design

The Design Standards given in Indian Roads Congress (IRC) Standards, Codes, Guidelines and Special Publications will be referred[2]. While DPR uses different design concept in each bypass (e.g. different road width, application of minimum design speed, minimum radius of horizontal curves and application of transition curves), it is proposed that uniform design criteria is used for all bypasses as well as the improvement of NH54. The summary of Geometric Design Criteria for this project is presented below.

Table 2.1 Summary of Geometric Design Criteria for Highway

	Design Elements		Type/Value	Remarks
1	Highway Classification		National	
2	Terrain Classification		Steep	
3	Design Speed (km/h)			
	Ruling (km/h)		40	
	Minimum (km/h)		30	
4	Cross-Sectional Elements	Basic Lane Width (m)	3.5	
		Number of Lanes	2	
		Formation Width (m)	12.0 (10.0)	() for exceptional sections only
		Carriageway Width (m)	2 x 3.5	
		Outer Shoulder Paved Width (m)	2 x 1.5 (0.9)	
		Outer Shoulder Earthen Width (m)	2 x 1.0 (0.6)	
		Crossfall of Roadway (%)	2.5	

[2] They are mainly: IRC:73-1980 – Geometric Design Standards for Rural (Non-urban) Highways; IRC:52-2001 – Recommendations about the Alignment Survey and Geometric Design of Hill Roads; IRC:SP:48-1998 – Hill Road Manual

Design Elements			Type/Value	Remarks
		Slope of Earthworks		
		Fill	V : H = 1:1.75	
		Cut (soil)	V : H = 1:1.2	Varies
		Cut (rock)	V : H = 1:0.2-0.5	Varies
5	Sight Dist.	Stopping Sight Distance, SSD (m)	30 (45)	() 40km/h
		Intermediate Sight Distance, ISD (m)	60 (90)	() 40km/h
		Overtaking Sight Distance, OSD (m)	(165)	() 40km/h
6	Horizontal Alignment	Horizontal Curve		
		Absolute Minimum Radius of Horizontal Curve (m)	30	
		Ruling Minimum Radius of Horizontal Curve (m)	50	
		Widening of Carriageway on Horizontal Curves		
		Widening for Absolute Minimum Radius (21m-40m)	1.5	
		Widening for Ruling Minimum Radius (41m-60m)	1.2	
		Superelevation (Se)		
		Maximum Se for Absolute Minimum Radius (%)	7.0	
		Superelevation Runoff Rate	1/60	
		Transition Curve		
		Minimum Length for Absolute Minimum Radius (m)	30	
		Minimum Length for Ruling Minimum Radius (m)	20	
7	Vertical Alignment	Vertical Gradient		
		Ruling Gradient (%)	6.0	
		Critical length of continuous Ruling Gradient (m)	2000	120m rise in 2km for steep terrain
		Limiting Gradient (%)	7.0	
		Exceptional Gradient (%)	8.0	
		Critical Length for Exceptional Gradient (m)	100	
		Minimum Gradient for Drainage (%)	0.5	Cut sections with lined side
		Vertical Curve		
		Minimum Length of Vertical Curve (m)	15	
		Minimum Radius of Summit (Crest) Curve (m)		
		Absolute Minimum Radius (m)	205	From SSD
		Minimum Radius (m)	375	From ISD
		Desirable Minimum Radius (m)	1500	From OSD
		Minimum Radius of Valley (Sag) Curve (m)		
		Absolute Minimum Radius (m)	355	

Source: JICA Study Team

The minimum paved shoulder width is 1.5m. However, the small width between the end of paved shoulder and the side drain shall also be paved for smooth surface drainage to the drain and also to avoid damaging of this small unpaved area by intrusion of water. Likewise, when there is retaining wall in the valley side, the width between the end of paved shoulder and the parapet of retaining wall shall also be paved for the same reason.

2.2.2 Earthworks

1) Cut Slope

Cut grade of slope above the retaining walls along the road shall be decided based on geological and geotechnical condition of slope. Table 2.2 shows design criteria of cut grades for each rock and soil classification comparing those in IRC. Because there are many slope failure on the existing cut slope with 1:0.3 consisting of weathered and loosen rock, the soft rock shall be cut with gentler grade than IRC and 1:0.5 to 1:0.8 grades. Harder rock slope can be applied steeper cut grade; namely very hard rock and hard slope shall be cut with 1:0.2 and 1:0.3 respectively. On the other hand, loosen and weakened rock and soil slope shall be carefully cut with gentler cut grades more than 1:0.8.

Against rock slope which is cracky and has a risk of rockfall or slope failure, crib work shall be applied for prevention of damage, which can deter surface failure and rockfall with around 10 m3 (less than 3m width and less than 1m depth) on the cut slope. In case that larger landslide is concerned, landslide countermeasure such as anchor and rock-bolt works need to be planned individually in the

countermeasure design for the critical slopes.

For prevention of erosion and surface failure and also for landscape improvement, most of cut slope shall be covered by hydroseeding work or seeding and mulching, and will be greened. The thickness of the sprayed hydroseeding shall be varied from 3 to 7 cm depending on the geotechnical condition. The cut slope of soft rock which is cut with 1:0.8 is applied 5cm thick hydroseeding. Seeding and mulching is applied for soil cut slope. As very hard or hard rock slope consists of intact bed rock and is cut with steep grade, the vegetation work including hydroseeding cannot be applied because the plant cannot be expected to grow on such slope.

Table 2.2 Design Criteria of Cut Grade and Protection Work

IRC Standard*		JICA Study Team Rock/Soil Classification			Cut Grade	Slope Protection Work
Classification	Cut Grade					
Hard Rock	**80 ~ 90 degree**	Rock	Very Hard		**1:0.2**	No protection work
			Hard	No Risk	**1:0.3**	No protection work
				Landslide Risk		Crib work
Ordinary Soft Rock	**1:0.25 ~ 1:0.125**		Soft	Non-Dip Slope	**1:0.5**	No protection work
				Dip Slope	**1:0.8**	Hydroseeding (t=5 cm)
Ordinary Soil/ Heavy Soil	**1:1.0 ~ 1:0.5**	Soil	Dense Soil		**1:1.0**	Seeding and Mulching
			Loose Soil		**1:1.2**	Seeding and Mulching

*IRC: SP:48: 1948 Clause 7.4
Source: JICA Study Team

2) Embankment on the Valley Side

Slope grade of embankment slope is generally decided based on the embankment material and total slope height. Because generated soil by cutting is expected to utilize as embankment material in this project, the embankment material is composed of gravelly soil derived from sandstone and shale. The slope gradient of embankment is proposed as shown in Table 2.3. In order to prevent surface failure on the embankment slope, retaining wall such as gabion wall shall be built on the toe of slope. And turfing shall be implemented on the embankment slope for prevention of erosion and landscape improvement.

Table 2.3 Design Criteria of Embankment Slope and Slope Protection Work

IRC Standard*		Embankment Material	Height	Grade	Slope Protection Work
Classification	Grade				
Embankment	**1:2.0**	Gravelly Sand derived from Cutting	less than 5 m	**1:1.5**	Turfing (Sodding)
			5 ~ 20 m	**1:2.0**	Turfing (Sodding)

*IRC: 36-1970
Source: JICA Study Team

3) Retaining Wall

Retaining walls shall be built on the toe of almost all slopes on hill side along the road in order to prevent a small slope failure on the first step of cutting and to maintain the side ditch. Table 2.4 shows design criteria of the retaining wall. The type of the retaining wall should be changed to reduce the amount of cutting considering slope height. Namely, a large retaining wall type with 65 cm thickness should be applied for higher slope. On the other hand, a small one with 35 cm thickness should be applied for other lower slope. Gabion wall, which has high permeability, should be adopted against the slope where the spring water is found and groundwater level is presumed to be high. In steep slope consisted of very hard rock strata, gravity-type retaining wall with a rock fall prevention fence should be built at the toe of cut slope to protect the road.

Table 2.4 Design Criteria of Retaining Wall on Hill Side

Slope Type		Wall Height	Retaining Wall Type (Grade on Front Slope)	
Rock	Very Hard	**Less than 3.0 m**	Rockfall Prevention Wall	1:0.25
	Hard	**Less than 3.0 m**	Breast Wall Type-A	1:0.3
		3.0 ~ 7.0 m	Breast Wall Type-B	1:0.5

			3.0 ~ 7.0 m	Breast Wall Type-C	1:0.3
	Soft		**Less than 3.0 m**	Breast Wall Type-A	1:0.3
			3.0 ~ 7.0 m	Breast Wall Type-B	1:0.5
			3.0 ~ 7.0 m	Breast Wall Type-C	1:0.3
		High Groundwater Level	**Less than 8.0 m**	Gabion Wall	1:0.3~
Soil	Dense Soil		**Less than 3.0 m**	Breast Wall Type-A	1:0.3
			3.0 ~ 7.0 m	Breast Wall Type-B	1:0.5
		High Groundwater Level	**Less than 8.0 m**	Gabion Wall	1:0.3~
	Loose Soil		**Less than 3.0 m**	Breast Wall Type-A	1:0.3
			3.0 ~ 7.0 m	Breast Wall Type-B	1:0.5
		High Groundwater Level	**Less than 8.0 m**	Gabion Wall	1:0.3~

Source: JICA Study Team

4) Embankment Structure

Retaining walls are built in front of the road embankment with the road widening on valley side,. Type of retaining wall should be selected depending on slope topography on valley side. For gentle and low valley slope which is gentler than 30 degree, gravity wall is frequently used for soil retaining. Because the gravity walls which has vertical or very steep grade on front slope need to excavate largely behind the wall in construction, it is necessary to pay attention to ensure the present traffic while construction. Steep and high slope need the reinforced earth wall which can be built more than 20m in height. Table 2.5 shows design criteria of embankment structure.

Table 2.5 Design Criteria of Embankment Structure

Retaining Wall Type		Height	Grade of Front Slope	Apply to
Gravity Wall	Type-A	less than 3 m	**Vertical**	Gentle and Low Slope
	Type-B	less than 5 m	**1:0.1**	Gentler than 30 degree
Reinforced Earth Wall		5 ~ 20 m	**1:0.1**	High and Steep Slope

Source: JICA Study Team

5) Landslide Prevention Design

Basically, design of road alignment have to be planned not to promote the landslide movement. But, unavoidably if the road alignment goes through the landslide, landslide prevention measures have to planned and designed for the landslide. In terms of the landslide which is active or is concerned to be destabilized by cutting or banking, landslide countermeasure is required. The landslide prevention measures are mainly divided into three types; namely groundwater drainage work, earth work such as earth removal and counterweight fill, and restraint work including anchor, rock-bolt, and pile work. In general, groundwater drainage work is the cheapest followed by earth work. But they are often constrained by topographical, geotechnical, and groundwater condition. On the other hand, restraint work which prevents the landslide movement by force is generally expensive, but their technique can be adopted as permanent countermeasure. Therefore, restrain works shall be introduced by combination of groundwater drainage works and earth works considering the cost reduction of the countermeasures.

2.2.3 Drainage Design

It is required to facilitate culvert or side ditch on road for drain water surrounding or upstream of road to downstream properly. Specially, hill road is always suffered from large volume of water fallen from mountain slope towards to the road. It is quite important to protect the road by arranging cross drainage appropriately to satisfy the discharge from crossing water. The new drainage system is designed by based on hydrological calculation result. Based on obtained location of water crossing and water discharge, dimension and locations for drainage system are determined. For cross drainage structure, appropriate culvert type is selected by taking account of economy, construction workability, and maintenance ability. The design is based on the IRC standard in principal. For detailed design stage, it shall be designed based on IRC standard.

2.2.4 Bridge Design

NH54 bypass route is planned passing through mountainous area. In order to cross over valleys among mountains, cross structures such as bridge and culvert are required. Bridge is planned at two location of Serchhip bypass.

Serchhip bypass at km 4+530

- It locates at about 4.5km from beginning point of Serchhip bypass.
- The route crosses the valley as curve section of horizontal alignment.
- Minor bride is enough because crossing length on valley is comparably short.
- Water flow is confirmed when site investigation was conducted in January 2016.
- Some boulders and rocks are appeared above the ground in river bed.
- Vegitations and shrubs are flourished at around site.

Serchhip bypass at km 10+800

- It locates at about 10.8km from beginning point, 0.8km from end point of Serchhip bypass.
- The route crosses the valley as straight section of horizontal alignment.
- Major bride is required because crossing length on valley is comparably large.
- Water flow is confirmed when site investigation was conducted in January 2016.
- Some boulders and rocks are appeared above the ground in river bed.
- Vegetation, shrubs and trees are flourished at around site.

2.2.5 Preliminary Study of Spoil Bank

Concerning the result of preliminary design for NH-54 Bypass, the necessary volume of spoil bank has been calculated as shown below.

Table 2.6 Required Volume for Spoil Bank

Bypass Name	Item	Volume of Generated Soil	Coefficient of Compaction	Volume of Compacted Soil	Required Volume of Spoil Bank
		Cu.m		Cu.m	Cu.m
Chhiahtlang Bypass	Cut Soil	127,499	0.9	114,749	77,238
	Fill Soil			37,511	
Serchhip Bypass	Cut Soil	743,768	0.9	669,391	481,306
	Fill Soil			188,085	
Hnahthial Bypass	Cut Soil	379,505	0.9	341,555	252,047
	Fill Soil			89,508	
Lawngtlai Bypass	Cut Soil	247,013	0.9	222,312	154,547
	Fill Soil			67,765	

Source: JICA Study Team

(1) Condition of Spoil Bank Selection

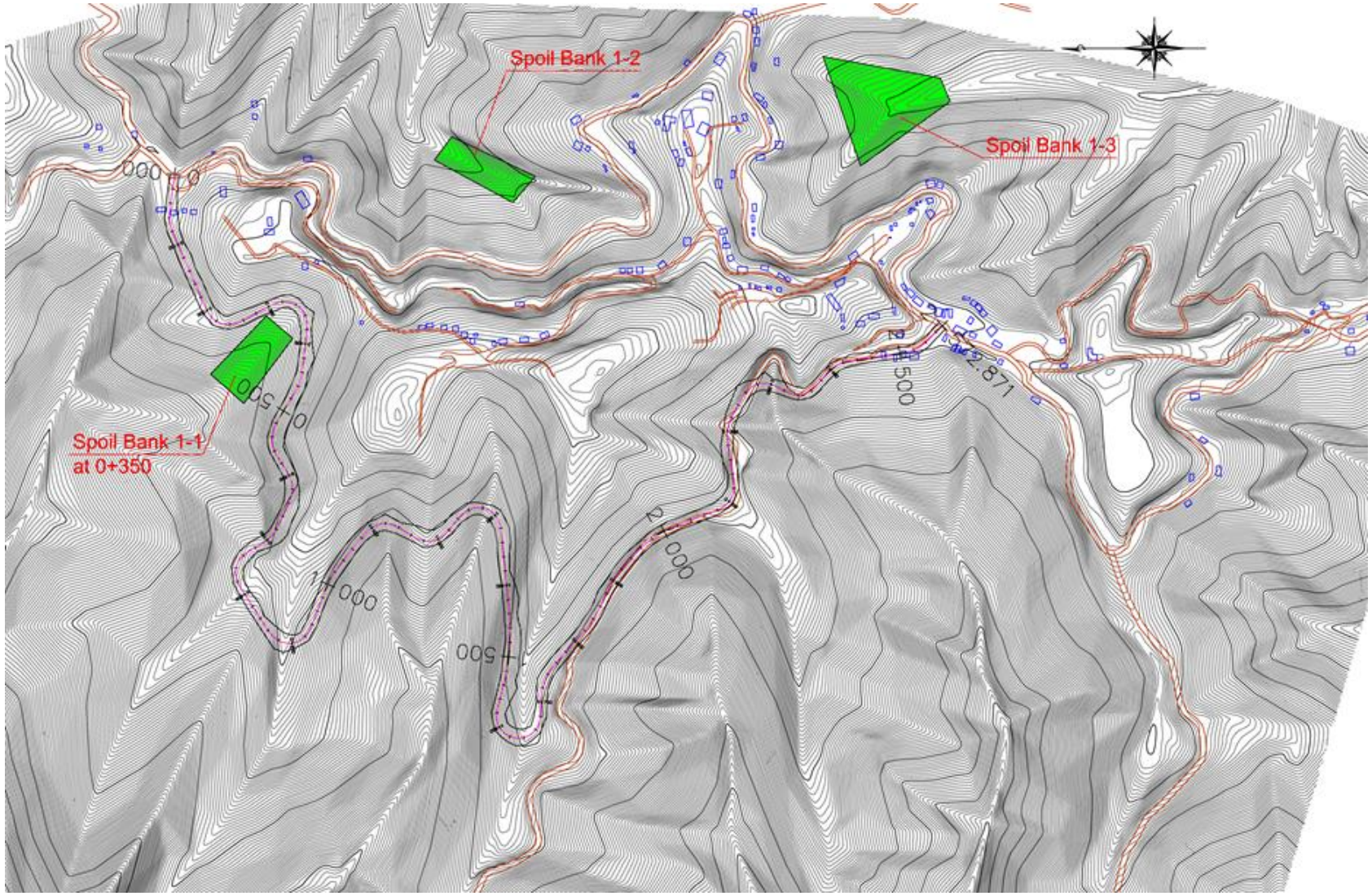
JICA Study Team has examined to identify t

Target locations with have sufficient and required conditions for spoil bank construction have been identified based on the following criteria: To find out suitable place along NH-54 Bypass with following condition;

- ✓ Ground shape with concavity topography
- ✓ Less ground gradient than 22 degree which is assumed as average angle of spoil bank slope with necessary steps
- ✓ No built-up area and No protected area / national sanctuary

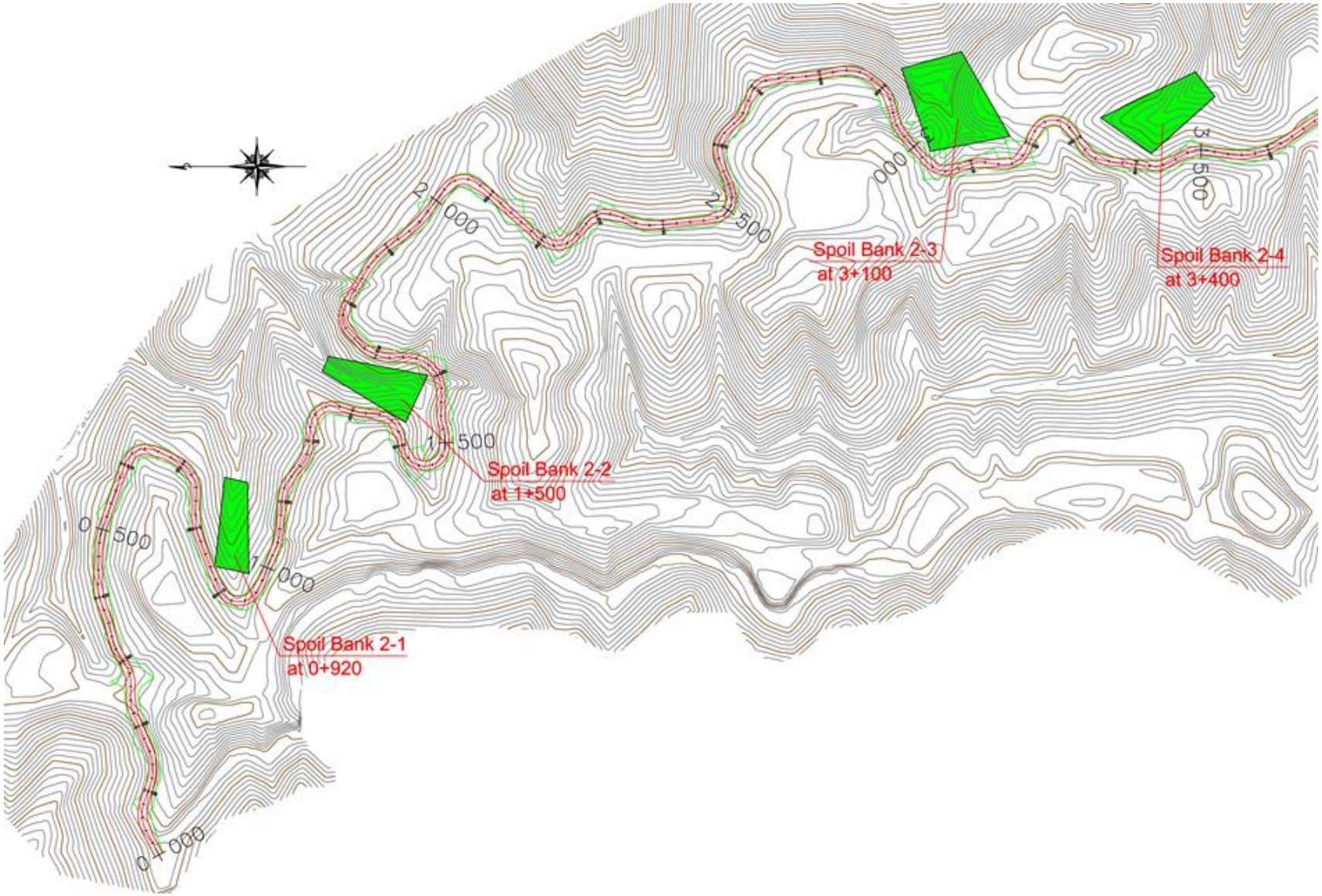
- ✓ To be able to construct the spoil bank in less than 30m height

Proposed locations and capacity of spoil bank that meet those criteria are presented in subsequent figures and Tables.



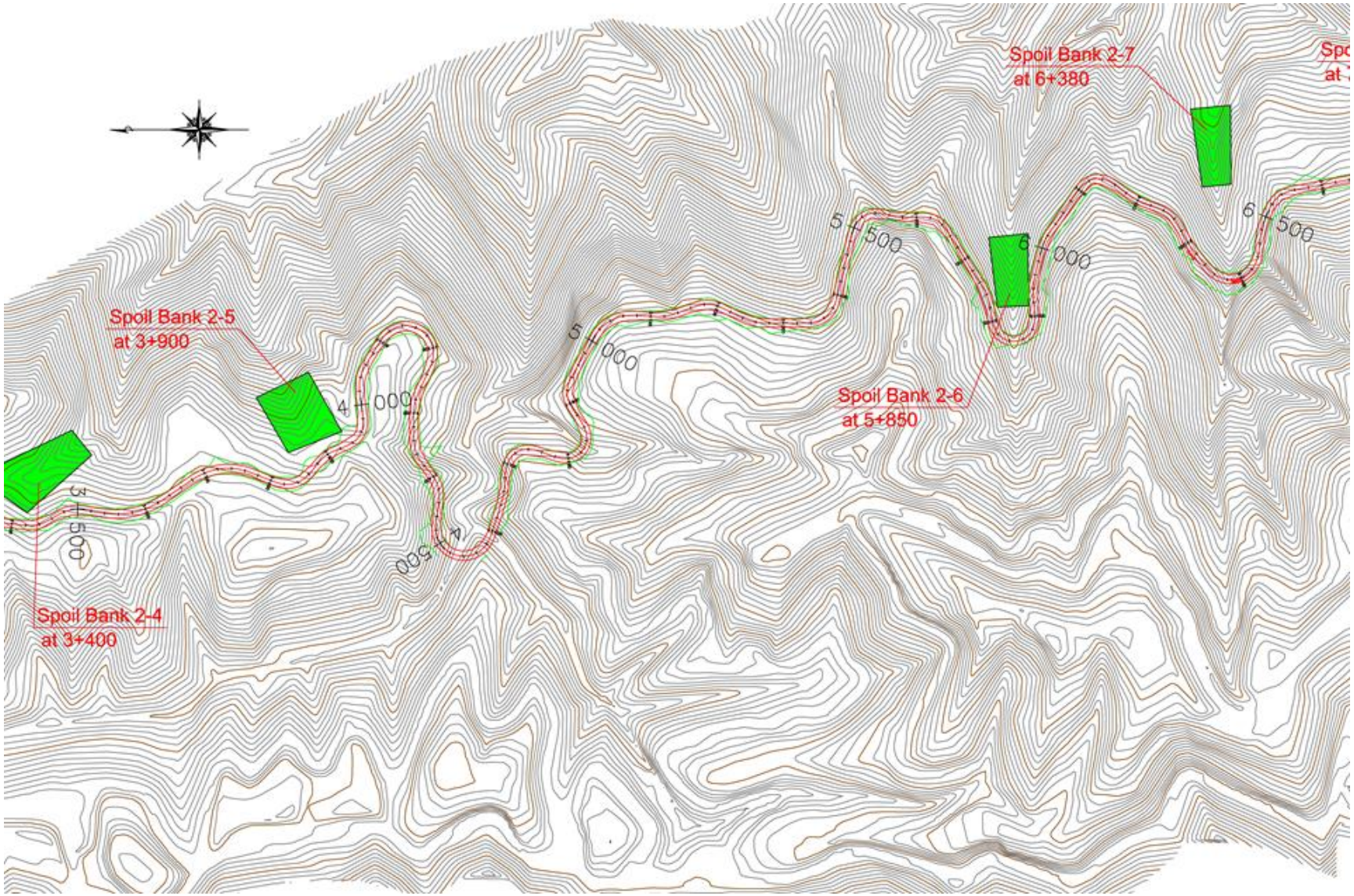
Source: JICA Study Team

Figure 2.5 Plan for Locations of Spoil Bank (Chhiahtlang Bypass)



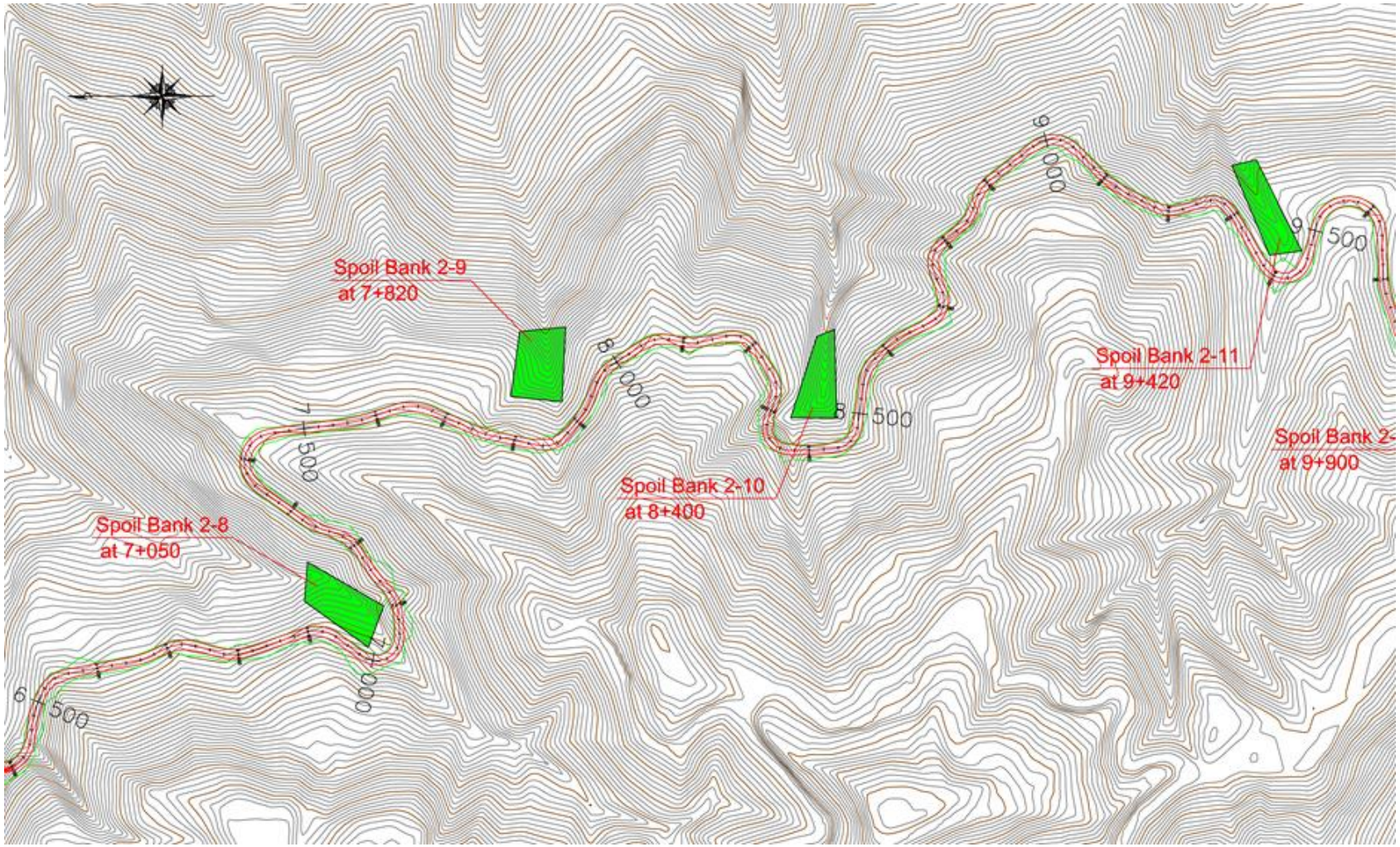
Source: JICA Study Team

Figure 2.6 Plan for Locations of Spoil Bank (Serchhip Bypass) -1/4



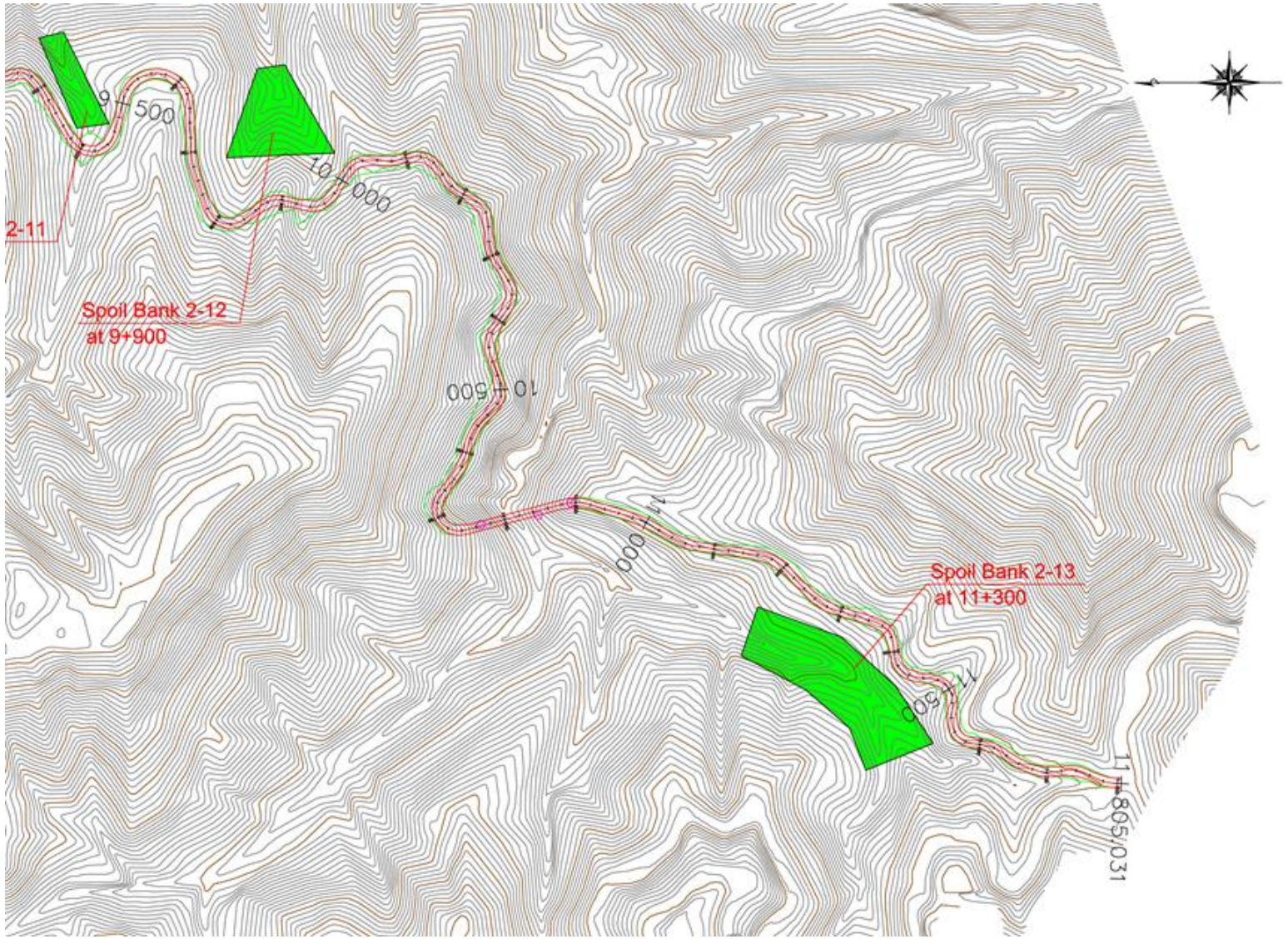
Source: JICA Study Team

Figure 2.7 Plan for Locations of Spoil Bank (Serchhip Bypass) -2/4



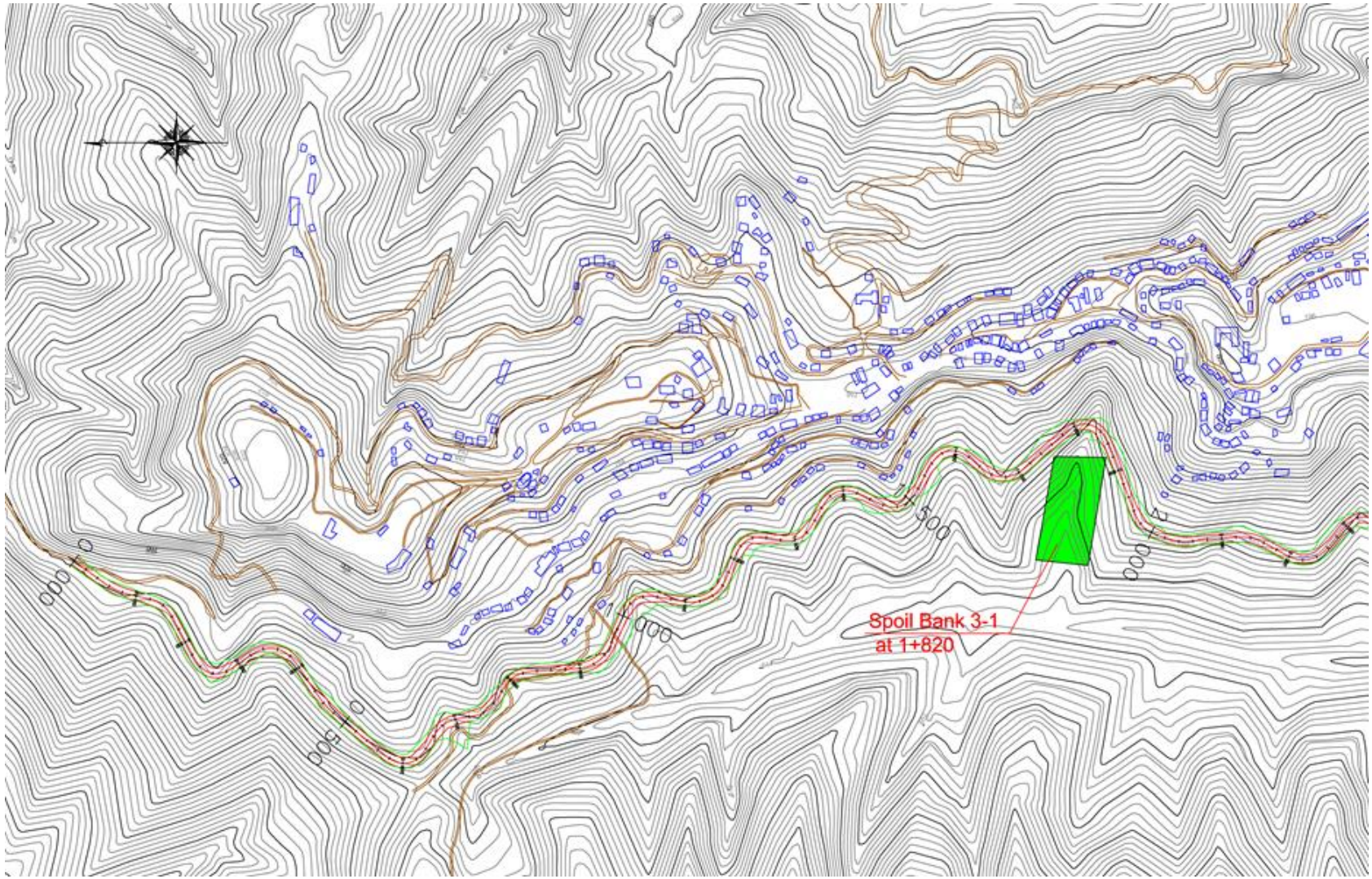
Source: JICA Study Team

Figure 2.8 Plan for Locations of Spoil Bank (Serchhip Bypass) -3/4



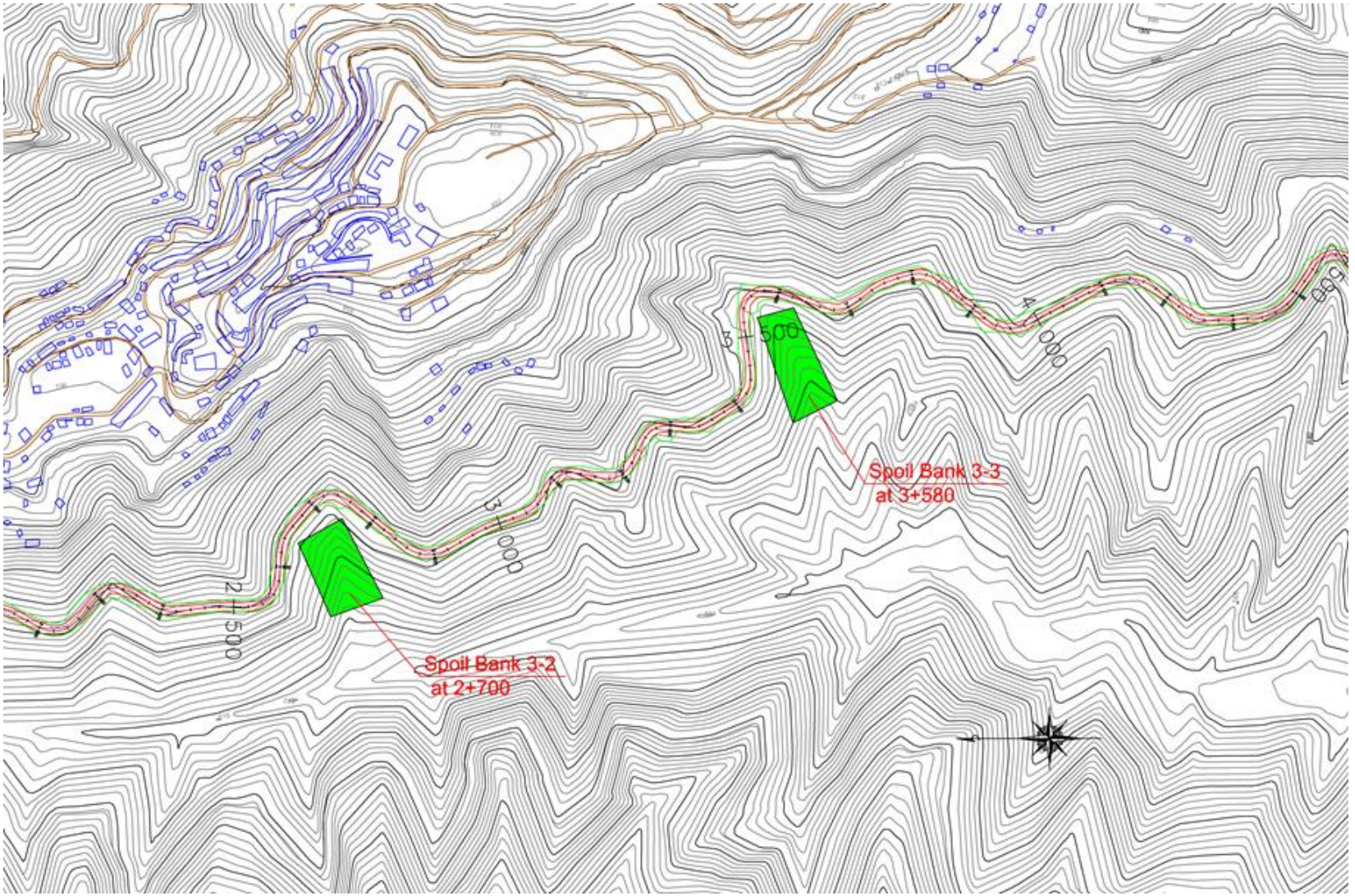
Source: JICA Study Team

Figure 2.9 Plan for Locations of Spoil Bank (Serchhip Bypass) -4/4



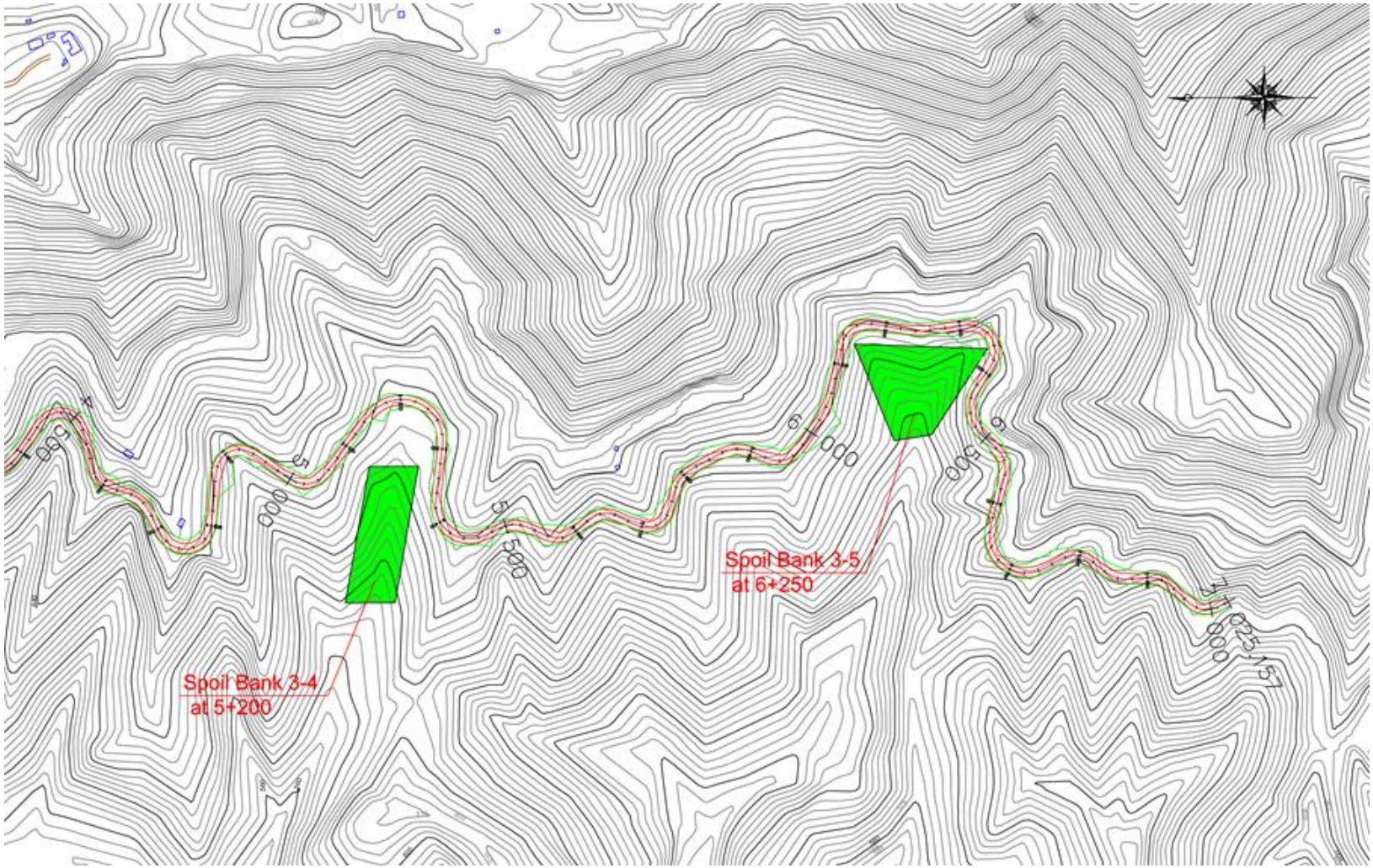
Source: JICA Study Team

Figure 2.10 Plan for Locations of Spoil Bank (Hnathial Bypass) -1/3



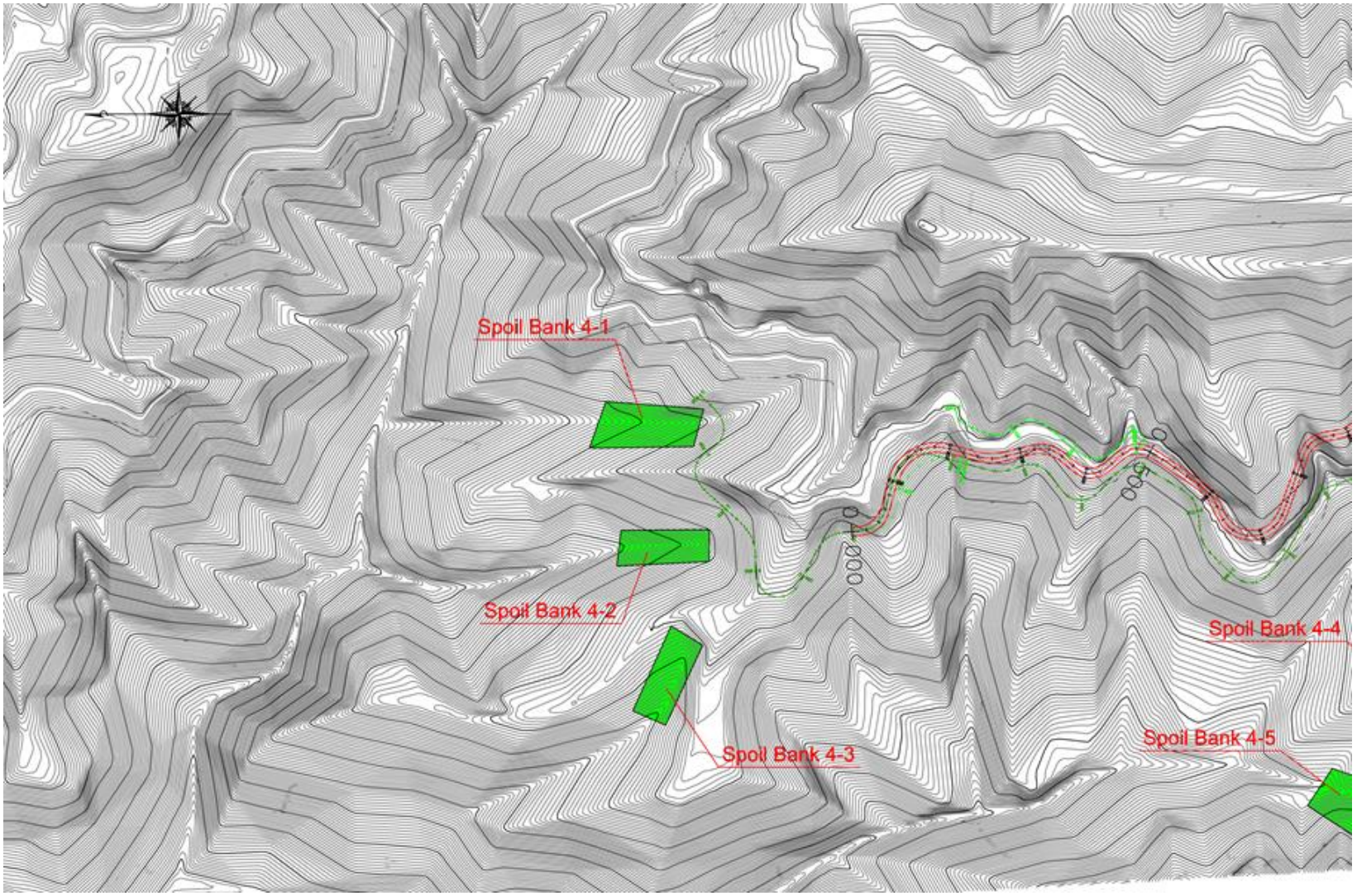
Source: JICA Study Team

Figure 2.11 Plan for Locations of Spoil Bank (Hnathial Bypass) -2/3



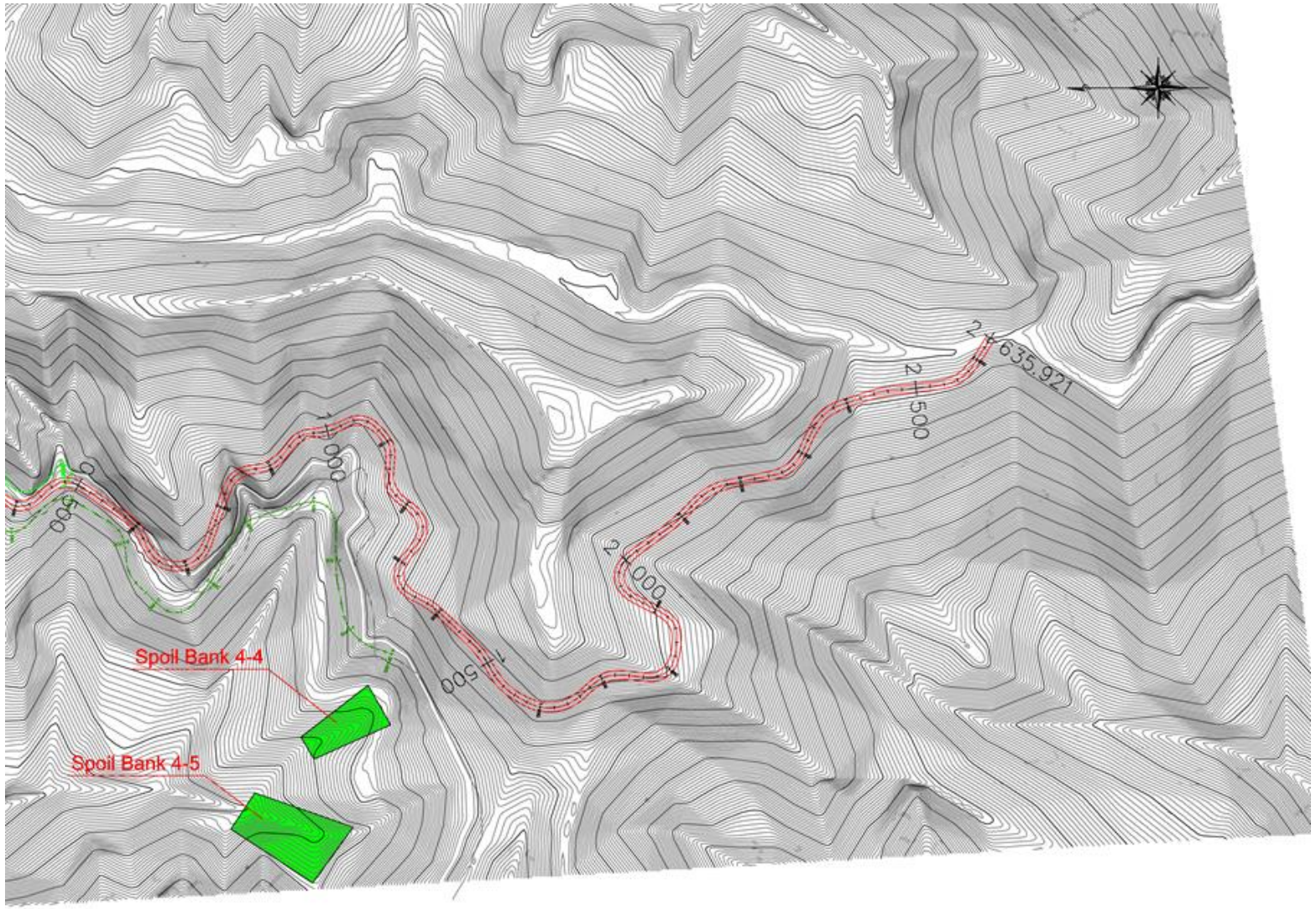
Source: JICA Study Team

Figure 2.12 Plan for Locations of Spoil Bank (Hnathial Bypass) -3/3



Source: JICA Study Team

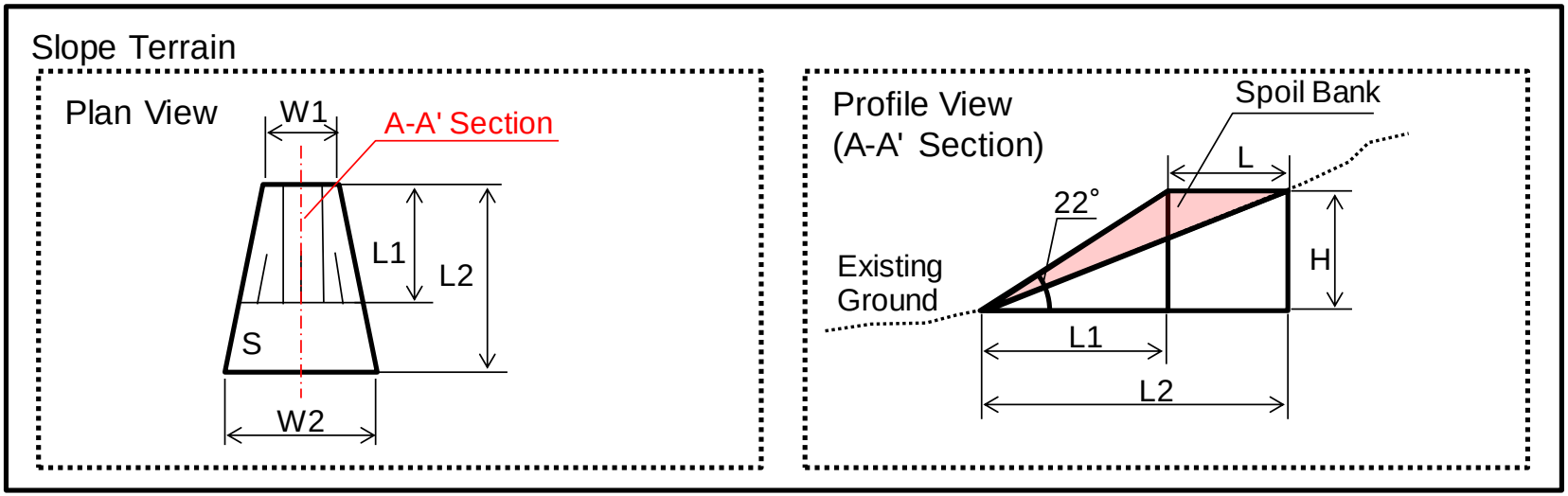
Figure 2.13 Plan for Locations of Spoil Bank (Lawngtlai Bypass) -1/2



Source: JICA Study Team

Figure 2.14 Plan for Locations of Spoil Bank (Lawngtlai Bypass) -2/2

Table 2.7 Capacities of Spoil Bank-1/2



Bypass Name	Sl. No.	STA.	H	L2	W1	W2	L1 =H/tan22	L=L2-L1	L/L2	S	V	D1	Volime of Spoil Bank	
													Plan	Require
			m	m	m	m	m	m	%	m2	m3	m	m3	m3
Chhiahtlang Bypass														
	1-1	0+350	30	101	55	43	74.3	26.7	26%	1,286	12,860	80.1	12,860	
	1-2	-	30	113	43	37	74.3	38.7	34%	1,536	15,360	80.1	15,360	
	1-3	-	30	132	145	32	74.3	57.7	43%	5,023	50,230	80.1	50,230	
												Total	78,450	77,238
Serchhip Bypass														
	2-1	0+920	30	130	35	50	74.3	55.7	42%	2,320	23,200	80.1	23,200	
	2-2	1+500	30	142	24	75	74.3	67.7	47%	3,303	33,030	80.1	33,030	
	2-3	3+100	30	133	90	117	74.3	58.7	44%	6,056	60,560	80.1	60,560	
	2-4	3+400	30	137	46	89	74.3	62.7	45%	4,161	41,610	80.1	41,610	
	2-5	3+900	30	94	83	82	74.3	19.7	20%	1,551	15,510	80.1	15,510	
	2-6	5+850	30	102	55	45	74.3	27.7	27%	1,377	13,770	80.1	13,770	
	2-7	6+380	30	113	57	42	74.3	38.7	34%	1,901	19,010	80.1	19,010	

Source: JICA Study Team

Table 2.8 Capacities of Spoil Bank-2/2

Bypass Name	Sl. No.	STA.	H	L2	W1	W2	L1 =H/tan22	L=L2-L1	L/L2	S	V	D1	Volime of Spoil Bank	
													Plan	Require
			m	m	m	m	m	m	%	m2	m3	m	m3	m3
Serchhip Bypass	2-8	7+050	30	113	53	59	74.3	38.7	34%	2,151	21,510	80.1	21,510	
	2-9	7+820	30	95	62	69	74.3	20.7	21%	1,306	13,060	80.1	13,060	
	2-10	8+400	30	116	26	62	74.3	41.7	35%	1,786	17,860	80.1	17,860	
	2-11	9+420	30	135	34	44	74.3	60.7	44%	2,316	23,160	80.1	23,160	
	2-12	9+900	30	120	38	146	74.3	45.7	38%	4,195	41,950	80.1	41,950	
	2-13	11+300	30	273	69	98	74.3	198.7	72%	16,412	164,120	80.1	164,120	
												Total	488,350	481,306
Hnathial Bypass														
	3-1	1+820	30	149	73	72	74.3	74.7	50%	5,401	54,010	80.1	54,010	
	3-2	2+700	30	117	76	69	74.3	42.7	36%	3,053	30,530	80.1	30,530	
	3-3	3+580	30	147	68	51	74.3	72.7	49%	4,285	42,850	80.1	42,850	
	3-4	5+200	30	186	67	66	74.3	111.7	60%	7,421	74,210	80.1	74,210	
	3-5	6+250	30	123	51	179	74.3	48.7	39%	5,516	55,160	80.1	55,160	
												Total	256,760	252,047
Lawngtlai Bypass														
	4-1	-	30	138	68	54	74.3	63.7	46%	3,872	38,720	80.1	38,720	
	4-2	-	30	123	49	43	74.3	48.7	39%	2,206	22,060	80.1	22,060	
	4-3	-	30	124	49	50	74.3	49.7	40%	2,455	24,550	80.1	24,550	
	4-4	-	30	118	36	64	74.3	43.7	37%	2,183	21,830	80.1	21,830	
	4-5	-	30	142	61	97	74.3	67.7	47%	5,272	52,720	80.1	52,720	
												Total	159,880	154,547

Source: JICA Study Team

CHAPTER 3 POLICY, LEGAL AND INSTITUTIONAL FRAMEWORK

3.1 National Level Laws and Regulations

As per the Environmental Protection Act in 1986 and its enforcement rights given to Ministry of Environment & Forest (MOEF), MOEF has overall authority for the administration and implementation of government policies, laws and regulations, sustainable development and pollution control in India. MOEF identifies the need to enact new laws and amend existing environmental legislation when required, in order to continue to conserve and protect the environment. At the state level, the Department of the Environment and the Department of Forest perform a similar role to MOEF. The acts are implemented by Central Pollution Control Board (CPCB) and respective State Pollution Control Boards (SPCBs). Policy Guidelines, Acts and Regulations pertaining to the protection and improvement of environment that are relevant to this project has been identified and discussed below.

3.1.1 The Environment (Protection) Act, 1986

The Environment (Protection) Act, 1986 is the umbrella legislation providing for the protection of environment in the country. Subject to the provisions of this Act, the Central Government, shall have the power to take all such 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 act Environment (Protection) Rules, had been formulated in 1986. The Rules provided for various standards for emission and discharge of environmental pollutants (Schedule I to IV). The Central Government has delegated the powers vested on it (under section 5 of the Act) to the State Govt. of Mizoram. This law is applicable to this project for environment protection in general.

3.1.2 The Forest (Conservation) Act, 1980 (amended in 1988)

The Forest (Conservation) Act, 1980 amended in 1988 pertains to the cases of diversion of forest area and felling of roadside plantation. Depending on the size of the tract to be cleared, clearances are applied for at the following levels of government:

- If the area of forests to be cleared or diverted exceeds 20ha (or, 10ha in hilly area) then prior permission of Central Government is required;
- If the area of forest to be cleared or diverted is between 5 to 20ha, the Regional Office of Chief Conservator of Forests is empowered to approve;
- If the area of forest to be cleared or diverted is below or equal to 5ha, the State Government can give permission; and,
- If the area to be clear-felled 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.

3.1.3 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 Boards (CPCB and SPCBs) whose 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.

3.1.4 The Air (Prevention and Control of Pollution) Act, 1981

The CPCB and the SPCBs 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).

3.1.5 The Motor Vehicles Act, 1988

In 1988, the Indian Motor Vehicles Act empowered the State Transport Authority to enforce standards for vehicular pollution and prevention control. The authority also checks emission standards of registered vehicles, collects road taxes, and issues licenses. In August 1997, the Pollution under Control Certificate (PUC) program was launched in an attempt to crackdown on the vehicular emissions in the states.

3.1.6 Construction and Demolition Waste Management Rules, 2016

The new Rules requires waste generators to segregate construction and demolition waste and deposit at collection centre or handover it to the authorized processing facilities. Waste generators also must ensure that there is no littering or deposition to prevent obstruction to the traffic or the public or drains. Large generators (who generate more than 20 tons or more in one day or 300 tons per project in a month) shall submit waste management plan and get appropriate approvals from the local authority before starting construction or demolition work.

3.1.7 Solid Waste Management Rules, 2016

The new Rules requires replaced the Municipal Solid Wastes (Management and Handling) Rules, 2000. The new Rules requires waste generators to segregate waste into three streams – Biodegradables, Dry (Plastic, Paper, metal, Wood, etc.) and Domestic Hazardous waste (diapers, napkins, mosquito repellants, cleaning agents etc.) before handing it over to the collector.

3.1.8 Mizoram (Land Acquisition, Rehabilitation and Resettlement) Act, 2016

The national level law to govern land acquisition in India is the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013, which took effect on January 1st, 2014, replacing the Land Acquisition Action 1894. However, the State Government of Mizoram issued Notification (No. H. 11018/8/2010-REV, dated January 5th, 2015) stating that the new Act will not be used in Mizoram on the ground that being under the Sixth Schedule of the Constitution, land in the State belongs to the individuals and not the Government. The Government

enacted the Mizoram (Land Acquisition, Rehabilitation and Resettlement) Act, 2015, on May 6th, 2016. The Mizoram Act generally follows the LARR 2013 but there are several differences in terms of the additional benefits to rural area and *solatium* to be added to the compensation. More detailed explanations are provided in RAP report.

3.2 State Level Laws and Regulations

Apart from the new land bill discussed above, Mizoram has its own biodiversity rules (Mizoram Biodiversity Rules 2010) and forest act (the Mizoram Forest Act, 1955 and its amendment), but they do not trigger additional requirements in terms of environmental and social considerations other than those already prescribed in national-level legislation.

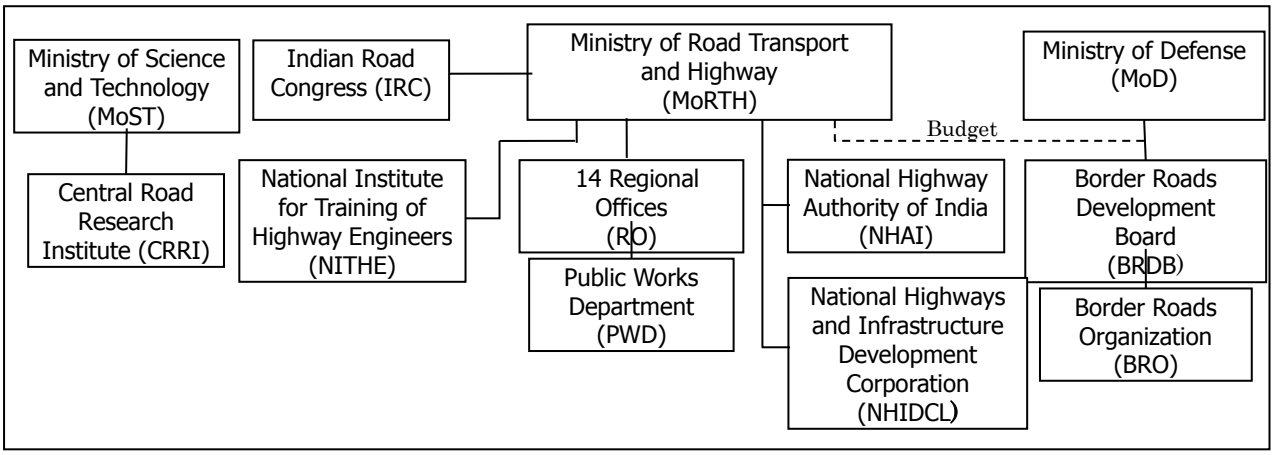
3.3 Institutional Setup

Strengthening & widening of NH54 has been initiated and is being carried out by the NHIDCL, under the auspice of Ministry of Road Transport & Highways (MORTH). Though the primary responsibility of the project rests with the NHIDCL, a brief discussion on the various institutions involved and their level of responsibilities in the project implementation is presented in the following sections.

3.3.1 Road Sector Institutions

(1) National Level Institutions

National Highways development has been promoted by National Highway Authority of India (NHAI) and Regional Offices (RO) under Ministry of Road Transport and Highway (MORTH), and 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 area of India, and started operation from 1st January 2015. Figure 3.1 shows overall structure of organizations related to national highways development.



Source: Ministry of Road Transport and Highway (JICA Study Team modified)

Figure 3.1 Organizational Structures for National Highway Development

NHAI was set up by the National Highways Authority of India Act of 1988. It is the main nodal agency for developing, managing and maintaining India's network of National Highways. It became an autonomous body in 1995. The NHAI maintains 70,934 Km of National Highways and Expressways across India. NHIDCL started operation from 1st January 2015 and development of the target roads of this study is being promoted under NHIDCL.

NHIDCL is a fully owned company of the Ministry of Road Transport & Highways, Government of India. The company promotes, surveys, establishes, designs, builds, operates, maintains and upgrades National Highways and Strategic Roads including interconnecting roads in parts of the country which share international boundaries with neighboring countries. The regional connectivity so enhanced would promote cross border trade and commerce and help safeguard India's international borders. This would lead to the formation of a more integrated and economically consolidated South and South East Asia. In addition, there would be overall economic benefits for the local population and help integrate the peripheral areas with the mainstream in a more robust manner. An approximate aggregate length of 10,000 km has been identified to begin with for development through this company. The company envisages creating customized and specialized skills in terms of addressing issues like complexities of geographical terrains and addressing extensive coordination requirements with security agencies. The company would also endeavor to undertake infrastructure projects including but not restricted to urban infrastructure and urban or city transport and to act as an agency for development of all types of Infrastructure. The company envisages working towards cross sharing of technical know-how and enhancing opportunities for business development with other nations and their agencies including the multilateral organizations and institutions.

The company also proposes to improve road connectivity and efficiency of the international trade corridor, by expanding about 500 km 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.

(2) State-level Institutions

Public Works Department (PWD) Mizoram is the premier agency of the government of Mizoram engaged in planning, designing, construction and maintenance of Government assets in the field of built environment and infrastructure development. Assets in infrastructure development include Roads, Bridges, City Centers, Footpaths, New Capital Complex, and Airport, and assets in built environment include Hospitals, Schools, Colleges, Technical Institutes, Police Buildings, Prisons, Courts among others. PWD Mizoram 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.

3.3.2 Environmental Institutions

The environmental regulations, legislation, policy guidelines and control that may impact this project

are the responsibility of a variety of government agencies. In all, as discussed in the subsequent sections, the following agencies would play important roles in this project.

(1) Ministry of Environment and Forests (MOEF)

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 and Forests (MOEF). Established in 1985, the MOEF is the agency primarily responsible for the review and approval of EIAs pursuant to GOI legislation.

(2) MOEF Regional Offices

The Ministry of Environment and Forests (MOEF) has set up regional offices, with each region having an office. The office that cover North Eastern zone including Mizoram is located at Shillong, Meghalaya. This office is responsible for collecting and furnishing information relating to EIA of projects, 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) Central Pollution Control Board (CPCB)

Statutory authority attached to the MOEF and located in New Delhi, the main responsibilities include inter alia the following:

- Planning and implementing water and air pollution programs;
- Advising the Central Government on water and air pollution programs;
- Setting air and water standards; and
- 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 Mizoram State Pollution Control Board (MSPCB).

(4) Departments of Environment and Forests (DOEF)

They perform the functions similar to the MOEF at the state level.

(5) Mizoram State Pollution Control Board (M-SPCB)

The M-SPCB has the mandate for environmental management at the state level, with emphasis on air and water quality. The board 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 the Cess Act, etc.;

- Conducting and organizing public hearings for projects as defined by the various Acts and as stipulated by the Amendment (April 1997) to the EIA Act; and,
- Issuing No-objection Certificates (NOC) for industrial development defined in such a way as to include road projects as the Third National Highway Project.

(6) Mizoram State Forest Department

The Mizoram State Forest Department is responsible for the protection and managing the forest designated areas within the state. The Forest Department works out 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 and for chalking out specific plans and policies with respect to the conservation, protection and development of the forest areas. The Forest department will be responsible for granting clearances for forest areas that need to be cleared for the project, according to the provisions of the Forest (Conservation) Act, 1980.

3.4 Requirements of Clearance and Permits

As discussed earlier, Environmental Clearance is not required for this project as the scale of widening and land acquisition for this project is not significant enough not trigger the requirement. However, the forest clearance permit will have to be obtained prior to the commencement of construction activity, as per the requirement of the Forest Act. According to the discussions held with Department of Environment and Forests, the application will be processed at various Forest Department offices at Division, State and Central Government level depending on forest land requirement for non-forest purposes. Part 1 of the application format has to be filled in by NHIDCL, the project proponent while Part 2 of the application will be cleared by the Forest Division. Part 3 will be cleared at State Environment and Forest Department while Part 4 (at Nodal Officer under Forest Conservation Act) and Part 5 (Secretary of Department of Environment and Forest at Government of Meghalaya) will clear them before forwarding it to Ministry of Environment and Forest in Delhi for appraising and issuing Forest Clearance.

Also, various clearance will be required for setting up hot-mix plants, batching plants, etc., under the Air and the Water Acts. Clearance from the State Department of Mining is required for establishing quarries. Clearance from the Sate Ground Water Boards/Authorities is required for establishment of new tube-wells/bore-holes in case they are required during construction work. Also, 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 this project. With limited possibility, the provisions of the Hazardous Wastes (Management and Handling) Rules, 1989 and the Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996 may also apply during the construction and the operation periods. The applicability of environmental and other relevant rules and acts is shown in Table 3.1 below.

Table 3.1 Clearance Requirements

No.	Activity	Statute	Requirement	Competent Authority	Responsible Agency for Obtaining Clearance	Time Required
Pre-Construction Stage (Responsibility: MORTH)						
2	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
3	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	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	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	Contractor	2-3 months
4	Storage of fuel oil, 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)	Contractor	4-6 months
5	Quarry Operation	State Minor Mineral Concession Rules, The Mines Act of1952, Indian Explosive Act of1984, Air Act of1981 and Water Act of 1974	Quarry Lease Deed and Quarry License	State Department of Mines and Geology	Contractor	4-6 months
6	Extraction of ground water	Ground Water Rules of 2002	Permission for extraction of ground water for use in road construction	State Ground Water Board	Contractor	4-6 months

			activities			
7	Engagement of labor	Labor Act	Labor license	Labor Commissioner	Contractor	2-3 months
8	Construction waste disposal, including surplus soil and solid waste disposal	Construction and Demolition Waste Management Rules 2016, and Sold Waste Management Rules 2016	Waste Management Plan	District Governments	Contractor	4-6 months
9	Surplus soil disposal sites	Construction and Demolition Waste Management Rules, 2016 and Solid Waste Management Rules, 2016	Identification and selection of disposal site	District Governments	Contractor	4-6 months

Source: JICA Study Team

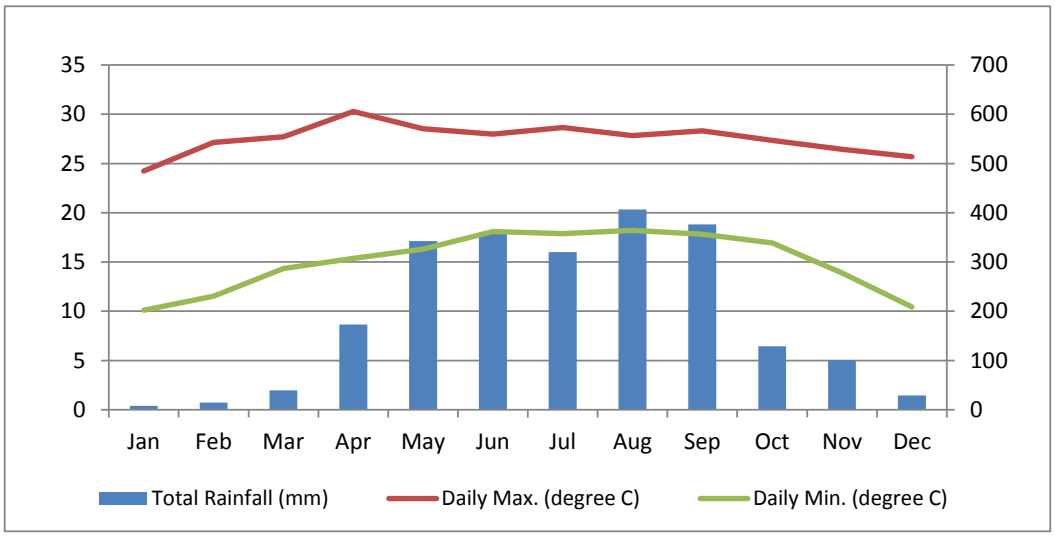
CHAPTER 4 ENVIRONMENTAL AND SOCIAL BASELINE

This chapter assesses existing environment and socio-economic conditions against which likely environmental and social impacts of the project will be analyzed. The baseline data presented below have been collected by monitoring surveys as well as literature reviews and interactions with local people and government officials at various levels. A more detailed socio-economic profile can be found in the RAP report prepared for this project. The Scoping Matrix that summarizes likely scale of impacts for various components is included in Chapter 6, and Environmental Checklist as per JICA Guideline is included in Appendix A.

4.1 Natural Environment

4.1.1 Climate

Mizoram has a mild climate, relatively cool in summer 20 to 29 °C (68 to 84 °F)[3] and winter temperatures range from 7 to 22 °C. The region is influenced by monsoon, raining heavily from May to September with little rain in the dry-season. The climate pattern is moist tropical to moist sub-tropical, with average state rainfall 2540 mm per annum.



Source: Meteorological Data of Mizoram 2015

Figure 4.1 Monthly rainfall and daily max/min temperature in Aizawl (average between 2011 and 2015)

Annual rainfall in three reporting centers near the proposed bypass is presented below. Lawngtlai (BP4) area tends to have lower rainfall compared to other areas.

[3] This is the long-term average. However, 2015 was exceptionally hot year with temperature of 30°C or more was recorded in 10 out of 12 months. Between 2011 and 2014, temperature over 30°C was recorded only twice.

Table 4.1 Annual Rainfall Soil Structures in Project Area

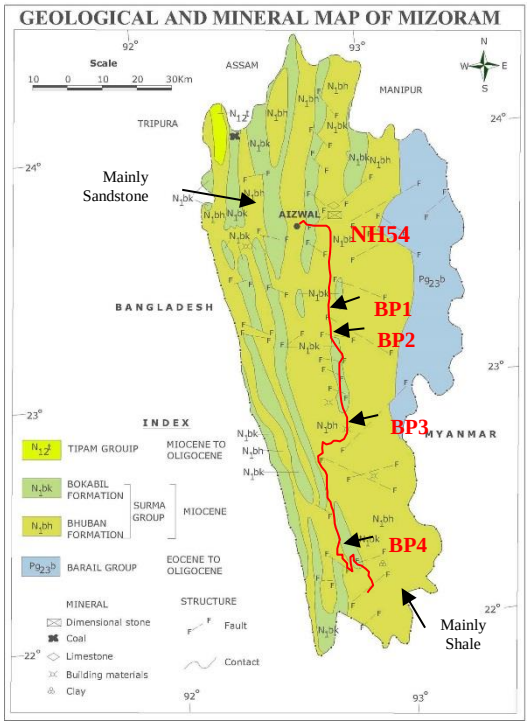
Report Center	Annual Rainfall in mm				
	2011	2012	2013	2014	2015
Serchhip (for BP1 and 2)	1940.3	1784.8	1725.9	1811	2214.7
Hnathial (BP3)	1924.3	2105.1	2046.3	1720.3	1942
Lawngtlai (BP4)	NA	887.7	1768.9	1541.3	1673.4

Source: Meteorological Data of Mizoram 2015

4.1.2 Topography, Geology, and Soil

The North-East India is located on the north-east edge of the Himalayan orogenic belt resulted from Indo-Eurasian continental plate collision that took place during Cenozoic era, and represents one of the youngest and the highest mountain range in the world. The Himalayan orogenic belt has a unique agglomeration with a diversified geological setup. The various topographic features include the Himalayan mountain belt in the north, the Indo-Myanmar Range in the east, Shillong Massif Plateu in the west, and the expansive Brahmaputra forming the Assam plains in between.

Mizoram state is predominately composed of mountainous terrain of tertiary rocks. The mountain ridges strike north to south direction in parallel series. The mountain ranges are separated from one another by narrow deep river valleys. The elevation ranges from 40 meters to 2,157 meters, the highest point at Phawngpui. There are only a few and small patches of flat lands, which are mostly intermontane basins. Figure 4.4 shows the geological map of the Mizoram state. According to this map, the geology along NH54 consists of Bokabil formation and Bhuban formation of Surma groups.



Source: Geological Survey in India

Figure 4.2 Gological Map of Mizoram

Soil texture, in general, varies from sandy loams, clayey loams to clay. Although the soils are mature, profuse rainy spells in the region coupled with the high gradients have accelerated the problem of leaching of the loose soils. These soils are highly porous with low water holding capacity and this is the main cause of the low water table in Mizoram. The soils of Mizoram are deficient in potassium, phosphorous, nitrogen and humus. The traditional jhum cultivation has adversely affected the productivity. Although superficial greenery is observed owing to the profuse rainfall, the tract is actually in the process of fast degradation. The pH of these soils is acidic to neutral due to excessive leaching. The soil structure of the project area is summarized below.

Table 4.2 Soil Structures in Project Area

District	Soil pH	Nitrogen (Kg/ha)	Phosphorus (Kg/ha)	Potash (Kg/ha)
Serchhip	5.53	264	12	277
Lunglei	5.38	251	10	147
Lawngtlai	5.95	229	16	221

Source: Soil Information System

4.1.3 Flora and Fauna

Mizoram is the highest forest cover state in the India, having about 90 % of the total geographical area is under forest (India State Forest Report FSI, 2013). Mizoram is a hilly region receiving heavy rainfall with soil characteristics conducive for luxuriant growth. Flora and fauna assessment were carried out for all the three districts that the targeted section of NH54 by-passes through. Floral/Vegetation assessment carried out through quadrate methods; for trees 10mx10m, for shrubs 5mx5m and for Herbs 1m x1m square shaped quadrats were used. Quadrates were laid randomly in the corridors upside and downside of the road. All species in the quadrats were recorded & ecological parameters such as density and frequency were calculated. Faunal species were recorded with the visual observation during site visits, secondary data from the forest department and local information from peoples. The flola and fauna survey was carried out twice, during the dry season (from February to March 2016) and the rainy season (from May to July 2016).

(1) Flora

The major areas are under tropical semi-evergreen forests and sub-tropical forests. The vegetation consists of trees, shrubs, herbs and climbers. The forest exhibits a clear zonation consisting of different species of trees.

(i) The tropical wet evergreen with tall dense trees.
(ii) The tropical, semi-evergreen with deciduous species.
(iii) The Montane sub-tropical with broad leaved evergreen species

During the field study the undergrowth is dense with herbaceous plants. Evergreen and diverse forests are also present in the middle and lower canopies. Musa spp. are also common in the slopes. Ferns,

palms orchids, bryophytes and orchids are also fairly common in the study area. Due to traditional practice of jhumming cultivation, large areas of forests are being converted into barren land. However, the department environment and forest is taking steps to regenerate the forest area either naturally and/or artificially through plantation. In most parts these plantations consists of teakwood trees.

Jhumming and shifting cultivation is the principal method of cultivation and majority of the rural population is engaged in cultivation. In jhum cultivation the vegetation are cut and allowed to dry. After some days the forests are burnt and the area is cleared for cultivation. Many tree species are destroyed during the process but bamboo regrows as soon as favorable temperature and seasonal monsoon arrive. Therefore, in abandoned jhum land the first plant to grow is bamboo. Some important associates found growing along with bamboos are *Emblica officinalis, Litsea monopetala, Pterospermum acerifolium, Terminalia myriocarpa, Caryota mitis, Artocartus chama, Duabanga grandiflora, Albizia procera, Gmelina arborea*, *Syzygium* species.

Maize, wheat, palms and oil seeds, pulses, peas, ginger, groundnut, papaya, pineapple, cash crops like tapioca and vegetables like potato, tomato and beans are grown in the study area. A small patch of tea plantation was also found in the study area of Chhiathlang (BP1).

The floral diversity recorded during the field study and secondary data collected from the Environment and Forest Department, Mizoram are listed in the Table below. The common name, local name, IUCN red list category and IWPA category (wherever applicable) and field observation are presented below.

Table 4.3 Flora in Mizoram and Project Area

SL. NO.	BOTANICAL NAMES	COMMON NAME	LOCAL NAMES	IUCN CATEGORY	IWPA CATEGORY	Field Observation
1	*Abelmoschus manihot*	Ladies Finger	Ui chhu me	Not Assessed		Spotted at Hnahthial
2	*Acacia intsia*	Acacia	Vawkpui-ruan gruh	LC ver 3.1		Spotted at Hnahthial & Chhiathlang
3	*Acacia pennata*	Climbing Acacia	Khanghu	LC ver 3.1		
4	*Acacia pruinescens*	--	Khangpawl	Not Assessed		Spotted at all four BP areas
5	*Achyranthes aspera*	Chaff Flower	Ui-hlo	Not Assessed		Spotted at all four BP areas
6	*Achyranthes bidentata*	Oxknee	Vangvat-hlo	Not Assessed		
7	*Acmella paniculata*	Spot Flower	Ankasate	LC ver 3.1		Spotted at all four BP areas
8	*Acmella uliginosa*	Marsh Cress	Ansate	LC ver 3.1		Spotted at all four BP areas
9	*Acrocarpus fraxinifolius*	Pink Cedar	Nganbawm	Not Assessed		
10	*Aeschynomene indica*	Curly indico	Hlo-nuar-suak	LC ver 3.1		
11	*Aganope thyrsiflora*	--	Hulhu	Not Assessed		
12	*Ageratina adenophora*	Crofton Weed	Nepal-tlangsam	Not Assessed		

SL. NO.	BOTANICAL NAMES	COMMON NAME	LOCAL NAMES	IUCN CATEGORY	IWPA CATEGORY	Field Observation
13	*Ageratum conyzoides*	Floss Flower	Vai len hlo	Not Assessed		Spotted at all four BP areas
14	*Ageratum houstonianum*	Bluemink	Vai-lenhlo-chi khat	Not Assessed		Spotted at Serchhip & Chhiathlang
15	*Aglaia chittagonga*	Priyangu	Thehleikhak	LC ver 3.1		
16	*Aglaia edulis*	Droopy leaf	Rai-thei	Lower Risk/Near Threatened ver 3.1		
17	*Aglaomorpha coronans*	Santa Rose Fern	Awmvel/Tuai bur	Not Assessed		Spotted at Serchhip
18	*Alangium chinense*	Chinese Alangium	Arsa-rim-nam	Not Assessed		
19	*Albizia chinensis*	Chinese Albizia	Vang	Not Assessed		Spotted at Hnahthial, Serchhip & Chhiathlang
20	*Albizia odoratissima*	Fragrant Albizia	Thingri	Not Assessed		
21	*Albizia procera*	White Siris	Kangtek	Not Assessed		
22	*Alocasia fallax*	Dwarf Taro	Zawng-bai-bi ng	Not Assessed		Spotted at Hnahthial
23	*Alseodaphne petiolaris*	--	Khuangthulh	Not Assessed		
24	*Alstonia scholaris*	Devil Tree	Thuamriat	LC ver 2.3		Spotted at Hnahthial, Serchhip & Chhiathlang
25	*Amaranthus spinosus*	Thorny Pigweed	Lenhling	Not Assessed		Spotted at Hnahthial, Serchhip & Chhiathlang
26	*Amaranthus viridis*	Green amaranth	Lenghling-hli ng-nei-lo	Not Assessed		Spotted at Hnahthial, Serchhip & Chhiathlang
27	*Amomum maximum*	Java Cardamon	Aidu	Not Assessed		
28	*Ananas comosus*	Pineapple	La-khuih-thei	Not Assessed		Spotted at Hnahthial, Serchhip & Chhiathlang
29	*Angiopteris evecta*	Giant Fern	Kawksa-ke	Not Assessed		
30	*Anogeissus acuminata*	Yon	Zairum	Not Assessed		
31	*Antidesma acidum*	Amti	Thurte an	Not Assessed		
32	*Antidesma bunius*	Bignay	Tuaitit	Not Assessed		
33	*Aporosa octandra*	--	Chhawntual	Not Assessed		
34	*Arenga pinnata*	Sugar Palm	Thangtung	Not Assessed		
35	*Aeridis rosea*	Orchids	Nauban	Not Assessed		Spotted at Hnahthial & Chhiathlang
36	*Arisaema album*	Cobra lily	Mitthi-vaimim	Not Assessed		
37	*Artemisia vulgaris*	Mugwort	Sai	Not Assessed		
38	*Artocarpus heterophyllus*	Jackfruit	Lamkhuang	Not Assessed		Spotted at all four BP areas

SL. NO.	BOTANICAL NAMES	COMMON NAME	LOCAL NAMES	IUCN CATEGORY	IWPA CATEGORY	Field Observation
39	*Artocarpus lacucha*	Lakooch	Theitat	Not Assessed		
40	*Baccaurea ramiflora*	Bhooby Tree	Pangkai	Not Assessed		
41	*Balakata baccata*	Seleng	Thingvawkpui	Not Assessed		
42	*Bambusa spp.*	Bamboo		Not Assessed		Spotted at all four BP areas
43	*Bauhinia variegata*	Kachnar	Vaube	LC ver 3.1		Spotted at all four BP areas
44	*Bidens pilosa*	Black Jack	Vawkpuithal	Not Assessed		Spotted at Hnahthial & Chhiathlang
45	*Bischofia javanica*	Uriam	khuangthli	Not Assessed		
46	*Blechnum spp.*		Kawk ma ther	Not Assessed		Spotted at Serchhip
47	*Bombax ceiba*	Semul	Phunchawng	Not Assessed		Spotted at all four BP areas
48	*Bombax insigne*	Didu	Pang	Not Assessed		
49	*Breynia retusa*	Cup Saucer Plant	Pi-bengbeh	Not Assessed		
50	*Bruinsmia polysperma*	--	Theipaling-kawh	Not Assessed		
51	*Buddleja asiatica*	White Butterfly Bush	Serial	Not Assessed		
52	*Byttneria aspera*	--	Zawngluanghrui	Not Assessed		
53	*Byttneria pilosa*	--	Sazuknghawnghlap	Not Assessed		
54	*Cajanus goensis*	--	Zawngbete	Not Assessed		
55	*Callicarpa arborea*	Beautyberry Tree	Hnahkiah	Not Assessed		
56	*Camellia sinensis*	Tea	-	Not Assessed		Spotted at Chhiathlang
57	*Carica papaya*	Papaya	Thing-fang-hma	Not Assessed		Spotted at all four BP areas
58	*Caryota urens*	Solitary Fishtail Palm	Meihle	LC ver 3.1		
59	*Cassia fistula*	Amaltar	Ngai-ngaw	Not Assessed		
60	*Castanopsis tribuloides*	Chestnut	Thingsia	Not Assessed		
61	*Ceiba pentandra*	Ceiba	Japan-pang			Spotted at all four BP areas
62	*Celtis tetrandra*	Nettle Tree	Anku	Not Assessed		
63	*Centella asiatica*	Pennywort	Lambak	LC ver 3.1		
64	*Cephalotaxus griffithii*	Griffith's Plum Yen	Thinglenbuang	Vulnerable ver 3.1		
65	*Cheilocostus speciosus*	Kew	Sumbul	Not Assessed		
66	*Chromolaena odorata*	Floss Flower	Tlangsam	Not Assessed		
67	*Chukrasia tabularis*	Chickrassy	Zawngtei	LC ver 3.1		
68	*Cinnamomum tamala*	Bay leaf	Hnahrimtui/Tejpata	Not Assessed		
69	*Cissampelos pareira*	Akanadi	Hnahbialhrui	Not Assessed		
70	*Cissus javana*	Begonia	Sanghar-hmai	Not Assessed		Spotted at all four BP areas

SL. NO.	BOTANICAL NAMES	COMMON NAME	LOCAL NAMES	IUCN CATEGORY	IWPA CATEGORY	Field Observation
71	*Cissus repens*	--	Hruipawl	Not Assessed		
72	*Clausena excavata*	Pink Limberry	Arpa-sentil	Not Assessed		
73	*Clerodendrum glandulosum*	Glory Bower	Phuihnam	Not Assessed		
74	*Clerodendrum infortunatum*	Hillglory Flower	Phuihnamchhia	Not Assessed		Spotted at all four BP areas
75	*Colona floribunda*	--	Hnahthap	Not Assessed		
76	*Conyza bonariensis*	Hairy Horseweed	Buarzen	Not Assessed		
77	*Cordia fragrantissima*	--	Muk	Not Assessed		
78	*Croton caudatus*	Rushfoil	Ranlungdamdawi	Not Assessed		
79	*Cyathea chinensis*	--	Kawkpui	Not Assessed		
80	*Cymbidium spp*	Orchids	Nauban	Not Assessed		Spotted at Hnahthial & Chhiathlang
81	*Cynodon dactylon*	Bermuda Grass	Phul	Not Assessed		Spotted at all four BP areas
82	*Dalbergia obtusifolia*	--	Bianghrei	Not Assessed		Spotted at all four BP areas
83	*Dalbergia stipulacea*	Himalayan Dalbergia	Hruizaizawh	Not Assessed		Spotted at Lawngtlai
84	*Debregeasia longifolia*	Orange Wild Rhea	Lehngo	Not Assessed		
85	*Dendrobium spp*	Dendrobium	Nauban	Not Assessed		Spotted at all four BP areas
86	*Dendrocalamus hamiltonii*	Rhino Bamboo	Phulrua	Not Assessed		
87	*Dendrocalamus longispathus*	--	Rawnal	Not Assessed		
88	*Derris robusta*	Sea Derris	Thingkha	Not Assessed		
89	*Dimocarpus longan*	Lichi	Theifeimung	Near Threatened ver 3.1		
90	*Diospyros glandulosa*	--	Theivawkmit	Not Assessed		
91	*Dracaena spicata*	Dracaena	Phunhring	Not Assessed		
92	*Duabanga grandiflora*	Lampati	Zuang	Not Assessed		Spotted at Serchhip
93	*Dysoxylum excelsum*	--	Thingthupui	Not Assessed		
94	*Dysoxylum mollissimum*	--	Thingsaphu	Not Assessed		
95	*Elaeagnus latifolia*	Oleaster	Sarzukpui	Not Assessed		Spotted at Chhiahtlang
96	*Elaeocarpus lanceifolius*	--	Kharuan	Not Assessed		
97	*Elaeocarpus rugosus*	--	Theikel ek	Vulnerable ver 3.1		
98	*Elaeocarpus serratus*	Rosserynut	Vantha	Not Assessed		
99	*Elaeocarpus tectorius*	--	Umkhal	Not Assessed		
100	*Embelia ribes*	Embelia	Naufadawntuai	Not Assessed		
101	*Embelia vestita*	--	Tling	Not Assessed		
102	*Engelhardtia spicata*	Silapoma	Hnum	LC ver 3.1		

SL. NO.	BOTANICAL NAMES	COMMON NAME	LOCAL NAMES	IUCN CATEGORY	IWPA CATEGORY	Field Observation
103	*Ensete glaucum*	Snow Banana	Saisu	Not Assessed		
104	*Entada phaseoloides*	Ghila	Kawihrui	Not Assessed		Spotted at Serchhip
105	*Eranthemum strictum*	--	Lentupui	Not Assessed		
106	*Eriobotrya bengalensis*	--	Nghalchhun	Not Assessed		
107	*Erythrina stricta*	Tiger Claw	Fartuah	Not Assessed		Spotted at all four BP areas
108	*Etlingera linguiformis*	--	Buh-ai	Not Assessed		
109	*Eulalia trispicata*	--	Thang	Not Assessed		
110	*Euphorbia hirta*	Lal Dhudi	Zawhte-hlo	Not Assessed		
111	*Euphorbia spp.*		Chawng	Not Assessed		Spotted at Lawngtlai
112	*Eurya japonica*	Japanese Eurya	Sihneh	Not Assessed		
113	*Ficus auriculata*	Elephant Ear Fig	Theibal	Not Assessed		
114	*Ficus curtipes*	Bluntleaf Fig	Hnahhlun	Not Assessed		Spotted at Hnahthial
115	*Ficus elastica*	Indian rubber	Thelret	Not Assessed		
116	*Ficus hirta*	Hairy Fig	Sazutheipui	Not Assessed		
117	*Ficus hispida*	Devil Fig	Paihtemaian	Not Assessed		
118	*Ficus prostrata*	--	Theitit	Not Assessed		
119	*Ficus racemosa*	Goolar	Theichek/Chhohe	Not Assessed		
120	*Ficus retusa*	Laurel Fig	Rihnim	Not Assessed		
121	*Ficus semicordata*	Drooping Fig	Theitit/Theipui	Not Assessed		
122	*Ficus virens*	White Fig	Zaihri	Not Assessed		
123	*Firmiana colorata*	Bonefire Tree	Khaukhim	Not Assessed		
124	*Flacourtia jangomas*	Coffee Plum	Awmtawt	Not Assessed		
125	*Flueggea virosa*	Whiteberry Bush	Saisiak	Not Assessed		
126	*Garcinia lanceifolia*	--	Chengkek	Not Assessed		
127	*Garuga floribunda*	Garuga	Tuairam	Not Assessed		
128	*Garuga pinnata*	Garuga	Bungbutuairam	Not Assessed		
129	*Girardinia diversifolia*	Himalayan Nettle	Taiten	Not Assessed		
130	*Globba wengeri*	Dancing Girl	Ai-thing	Not Assessed		
131	*Glochidion heyneanum*	Velvety melon Featherfoil	Thingpawnchhia	Not Assessed		
132	*Glycosmis pentaphylla*	Ash Sheora	Arpatil	Not Assessed		
133	*Gmelina arborea*	Gomari	Thlanvawng	Not Assessed		
134	*Gnetum gnemon*	Joint Fir	Pelh	LC ver 3.1		
135	*Goniothalamus sesquipedalis*	--	Kham	Not Assessed		
136	*Gynocardia odorata*	Chaulmugra	Saithei	Not Assessed		

SL. NO.	BOTANICAL NAMES	COMMON NAME	LOCAL NAMES	IUCN CATEGORY	IWPA CATEGORY	Field Observation
137	*Haematocarpus validus*	--	Theichhungsen	Not Assessed		
138	*Hedyotis scandens*	--	Laikingtuibur	Not Assessed		
139	*Helicia excelsa*	--	Sialhma	Not Assessed		
140	*Heritiera papilio*	--	Thingsaiphaw	Not Assessed		
141	*Heteropanax fragrans*	Fragrant Aralia	Changkhen	Not Assessed		
142	*Hodgsonia heteroclita*	Chinese lordplant	Kha-um	Not Assessed		
143	*Homalomena aromatica*	Sugandhmati	Anchiri	Not Assessed		
144	*Hovenia dulcis*	Japanese Raisin Tree	Vautangbawk	Not Assessed		
145	*Hoya longifolia*	--	Hnahchhah	Not Assessed		
146	*Hydnocarpus kurzii*	Chaulmugra	Khawitur	DD ver 3.1		
147	*Ipomoea hederifolia*	Scarlet Creeper	Nipuipar	Not Assessed		
148	*Jasminum coarctatum*	--	Hlokha	Not Assessed		
149	*Jasminum nervosum*	Wild Kunda	Hruikha	Not Assessed		
150	*Juglans regia*	Walnut Tree	Khawkherh	Near Threatened ver 3.1		
151	*Kydia glabrescens*	--	Hnahbialthing	Not Assessed		
152	*Lagerstroemia speciosa*	Jarul	Thlado	Not Assessed		Spotted at Serchhip
154	*Lannea coromandelica*	Jhingan	Tawitaw-suak	Not Assessed		
155	*Laurocerasus undulata*	--	Theiarlung	Not Assessed		
156	*Leea indica*	Banicoat Berry	Kawlkar	Not Assessed		
157	*Leea compactiflora*	--	Kumtintuai	Not Assessed		
158	*Leucosceptrum canum*	--	Kawihthuang	Not Assessed		
159	*Ligustrum robustum*	Wild Preefet	Chawmzil	Not Assessed		
160	*Lindernia ruellioides*	Duckbill Pimpernel	Thasuih	LC ver 3.1		
161	*Lithocarpus dealbata*	Oak	Fah	_		
162	*Lithocarpus elegans*	Spike Oaks	Thingpuithing hnahsin	Not Assessed		
163	*Litsea cubeba*	Cubeba	Sernam	Not Assessed		
164	*Lobelia pyramidalis*	Lobelia	Berawchal	Not Assessed		
165	*Lygodium japonicum*	Climbing fern	Dawnzem	Not Assessed		
166	*Macaranga denticulata*	Mallata	Kharpa	Not Assessed		
167	*Macaranga peltata*	Chandada	Kharduap	Not Assessed		
168	*Maesa montana*	Maesa	Arngeng	Not Assessed		
169	*Magnolia champaca*	Champa	Ngiau	LC ver 3.1		
170	*Magnolia hodgsonii*	Heart Flower	Thingtumbu	LC ver 3.1		
171	*Mallotus paniculatus*	Panicled Mallotus	Kharpawl	Not Assessed		

SL. NO.	BOTANICAL NAMES	COMMON NAME	LOCAL NAMES	IUCN CATEGORY	IWPA CATEGORY	Field Observation
172	*Mallotus philippensis*	Rohini	Thingkhei	Not Assessed		
173	*Mammea suriga*	Surangi	Suktlawng	Not Assessed		
174	*Mangifera indica*	Am	Ramtheihai	Data Deficient ver 3.1		Spotted at all four BP areas
175	*Melocalamus compactiflorus*	Pear Bamboo	Sairil	Not Assessed		
176	*Melocanna baccifera*	Muli Bamboo	Mautak	Not Assessed		
177	*Merremia umbullata*	Hogvine	Thianpa	_		
178	*Merremia vitifolia*	Grape glory	Thiannu	Not Assessed		Spotted at all four BP areas
179	*Mesua ferrea*	Mesua	Herhse	Not Assessed		Spotted at Hnahthial, Serchhip & Chhiathlang
180	*Micromelum minutum*	Orangeberry	Vawkpuitaisen	Not Assessed		
181	*Mikania micrantha*	Bittervine	Japanhlo	Not Assessed		
182	*Milletia pachycarpa*	--	Rulei	_		
183	*Mimosa pudica*	Shameplant	Hlonuar	LC ver 3.1		Spotted at all four BP areas
184	*Molineria capitulata*	Palm Grass	Phaiphak	_		
185	*Morinda angustifolia*	Thin leaved Morinda	Lum	_		
186	*Mucuna bracteata*	--	Hruiduk	LC ver 3.1		
187	*Mucuna imbricata*	Lyon Bean	Zawngkawi	LC ver 3.1		
188	*Mucuna pruriens*	Velvet Bean	Uiteme	Not Assessed		
189	*Musa spp.*	Banana	Vaibalhla/Changthir	Not Assessed		
190	*Mussaenda roxburghii*	Himalayan Mussaenda	Vakep	Not Assessed		
191	*Neolamarkia cadamba*	Kadam	Banphar			
192	*Neonauclea purpurea*	Phuga	Lungkhup	Not Assessed		
193	*Oroxylum indicum*	Pharrai	Archangkawm	Not Assessed		
194	*Osbeckia crinita*	--	Builukham	Not Assessed		
195	*Ostodes paniculata*	Paniculate Ostodes	Beltur	Not Assessed		
196	*Oxyspora paniculata*	Oxyspora	Khampa/Khampui	Not Assessed		Spotted at Hnahthial
197	*Parkia timoriana*	Tree bean	Zawngtah	Not Assessed		
198	*Passiflora nepalensis*	--	Nauawimuhrui	Not Assessed		
199	*Pericampylus glaucus*	Mooseed	Khauchhim	Not Assessed		
200	*Persicaria chinensis*	Chinese Knotweed	Taham	Not Assessed		
201	*Phyllanthus emblica*	Amla	Sunhlu	Not Assessed		
202	*Phyllanthus urinaria*	Hazarmani	Mitthi-sunhlu	Not Assessed		
203	*Physalis angulata*	Wild Gooseberry	Kelasairawphit	Not Assessed		
204	*Plantago major*	Cart track plant	Kelbaan	Not Assessed		

SL. NO.	BOTANICAL NAMES	COMMON NAME	LOCAL NAMES	IUCN CATEGORY	IWPA CATEGORY	Field Observation
205	*Pleione praecox*	--	Nauban	Not Assessed		
206	*Protium serratum*	Murtenga	Bil	Not Assessed		
207	*Pteris vittata*	Lader Brake Fern	Chakawkte	LC ver 3.1		
208	*Pterospermum acerifolium*	Kanak Champa	Siksil	Not Assessed		
209	*Rhus chinensis*	Nutgall Tree	Khawmhma	Not Assessed		
210	*Rotheca serrata*	Bharangi	Leidumsuak	Not Assessed		
211	*Rubus alceifolius*	Black Cherry	Sialinutheihmu	Not Assessed		
212	*Rubus niveus*	Hill raspberry	Hmupa	Not Assessed		
213	*Rhynchostylis retusa*	Foxtail orchid	Nauban parbawr	Not Assessed		Spotted at Hnahthial & Chhiathlang
214	*Saccharum arundinaceum*	Hardy sugar cane	Rai ruang	Not Assessed		Spotted at Lawngtlai, Hnahthial & Chhiathlang
215	*Saccharum longisetosum*	--	Luang	_		Spotted at Lawngtlai, Hnahthial & Chhiathlang
216	*Sapindus mukorossi*	Reetha	Hlingsi	Not Assessed		
217	*Sapium eugeniaefolium*	--	Kausen	_		
218	*Saraca asoca*	Saraca	Mualhawih	Vulnerable ver 2.3		
219	*Schefflera venulosa*	Dwarf Umbrella Plant	Kelbuh	Not Assessed		
220	*Schima wallichii*	Chilauri	Khiang	Not Assessed		
221	*Scoparia dulcis*	sweet Broom weed	Thlumdemdem	Not Assessed		
222	*Senna tora*	Foetid Cassia	Kelbe	Not Assessed		Spotted at Lawngtlai, Hnahthial & Chhiathlang
223	*Setaria palmifolia*	Palm Grass	Hnahhrat	Not Assessed		
224	*Sida acuta*	Ban methi	Khingkhih	Not Assessed		
225	*Smilax glabra*	Chinese Smilax	Tluangngil	Not Assessed		
226	*Solanum anguivi*	Indian Nightshade	Tawkte	Not Assessed		Spotted at all four BP areas
227	*Solanum nigrum*	Black Nightside	Anhling	Not Assessed		
228	*Solanum rudepannum*	Turkeyberry	Tawkpui	Not Assessed		
229	*Solanum viarum*	--	Athlo	Not Assessed		
230	*Sonchus arvensis*	Corn saw Thistle	Khuanglawi	Near Threatened ver 3.1		
231	*Spondias pinnata*	Amra	Tawitaw	Not Assessed		
232	*Stemona tuberosa*	Wild Asparagus	Sang	Not Assessed		
233	*Sterculia lanceifolia*	--	TlingilehNgamainchhawlthuaina	Not Assessed		

SL. NO.	BOTANICAL NAMES	COMMON NAME	LOCAL NAMES	IUCN CATEGORY	IWPA CATEGORY	Field Observation
234	*Sterculia villosa*	Udal	Khaupui	Not Assessed		
235	*Stereospermum chelonoides*	Pader	Zihnghal	Not Assessed		
236	*Stixis suaveolens*	--	Theisawntlung	Not Assessed		
237	*Strobilanthes capitatus*	--	Ramting/Tumau	Not Assessed		
238	*Syzygium cumini*	Jaman	Lenhmui/Hmuipui	Not Assessed		
239	*Tabernaemontana divaricata*	Wax Flower	Keltebengbeh	Not Assessed		
240	*Terminalia myriocarpa*	Hollock	Char	Not Assessed		Spotted at Hnahthial, Serchhip & Chhiathlang
241	*Tetrameles nudiflora*	Maina	Thingdawl	LC ver 2.3		
242	*Themeda villosa*	Lyon's Grass	Phaiphek	Not Assessed		
243	*Thladiantha cordifolia*	Golden Creeper	Kangmang	Not Assessed		
244	*Thunbergia alata*	Sky flower	Vako	Not Assessed		
245	*Thysanolaena latifolia*	Bamboo Grass	Hmunphiah	Not Assessed		Spotted at all four BP areas
246	*Tithonia diversifolia*	Mexican Sunflower	Vaivakawnpar	Not Assessed		
247	*Toona ciliata*	Toon	Teipui	LC ver 2.3		
248	*Toxicodendron succedaneum*	Wax Tree	Chhimhruk	Not Assessed		
249	*Trema orientalis*	Charcoal Tree	Belphuar	Not Assessed		
250	*Trevesia palmata*	Snowflake Tree	Kawhtebel	Not Assessed		
251	*Trichosanthes cordata*	--	Van-um	Not Assessed		
252	*Trichosanthes tricuspidata*	Redball snakeground	Choakaum	Not Assessed		
253	*Triumfetta bogotensis*	--	Semeibawm	Not Assessed		
254	*Ulmus lanceifolia*	Eastern elm	Phan	Not Assessed		
255	*Urena lobata*	Caesar weed	Sehnap	Not Assessed		
256	*Vernonia volkameriifolia*	Himalayan Tree Vernonia	Tlaka-zangzaw	Not Assessed		
251	*Vitex canescens*	--	Thingsaihlum	Not Assessed		
252	*Vitex peduncularis*	--	Thingkhawilupa	Not Assessed		
253	*Vitex quinata*	--	Thlengreng	Not Assessed		
254	Zanthoxylum budrunga	Indian Prickly ash	Chingit	Not Assessed		
255	Ziziphus incurva	--	Hel	Not Assessed		
256	*Ziziphus oenoplia*	Jackal Jujube	Muvanlaihling/Nghardai	_		Spotted at Serchhip

(2) Fauna

Since the study area has extensive forests, the area can support fairly large variety of wild life. Various vertebrate and invertebrate animals are found in the forest. Mammals, avifauna, reptiles and insects

species are varied and are commonly found in the forests of the study area. During the field study snakes, squirrels and birds were spotted. Majority of the mammalian wildlife is limited to the deeper areas of the forest.

The mammalian and avian diversity sourced from secondary data collected from the Environment and Forest Department, Mizoram are listed in the Table below. The common name, local name, IUCN red list category, IWPA category and field observation are presented below.

Table 4.4 Fauna in Mizoram and Project Area

Sl. No.	Zoological names	Common Name	Local names	IUCN Category	IWPA Category	Field observation
MAMMALS						
1	*Arctictis binturong*	Binturong	Zamphu	Vulnerable ver 3.1	Schedule I	Not spotted
2	*Arctonyx collaris*	Hog Badger	Phivawk	Nearly Threatened ver 3.1	Schedule II	Not spotted
3	*Callosciurus erythraeus*	Pallas's/ red bellied tree Squirrel	Hleikapsen	Least Concern ver 3.1	Schedule II	Spotted
4	*Callosciurus pygerythrus*	Hoary billed Squirrel	Hleilubial	Least Concern ver 3.1	Schedule II	Not spotted
5	*Canis aureus*	Golden Jackal	Sihal	Vulnerable ver 3.1	Schedule II	Not spotted
6	*Capricornis rubidus*	Red Serrow	Saza	Nearly Threatened ver 3.1	Schedule I	Not spotted
7	*Catopuma temminckii*	Asiatic Golden Cat	Keisen	Nearly Threatened ver 3.1	Schedule I	Not spotted
8	*Dremomys lokriah*	Orange bellied Himalayan Squirrel	Hleimeipar	Least Concern ver 3.1	Schedule II	Not spotted
9	*Felis chaus*	Jungle Cat	Sa-uak	Least Concern ver 3.1	Schedule II	Not spotted
10	*Helarctos malayanus*	Sun Bear	Samang	Vulnerable ver 3.1	Schedule I	Not spotted
11	*Herpestes urva*	Crab eating Mongoose	Saphai-ruang	Least Concern ver 3.1	Schedule IV	Not spotted
12	*Hoolock hoolock*	Western Hoolock Gibbon	Hauhuk	Endangered ver 3.1	Schedule I	Not spotted
13	*Hystrix brachyura*	Malayan Porcupine	Sa-kuh	Least Concern ver 3.1	Schedule II	Not spotted
14	*Macaca assamensis*	Assam Macaque	Zo-zawng	Nearly Threatened ver 3.1	Schedule II	Not spotted
15	*Macaca mulatta*	Rhesus Monkey	Phaizawng	Least Concern ver 3.1	Schedule II	Not spotted
16	*Manis pentadactyla*	Chinese Pangolin	Saphu	Critically Endangered ver 3.1	Schedule I	Not spotted
17	*Martes flavigula*	Yellow throated Martes	Safia	Least Concern ver 3.1	Schedule II	Not spotted
18	*Melogale moschata*	Small toothed Ferreet Badger	Sahmaitha	Least Concern ver 3.1	Schedule II	Not spotted

Sl. No.	Zoological names	Common Name	Local names	IUCN Category	IWPA Category	Field observation
19	*Muntiacus vaginalis*	Northern Red Muntjac	Sa-khi	Least Concern ver 3.1	Schedule III	Not spotted
20	*Nycticebus bengalensis*	Bengal Slow Loris	Sahuai	Vulnerable ver 3.1	Schedule I	Not spotted
21	*Paguma larvata*	Masked Palm Civet	Zaw-buang	Least Concern ver 3.1	Schedule II	Not spotted
22	*Paradoxurus hermaphroditus*	Common Palm Civet	Zawhang/Zaw-reng	Least Concern ver 3.1	Schedule II	Not spotted
23	*Petaurista petaurista*	Common Giant flying squirrel	Vahluk	Least Concern ver 3.1	Schedule II	Not spotted
24	*Prionailurus bengalensis*	Leopard Cat	Ngharfang	Least Concern ver 3.1	Schedule I	Not spotted
25	*Ratufa bicolor*	Black Giant Squirrel	Awrrang	Nearly Threatened ver 3.1	Schedule II	Not spotted
27	*Sus scrofa*	Wild Boar	Sanghal	Least Concern ver 3.1	Schedule III	Not spotted
28	*Tamiops macclellandi*	Himalayan Striped Squirrel	Hleimualrang	Least Concern ver 3.1	Schedule II	Not spotted
29	*Trachypithecus pileatus*	Capped langur	Ngaubuang	Vulnerable ver 3.1	Schedule I	Not spotted
30	*Tupaia belangeri*	Northern Tree Shrew	Chepa	Least Concern ver 3.1	Schedule V	Not spotted
31	*Ursus thibetanus*	Asiatic Black Bear	Savawm	Vulnerable ver 3.1	Schedule I	Not spotted
BIRDS						
1	*Accipiter badius*	Shikra	Mu-te	Least Concern ver 3.1	Schedule I	Spotted in Serchhip
2	*Abroscopus spp.*	Warbler	Va-te	Least Concern ver 3.1	Schedule IV	Not spotted
3	*Acridotheres fuscus*	Jungle Myna	Vaiva	Least Concern ver 3.1	Schedule IV	Not spotted
4	*Aegithina tiphia*	Common Iora	Zairumva	Least Concern ver 3.1	Schedule IV	Not spotted
5	*Aethopyga spp.*	Sunbird	Dawithiama-ar	Least Concern ver 3.1	Schedule IV	Spotted in Chiahtlang
6	*Alcedo spp.*	Kingfisher	Kaikuangral	Least Concern ver 3.1	Schedule IV	Not spotted
7	*Alcippe nipalensis*	Nepal Fulvetta	Mitval	Least Concern ver 3.1	Schedule IV	Not spotted
8	*Alophoixus flaveolus*	White throated Bulbul	Daw-kek	Least Concern ver 3.1	Schedule IV	Not spotted
9	*Anthus spp.*	Pipit	Chip	Least Concern ver 3.1	Schedule IV	Not spotted
10	*Arachnothera magna*	Streaked Spiderhunter	Kireuh	Least Concern ver 3.1	Schedule IV	Not spotted
11	*Artamus fuscus*	Ashy Wood Shallow	Lengder	Least Concern ver 3.1	Schedule IV	Not spotted
12	*Bambusicola fytchii*	Mountain Bamboo Partridge	Vahlah	Least Concern ver 3.1	Schedule I	Not spotted

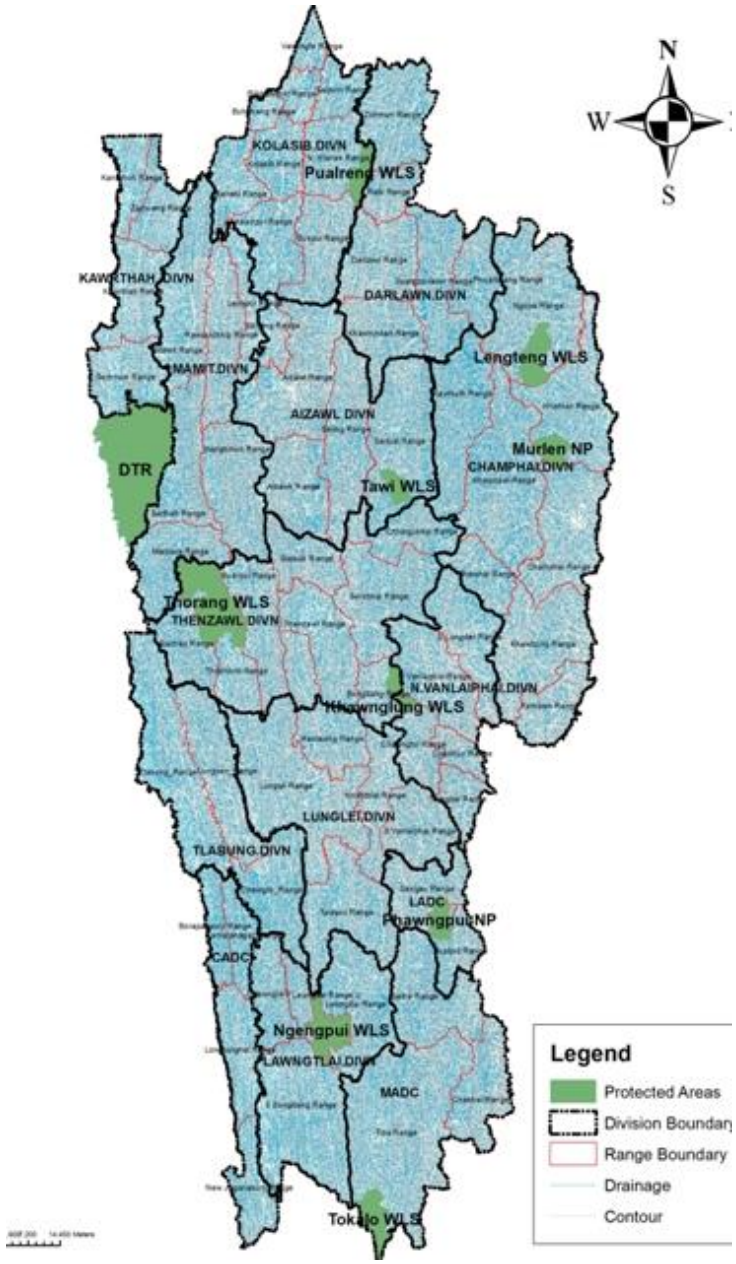
Sl. No.	Zoological names	Common Name	Local names	IUCN Category	IWPA Category	Field observation
13	*Caprimulgus spp.*	Large tailed Nightjar	Valambawk	Least Concern ver 3.1	Schedule IV	Not spotted
14	*Carpodacus erythrinus*	Common Rosefinch	Vasuih	Least Concern ver 3.1	Schedule IV	Not spotted
15	*Chaimarrornis leucocephalus*	River Chat	Vachalde	Least Concern ver 3.1	Schedule IV	Not spotted
16	*Chalcohaps indica*	Emerald Dove	Ramparva	Least Concern ver 3.1	Schedule IV	Spotted in Serchhip
17	*Chloropsis spp.*	Leaf Bird	Chhawlhring	Least Concern ver 3.1	Schedule IV	
18	*Copsychus spp.*	White rumped Shama	Vatelal	Least Concern ver 3.1	Schedule IV	Spotted at Chhiahtlang
19	*Coracias benghalensis*	Indian Roller	Va-pui	Least Concern ver 3.1	Schedule IV	Not spotted
20	*Coracina macei*	Larae Cuckoo Shrike	Irliak	Least Concern ver 3.1	Schedule IV	Not spotted
21	*Corvus macrohynchos*	Jungle Crow	Cho-ak	Least Concern ver 3.1	Schedule IV	Not spotted
22	*Cuculus micropterus*	Indian Cuckoo	Thangfenpabawp	Least Concern ver 3.1	Schedule IV	Not spotted
23	*Cyornis spp.*	Flycatcher	Vapawl/Vadumdeleng	Least Concern ver 3.1	Schedule IV	Not spotted
24	*Dendrocitta formosa*	Grey Treepie	Bemkawng	Least Concern ver 3.1	Schedule IV	Not spotted
25	*Dendrocopos spp.*	Fuluous Woodpecker	Thlohkawrha	Least Concern ver 3.1	Schedule IV	Not spotted
26	*Dendronanthus indicus*	Forest Wagtail	Se-hnungzui	Least Concern ver 3.1	Schedule IV	Not spotted
27	*Dicaem spp.*	Flower Pecker	Vate/Tiktik	Least Concern ver 3.1	Schedule IV	Not spotted
28	*Dicrurus aeneus*	Bronzed Drongo	Thlanthla	Least Concern ver 3.1	Schedule IV	Not spotted
29	*Dicrurus hottentottus*	Spangled Drongo	Kulherh	Least Concern ver 3.1	Schedule IV	Not spotted
30	*Dicrurus leucophaeus*	Ashy Drongo	Kakpawl	Least Concern ver 3.1	Schedule IV	Not spotted
31	*Dicrurus macrocercus*	Black drongo	Thlanthlapui	Least Concern ver 3.1	Schedule IV	Spotted at Chhiathlang
32	*Dicrurus paradiseus*	Greater Racket Tailed Drongo	Vakul	Least Concern ver 3.1	Schedule IV	Not spotted
33	*Dicrurus remifer*	Lesser Racket Tailed Drongo	Changhlawi	Least Concern ver 3.1	Schedule IV	Not spotted
34	*Ducula badia*	Mountain Imperial Pigeon	Bullut	Least Concern ver 3.1	Schedule IV	Spotted at Chhiathlang
35	*Enicurus spp.*	Spotted Forktail	Chinrang	Least Concern ver 3.1	Schedule IV	Not spotted
36	*Eunyias thallasina*	Flycatcher	Vapawl	Least Concern ver 3.1	Schedule IV	Spotted at Chhiathlang
37	*Gallus gallus*	Red Jungle Fowl	Ram-ar	Least Concern ver 3.1	Schedule IV	Not spotted

Sl. No.	Zoological names	Common Name	Local names	IUCN Category	IWPA Category	Field observation
38	*Garrulax spp.*	Laughing Thrush	Va-zar	Least Concern ver 3.1	Schedule IV	Spotted at Serchhip
39	*Glaucidium brodiei*	Collared Pigmy Owlet	Hrangkir	Least Concern ver 3.1	Schedule IV	Not spotted
40	*Gracula religiosa*	Hill Myna	Vaiva-diarkhim	Least Concern ver 3.1	Schedule I	Not spotted
41	*Hemixos flavala*	Ashy Bulbul	Kawlrit	Least Concern ver 3.1	Schedule IV	Not spotted
42	*Hieraaetus kienerii*	Rufuas-bellied Eagle	Mu-arla	Least Concern ver 3.1	Schedule IV	Spotted in Serchhip
43	*Hierococcyx sparverioides*	Large Hawk Cuckoo	Biakbairawk	Least Concern ver 3.1	Schedule IV	Not spotted
44	*Hierococcyx varius*	Brain fever Bird	Kiltheihrawk	Least Concern ver 3.1	Schedule IV	Not spotted
45	*Lanius spp.*	Chhemhur	Chhemhur	Least Concern ver 3.1	Schedule IV	Spotted at Serchhip
46	*Lonchura spp.*	Munia	Pit	Least Concern ver 3.1	Schedule IV	Spotted
47	*Lophura leucomelanos*	Kalij Pheasant	Va-hrit	Least Concern ver 3.1	Schedule I	Not spotted
48	*Macropygia unchall*	Barred Cuckoo Dove	Thumi-mei-sei	Least Concern ver 3.1	Schedule IV	Not spotted
49	*Megalaima lineata*	Lineated Barbet	Phaitawllawt	Least Concern ver 3.1	Schedule IV	Not spotted
50	*Megalaima virens*	Great Barbet	Zotawllawt	Least Concern ver 3.1	Schedule IV	Not spotted
51	*Meghalaima asiatica*	Blue throated Barbet	Tuklo	Least Concern ver 3.1	Schedule IV	Spotted at Serchhip & Chhiahtlang
52	*Monticola solitarius*	Blue Rock Thrush	Vainronghak	Least Concern ver 3.1	Schedule IV	Not spotted
53	*Motacilla spp.*	Wagtail	Lailen	Least Concern ver 3.1	Schedule IV	Not spotted
54	*Niltava spp.*	Flycatcher	Beairal/Vapawl	Least Concern ver 3.1	Schedule IV	Not spotted
55	*Nyctyornis athertoni*	Blue Beard Bee Eater	Tlak-awrh	Least Concern ver 3.1	Schedule IV	Not spotted
56	*Oriolus traillii*	Maroon Oriole	Changsen	Least Concern ver 3.1	Schedule IV	Not spotted
57	*Orthotomus spp.*	Tailorbird	Daikat	Least Concern ver 3.1	Schedule IV	Not spotted
58	*Pericrocotus spp.*	Scarlet Minivet	Bawng	Least Concern ver 3.1	Schedule IV	Spotted at Chhiahtlang
59	*Pernis ptilorhyncus*	Oriental Honey Buzzard	Khuai-mu	Least Concern ver 3.1	Schedule IV	Not spotted
60	*Phaenicophaeus tristis*	Green billed Malkoha	Va-zun	Least Concern ver 3.1	Schedule IV	Spotted at Chhiahtlang
61	*Phodilus badius*	Oriented Bay Owl	Tahngai-bengnei	Least Concern ver 3.1	Schedule IV	Not spotted
62	*Phylloscopus spp.*	Warbler	Vate	Least Concern ver 3.1	Schedule IV	Not spotted

Sl. No.	Zoological names	Common Name	Local names	IUCN Category	IWPA Category	Field observation
63	*Picus chloroplus*	Lesser yellownape Woodpecker	Thlohlupar	Least Concern ver 3.1	Schedule IV	Not spotted
64	*Pitta sordida*	Hooded Pitta	Buarchawm	Least Concern ver 3.1	Schedule IV	Not spotted
65	*Pomatorhinus spp.*	Babbler	Ngalvapual	Least Concern ver 3.1	Schedule IV	Not spotted
66	*Psittacula spp.*	Rose ringed Parakeet	Va-ki	Least Concern ver 3.1	Schedule IV	Not spotted
67	*Pycnonotus cafer*	Red Vented Bulbul	Tlaiberh	Least Concern ver 3.1	Schedule IV	Spotted at Chhiahtlang
68	*Pycnonotus spp.*	Black Crested Bulbul	Tukkhumvilik	Least Concern ver 3.1	Schedule IV	Not spotted
69	*Rhipidura albicollis*	White throated Fantail Flycatcher	Chang-arh	Least Concern ver 3.1	Schedule IV	Not spotted
70	*Rimator malacoptilus*	Long billed Wren Babbler	Hmunchhe-arpui	Least Concern ver 3.1	Schedule IV	Not spotted
71	*Sitta spp.*	Nuthatch	Suklet	Least Concern ver 3.1	Schedule IV	Not spotted
72	*Spelacornis longicaudatus*	Tawny Breasted Wren Babbler	Va-lei-sawt	Vulnerable	Schedule IV	Not spotted
73	*Spilornis cheela*	Crested Serpent Eagle	Muvanlai	Least Concern ver 3.1	Schedule IV	Not spotted
74	*Streptopelia chinensis*	Spotted Dove	Thuro	Least Concern ver 3.1	Schedule IV	Spotted at Chhiahtlang
75	*Sturnus malabaricus*	Grey headed Myna	Va-pawl	Least Concern ver 3.1	Schedule IV	Spotted at Serchhip & Chhiahtlang
76	*Treron spp.*	Green Pigeon	Vahui	Least Concern ver 3.1	Schedule IV	Not spotted
77	*Turdus boulboul*	Grey winged Blackbird	Vadartle	Least Concern ver 3.1	Schedule IV	Not spotted
78	*Turnix suscitator*	Barred Button Quail	Vahmim	Least Concern ver 3.1	Schedule IV	Not spotted
79	*Upupa epops*	Common Hoopoe	Chhuangtuar	Least Concern ver 3.1	Schedule IV	Not spotted
80	*Yuhina spp.*	Yuhina	Ruallubuk	Least Concern ver 3.1	Schedule IV	Spotted at Serchhip & Chhiahtlang
81	*Zosterops palbebrosa*	Oriental White Eye	Mitval	Least Concern ver 3.1	Schedule IV	Not spotted

4.1.4 Protected Area

There are a total of 10 protected area (National Park, Wildlife Sanctuary, and Tiger Reserve) in Mizoram, but the proposed bypasses do not traverse or border with any of them.



Source: Department of Environment and Forests, Government of Mizoram

Figure 4.3 Protected Area in Mizoram

According to the discussion with the official in State Environment and Forest Department, three Wildlife Sanctuaries, namely Tawi, Khawnglung and Ngengpui are located near the proposed bypasses Tawi WLS is located about 12 km north west of BP1 and 20 km north of BP2. Khawnglung WLS is located about 13 km east of BP3 and Ngengpui WLS is locared about 11 km south west of BP4. While no direct impacts to these WLSs are expected due to this project, their baseline condition and the list of key species in each WLS is shown below, against which, potential indirect impact can be monitored.

(1) Tawi Wildlife Sanctuary

The Tawi Wildlife Sanctuary is located between 23°29'N – 23°34'North and 92°54'E- 92°59' East, approx. 180 km from Aizawl, and its covering area is 35.75 km^2. This sanctuary provides shelter and protection of five rare and endangered species of wildlife mentioned in the Red Data Book of IUCN.

Table 4.5 Outline of Tawi Wildlife Sanctuary

No.	Item	Description	
1	Location	Approx. 180 km East of Aizawl (between 23°29'N – 23°34'North and 92°54'E-92°59' East)*)	
2	Area	35.75 km^2 *)	
3	Principal Species	Flora	- *Quercus species* - *Betula species* - *Wild orchids* - A few clumps of *Chimnobambusa collasa* etc.
		Fauna	- Clouded Leopard (Threatened) - Leopard Cat (Endangered) - Hoolock Gibbon (Endangered) - Serow (Threatened) etc.

Note: *) Finally notified in 2001 vide Government of Mizoram letter No.B.12012/1/91-FST Dt. 16th Nov/2001
Source: "Review Management Plan of Tawi Wildlife Sanctuary Mizoram for the period (2006-2007 to 2015-2016)", Wildlife Wing Environment & Forest Department Government of Mizoram

(2) Khawnglung Wildlife Sanctuary

The Khawnglung Wildlife Sanctuary is located between 23°04'N – 23°10'North and 92°55'E- 92°59' East and its covering area is approx. 35 km^2. This sanctuary provides shelter and protection of five rare and endangered species of wildlife mentioned in the Red Data Book of IUCN.

Table 4.6 Outline of Khawnglung Wildlife Sanctuary

No.	Item	Description	
1	Location	Between 23°04'08"N – 23°10'11"North and 92°55'11"E- 92°59'23" East	
2	Area	35 km^2	
3	Principal Species	Flora	(No significant survey has been implemented)
		Fauna	- Hoolock Gibbon - Rhesus Macaque - Assamese macaque - Stump Tailed Macaque - Phayre's Leaf Monkey - Capped Langur - Leopard - Clouded leopard - Himalayan black bear - Malayan sun bear - Sambar - Barking deer - Serow etc.

Source: "Review Management Plan of Khawnglung Wildlife Sanctuary Mizoram for the period (2008-2017)", Wildlife Division, Aizawl

(3) Ngengpui Wildlife Sanctuary

The Ngengpui Wildlife Sanctuary is located between 22°21'N – 22°30'North and 92°44'E- 92°50' East, approx. 280 km south of Aizawl and 39 km west of Lawngtlai. This area is under Lawngtlai

District and under Lawngtlai Rural development Block within Lai Autonomous District Council. Its covering area is approx. 110 km^2, notified as Wildlife Sanctuary in 1997 vide Govt. Notification No. B. 12012/4/01-FST dt 22.7.1997. Ngengpui Wildlife Sanctuary is very rich in biodiversity. The forest type of this area is Tropical Wet Evergreen Forest and Semi-evergreen Forest, and there are a number of medical plants. Regarding the fauna, Elephant, Gaur and other mammals can be found, also this area is one of the important bird areas (IBAs) in India from A1 (Globally threatened species) and A2 (Restricted range species).

Table 4.7 Outline of Ngengpui Wildlife Sanctuary

No.	Item	Description	
1	Location	Geographical coordinate 22°21'18"– 22°30'01" N and 92°44'30"- 92°50'37"E, It is close to Indo-Myanmar & Indo Bangladesh border.	
2	Area	110 km^2	
3	Principal Species	Flora	- *Raulfia serpentine* - *Bergenia ciliate* - *Ardisia macrocapa* - *Cautraya gracillis* - *Gardenis caronania* - *Rajanda longifolia* - *Zingiber purphotium* - Orchids etc.
		Fauna	- Elephant - Gaur - Serow - Sambar - Barking Deer - Leopard - Clouded Leopard (Threatened) - Marble Cat - Golden Cat - Leopard Cat - Hoolock Gibbon - Phayre's Leaf Monkey - Pig tailed macaques - Stump Tailed Macaques - Himalayan Black Bear - Malayan Sun Bear - Capped Langur - Slow Loris etc.

Source: "Review Management Plan of Ngenpui Wildlife Sanctuary Mizoram for the period (2010 - 2020)", Under CSS : Integrated Development off Wildlife Habitats.

No reserve forest will be affected by the project. However, the project runs through open forest, jhum land (shifting cultivation) and abandoned jhum area. Given that the forest and forest produces play an important role in local livelihood, efforts are needed to minimize deforestation and to disturbance during construction stage.

4.1.5 Hydrology

The hydrological study is conducted based on IRC:SP:13 "Guidelines for the design of small bridges and culverts" which is well used technical standard for hydrological study in Indian highway design. The analysis is conducted based on Rational Formulae for peak-off from catchment. The size of the

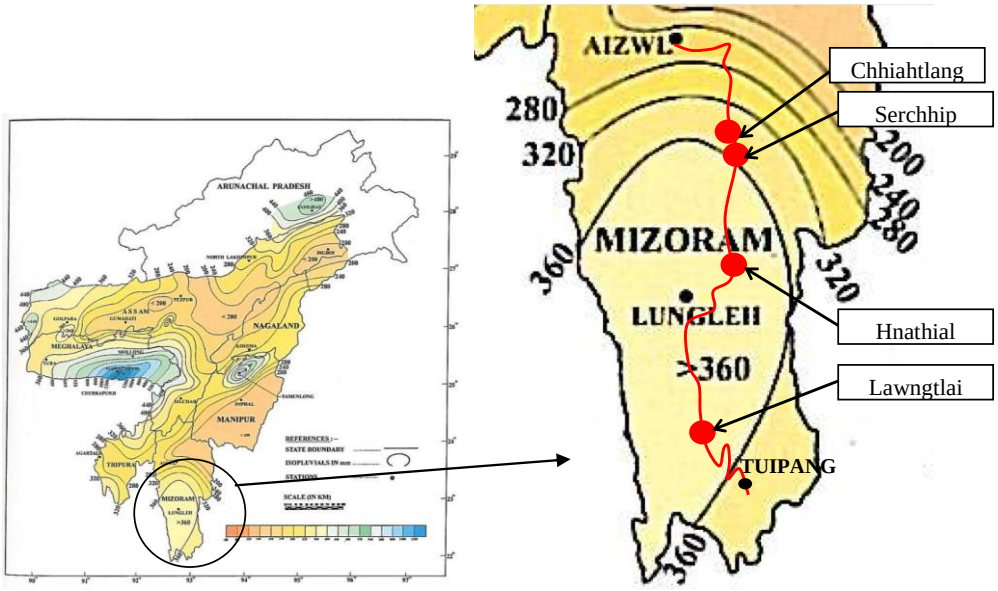
flood are determined by factors such as rainfall intensity, distribution in time and space, duration, catchment area, shape, slope and permeability of the soil and vegetable cover.

The rainfall intensity is based on the ATLAS of Statewise Generalised ISOPLUVIAL MAPs of Eastern India (Part-II), published by India Meteorological Department, Government of India. Rainfall intensity for each sections in NH54 Bypass is shown in Table 4.6 and the isopluvial map with the project location is shown in Figure 4.6. It is sectioned by range of rainfall intensity which value is read from higher edge of counter value.

Table 4.8 Rainfall Intensity for Each Bypass Section

Bypass No.	City	50Years- 24hours Rainfall intensity
Bypass No.1	Chhiahtlang	360mm/hr
Bypass No.2	Serchhip	360mm/hr
Bypass No.3	Hnathial	400mm/hr
Bypass No.4	Lawngtlai	400mm/hr

Source: JICA Study Team



Source: ATLAS of Statewise Generalised ISOPLUVIAL (Return Period) Maps of Eastern India (Part – II)

Figure 4.4 Isopluvial Map with Project Location for NH54 Bypass (For 50years)

4.1.6 Mineral Resources

Being a hilly state, Mizoram is rich in minerals. The figures on production of stone and sand are shown below. The stone and sand production is mainly concentrated in Aizawl, and in Mamit, Kolasib and Lunglei districts. Mizoram has mineral deposits of shell limestone, siltstone, clay mineral, coal seam, oil and gas. Building-quality stones are exported to Bangladesh. Numerous natural water springs in Mizoram also offers potential for manufacturing mineral water.

Table 4.9 Number of Quarry Permit Issued and Mineral Production

Year	No. of Quarry Permit Issued	Production form Quarry (Stone) (Cu.M)	Rs. in Lakhs	Sand Production (Cu.m)	Rs. in Lakhs
2005-2006	191	NA	NA	NA	NA
2006-2007	164	NA	NA	NA	NA
2007-2008	33	312797.083	37.54	36176.54	18.09
2008-2009	78	418208.316	50.19	118585.26	59.29
2009-2010	48	261488.330	31.38	62611.40	31.31
2010-2011	97	212937.325	85.18	136303.94	68.15

Source: Statistical Abstract of Mizoram 2011

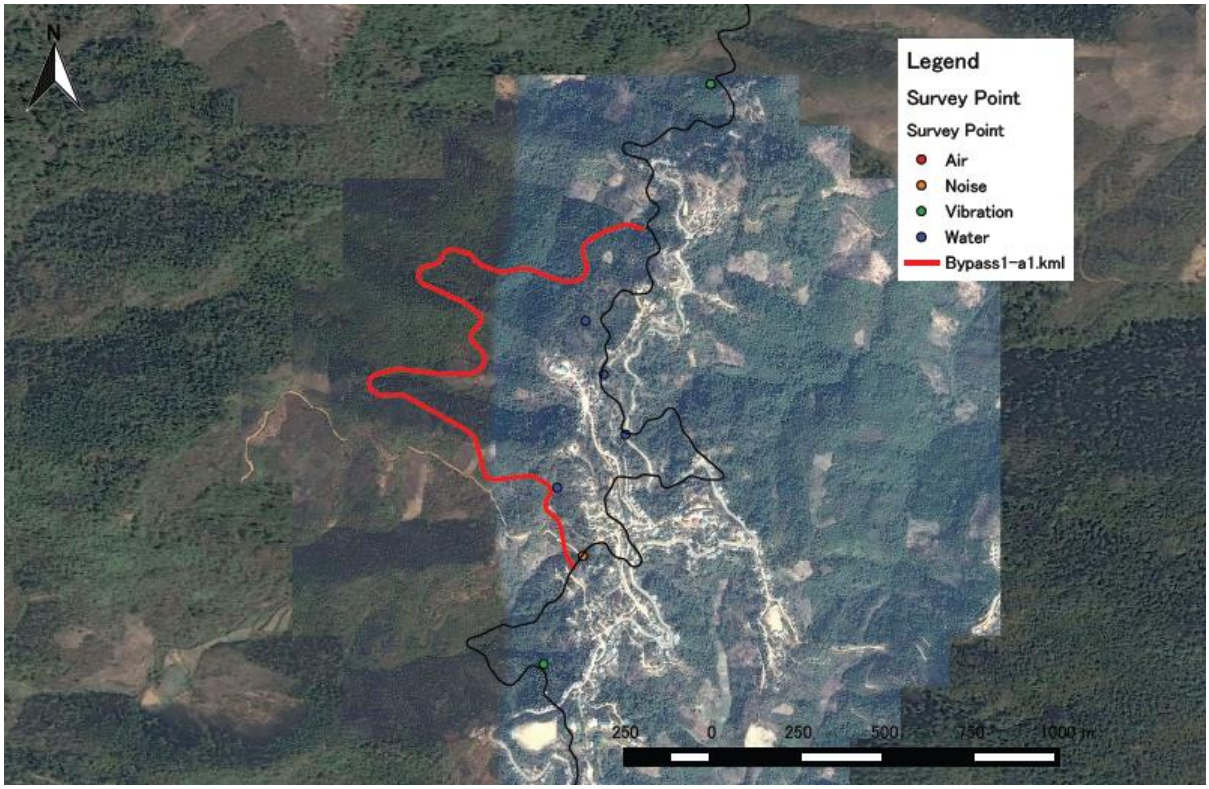
Table 4.10 District-wise Number of Quarry Permit Issued and Mineral Production, 2010-11

District	No. of Quarry Permit Issued	Production form Quarry (Stone) (Cu.M)	Rs. in Lakh)	Sand Production (Cu.m)	Rs. in Lakh
Mamit	4	11087.50	4.43	1980.00	0.99
Kolasib	6	11594.90	4.64	11312.20	5.66
Aizawl	28	171776.725	68.71	67189.04	33.59
Champhai	15	4913.95	1.97	29825.70	14.91
Serchhip	8	4799.70	1.92	5435.00	2.72
Lunglei	31	8294.55	3.32	20562.00	10.28
Lawngtlai	5	470	0.19	-	-
Saiha	-	-	-	-	-
Total	**97**	**212937.325**	**85.18**	**136303.94**	**68.15**

Note: Districts where the proposed bypasses are located are highlighted.
Source: Statistical Abstract of Mizoram 2011

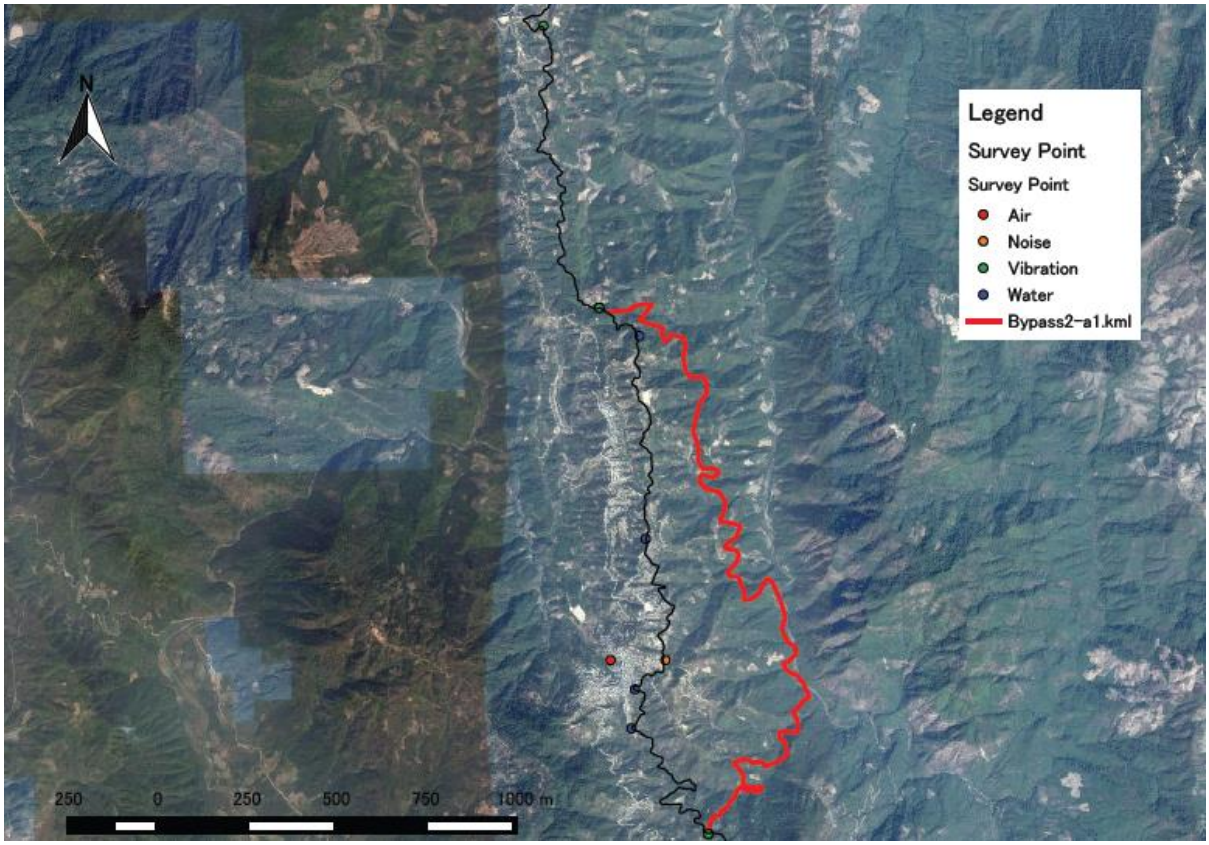
4.2 Living Environment

The survey points for Air Quality, Water Quality, Noise and Vibration is shown below.



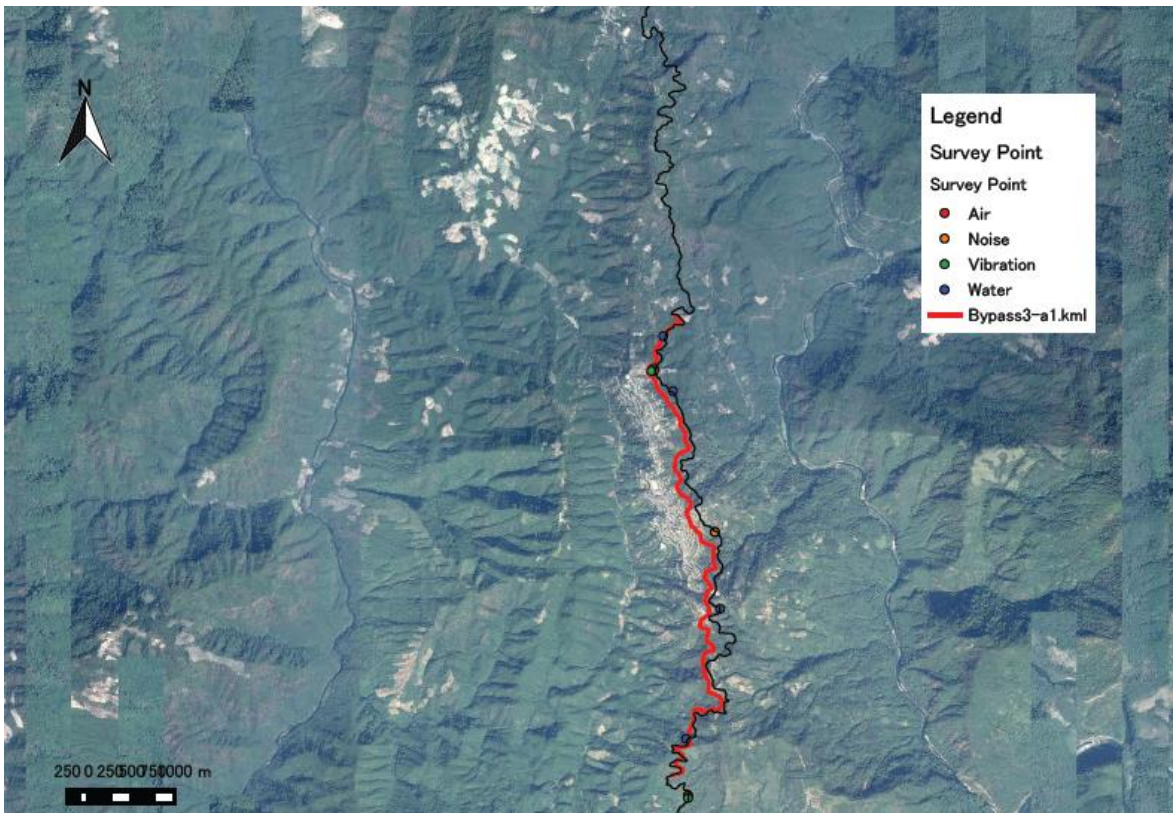
Source: JICA Study Team

Figure 4.5 Survey Points for Chhiathlang (BP1)



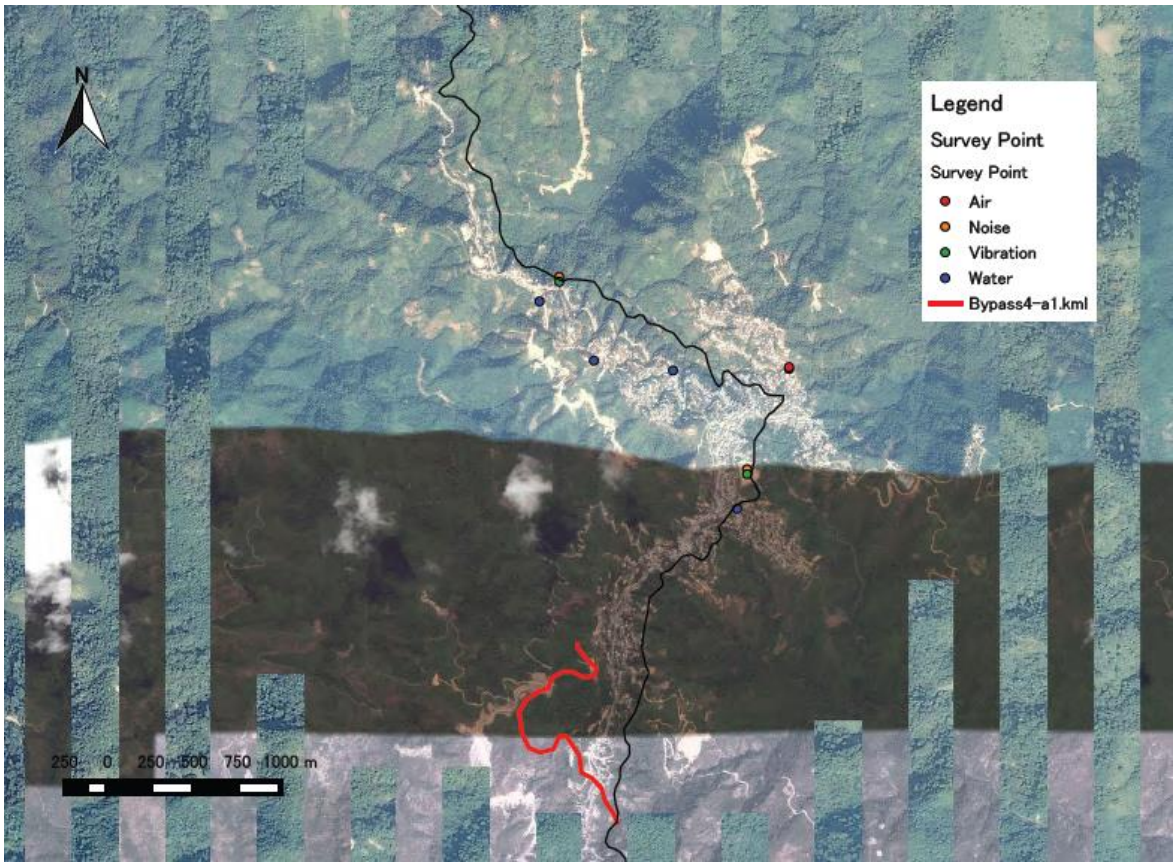
Source: JICA Study Team

Figure 4.6 Survey Points for Serchhip (BP2)



Source: JICA Study Team

Figure 4.7 Survey Points for Hnathial (BP3)



Source: JICA Study Team

Figure 4.8 Survey Points for Lawngtlai (BP4)

4.2.1 Air Quality

Ambient air quality of the study area was monitored in the pre monsoon/dry season and monsoon season to get an idea of baseline air quality scenario. The NAAQS Monitoring & Analysis Guidelines Volume-I, CPCB was followed for collection and analysis of ambient air samples. The ambient air quality monitoring (AAQM) stations were selected in the study areas of each by-pass. In Lawngtlai and Chhiahtlang two stations (start point and end point) were selected. Three points (start point, midpoint and end point) were selected as AAQM stations in Hnathial and Serchhip. The AAQM stations were based on the accessibility and availability of electricity.

Polltech $PM_{2.5}$ & PM_{10} ADS Fine Dust Sampler and Ecotech AAS Sampler with gaseous sampling attachment were used for ambient air quality monitoring. The results of PM_{10}, $PM_{2.5}$, SO_2, NO_x and lead concentration measurements during the study period are presented in the tables below. On the basis of tabulated data it can be inferred that the concentrations of the measured parameters complies the limits of the National Ambient Air Quality Standards, CPCB notification dated 18th November, 2009.

Table 4.11 National Ambient Air Quality Standards

Parameters	Particulate Matter (PM_{10}) in $\mu g/Nm^3$	Particulate Matter ($PM_{2.5}$) in $\mu g/Nm^3$	Sulphur Dioxide (SO_2) in $\mu g/Nm^3$	Nitrogen Dioxide (NO_2) in $\mu g/Nm^3$	Lead (Pb) in $\mu g/Nm^3$
Time Weighted Average Annual	60	40	50	40	0.5

Source: Central Pollution Control Board Notification, New Delhi the 18th Nov'2009

(i) Chhiathlang

Two ambient air quality stations were selected in the Chhiathlang bypass (near start point and end point) and the results are enumerated below.

A) Particulate Matter (Size less than 10 μm) PM_{10}

The concentration of PM_{10} at the AAQM station in Chhiathlang ranged from 36 $\mu g/Nm^3$ to 52 $\mu g/Nm^3$ in the dry season, and ranged from 27 $\mu g/Nm^3$ to 34 $\mu g/Nm^3$ in the monsoon season.

B) Particulate Matter (Size less than 2.5 μm) PM2.5

The concentration of $PM_{2.5}$ at the AAQM station ranged from 17 $\mu g/Nm^3$ to 32 $\mu g/Nm^3$ in the dry season, and ranged from 15 $\mu g/Nm^3$ 20 $\mu g/Nm^3$ in the monsoon season.

C) Sulphur Dioxide (SO_2)

The concentration of SO_2 ranged from 6 $\mu g/Nm^3$ to 12 $\mu g/Nm^3$ in the dry season, and ranged from <5 $\mu g/Nm^3$ to 7 $\mu g/Nm^3$ in the monsoon season.

D) Nitrogen Oxide (NOx)

The concentration of NOx ranged from 12 μg/Nm^3 to 18 μg/Nm^3 in the dry season, and ranged from 7 μg/Nm^3 to 11 μg/Nm^3 in the monsoon season.

E) Lead

The concentration of lead in ambient air was <0.01 μg/Nm^3 for both the locations and both seasons.

Table 4.12 Air Quality in Chhiathlang in Dry Season

Sampling Location:	Date of Sampling	Parameters				
		Particulate Matter (PM_{10}) in μg/Nm^3	Particulate Matter ($PM_{2.5}$) in μg/Nm^3	Sulphur Dioxide (SO_2) in μg/Nm^3	Nitrogen Dioxide (NO_2) in μg/Nm^3	Lead (Pb) in μg/Nm^3
Chhiahtlang Tourist Lodge, N:23^{0}23'41", E:92^{0}50'53" 5 m (approx.) From Edge of the Pavement	01/03/2016 to 02/03/2016	38	18	8	14	< 0.01
	02/03/2016 to 03/03/2016	36	17	7	12	< 0.01
	04/03/2016 to 05/03/2016	39	19	8	13	< 0.01
	05/03/2016 to 06/03/2016	38	17	6	12	< 0.01
Tetie's Tea Stall, Chhaitlang N:23^{0}22'53", E:92^{0}50'40" 1.5 m (approx.) From Edge of the Pavement	01/03/2016 to 02/03/2016	52	30	10	16	< 0.01
	02/03/2016 to 03/03/2016	50	29	11	17	< 0.01
	04/03/2016 to 05/03/2016	51	31	12	18	< 0.01
	05/03/2016 to 06/03/2016	50	32	10	17	< 0.01
Number of Sample		8	8	8	8	8
Max		52	32	12	18	< 0.01
Min		36	17	6	12	< 0.01
98th Percentile		51	31	11	17	< 0.01

Source: JICA Study Team

Table 4.13 Air Quality in Chhiathlang in Monsoon Season

Sampling Location:	Date of Sampling	Parameters				
		Particulate Matter (PM_{10}) in μg/Nm^3	Particulate Matter ($PM_{2.5}$) in μg/Nm^3	Sulphur Dioxide (SO_2) in μg/Nm^3	Nitrogen Dioxide (NO_2) in μg/Nm^3	Lead (Pb) in μg/Nm^3
Chhiahtlang Tourist Lodge, N:23^{0}23'41", E:92^{0}50'53" 5 m (approx.) From Edge of the Pavement	16/05/2016 to 17/05/2016	28	17	<5	8	< 0.01
	17/05/2016 to 18/05/2016	27	16	6	9	< 0.01
	19/05/2016 to 20/05/2016	28	17	7	11	< 0.01

Sampling Location:	Date of Sampling	Parameters				
		Particulate Matter (PM_{10}) in µg/Nm^3	Particulate Matter ($PM_{2.5}$) in µg/Nm^3	Sulphur Dioxide (SO_2) in µg/Nm^3	Nitrogen Dioxide (NO_2) in µg/Nm^3	Lead (Pb) in µg/Nm^3
	20/05/2016 to 21/05/2016	30	16	<5	7	< 0.01
Tetie's Tea Stall, Chhaitlang N:23^{0}22'53", E:92^{0}50'40" 1.5 m (approx.) From Edge of the Pavement	16/05/2016 to 17/05/2016	34	18	<5	9	< 0.01
	17/05/2016 to 18/05/2016	29	15	7	8	< 0.01
	19/05/2016 to 20/05/2016	32	17	<5	10	< 0.01
	20/05/2016 to 21/05/2016	31	20	6	11	< 0.01
Number of Sample		8	8	8	8	8
Max		34	20	7	11	< 0.01
Min		27	15	<5	7	< 0.01
98th Percentile		32	18	7	11	< 0.01

Source: JICA Study Team

(ii) Serchhip

Three ambient air quality stations were selected in the Serchhip bypass (near start point, mid-point and end point) and the results are enumerated below.

A) Particulate Matter (Size less than 10 µm) PM_{10}

The concentration of PM_{10} at the AAQM station in Serchhip ranged from 50 µg/Nm^3 to 56 µg/Nm^3 in the dry season, and ranged from 31 µg/Nm^3 to 38 µg/Nm^3 in the monsoon season.

B) Particulate Matter (Size less than 2.5 µm) $PM_{2.5}$

The concentration of $PM_{2.5}$ at the AAQM station ranged from 26 µg/Nm^3 to 35 µg/Nm^3 in the dry season, and ranged from 20 µg/Nm^3 to 27 µg/Nm^3 in the monsoon season.

C) Sulphur Dioxide (SO_2)

The concentration of SO_2 ranged from 7 µg/Nm^3 to 12 µg/Nm^3 in the dry season, and ranged from <5 µg/Nm^3 to 9 µg/Nm^3 in the monsoon season.

D) Nitrogen Oxide (NOx)

The concentration of NOx ranged from 12 µg/Nm^3 to 17 µg/Nm^3 in the dry season, and ranged from 8 µg/Nm^3 to 14 µg/Nm^3 in the monsoon season.

E) Lead

The concentration of lead in ambient air was <0.01 µg/Nm^3 for both the locations and both seasons.

Table 4.14 Air Quality in Serchhip in Dry Season

Sampling Location:	Date of Sampling	Parameters				
		Particulate Matter (PM_{10}) in $\mu g/Nm^3$	Particulate Matter ($PM_{2.5}$) in $\mu g/Nm^3$	Sulphur Dioxide (SO_2) in $\mu g/Nm^3$	Nitrogen Dioxide (NO_2) in $\mu g/Nm^3$	Lead (Pb) in $\mu g/Nm^3$
Aircel Mawiteii Store, New Serchip N:$23^0$20'51", E:$92^0$50'58" 1.5 m (approx.) From Edge of the Pavement	07/03/2016 to 08/03/2016	50	30	8	13	< 0.01
	08/03/2016 to 09/03/2016	52	26	7	12	< 0.01
	10/03/2016 to 11/03/2016	50	27	8	13	< 0.01
	11/03/2016 to 12/03/2016	51	28	8	14	< 0.01
Hotel Zemela Rooftop, Bazar Area, Serchip. N:$23^0$30'90", E:$92^0$85'67" 10 m (approx.) From Edge of the Pavement	07/03/2016 to 08/03/2016	54	34	9	16	< 0.01
	08/03/2016 to 09/03/2016	56	32	10	17	< 0.01
	10/03/2016 to 11/03/2016	53	33	9	16	< 0.01
	11/03/2016 to 12/03/2016	52	32	9	17	< 0.01
Tajmahal Hotel, Sailiam Kawn, Serchip, N:$23^0$17'24", E:$92^0$51'41" 1.5 m (approx.) From Edge of the Pavement	07/03/2016 to 08/03/2016	56	35	10	15	< 0.01
	08/03/2016 to 09/03/2016	55	34	12	16	< 0.01
	10/03/2016 to 11/03/2016	53	32	11	15	< 0.01
	11/03/2016 to 12/03/2016	54	34	12	17	< 0.01
Number of Sample		12	12	12	12	12
Max		56	35	12	17	< 0.01
Min		50	26	7	12	< 0.01
98th Percentile		56	34	12	17	< 0.01

Source: JICA Study Team

Table 4.15 Air Quality in Serchhip in Monsoon Season

Sampling Location:	Date of Sampling	Parameters				
		Particulate Matter (PM_{10}) in $\mu g/Nm^3$	Particulate Matter ($PM_{2.5}$) in $\mu g/Nm^3$	Sulphur Dioxide (SO_2) in $\mu g/Nm^3$	Nitrogen Dioxide (NO_2) in $\mu g/Nm^3$	Lead (Pb) in $\mu g/Nm^3$
Aircel Mawiteii Store, New Serchip N:$23^0$20'51", E:$92^0$50'58" 1.5 m (approx.) From Edge of the Pavement	16/05/2016 to 17/05/2016	37	23	<5	10	< 0.01
	17/05/2016 to 18/05/2016	34	21	8	13	< 0.01
	19/05/2016 to 20/05/2016	32	22	9	14	< 0.01

Sampling Location:	Date of Sampling	Parameters				
		Particulate Matter (PM_{10}) in µg/Nm^3	Particulate Matter ($PM_{2.5}$) in µg/Nm^3	Sulphur Dioxide (SO_2) in µg/Nm^3	Nitrogen Dioxide (NO_2) in µg/Nm^3	Lead (Pb) in µg/Nm^3
	20/05/2016 to 21/05/2016	31	24	7	12	< 0.01
Hotel Zemela Rooftop, Bazar Area, Serchip. N:$23^0$30'90", E:$92^0$85'67" 10 m (approx.) From Edge of the Pavement	16/05/2016 to 17/05/2016	36	25	6	12	< 0.01
	17/05/2016 to 18/05/2016	31	24	7	11	< 0.01
	19/05/2016 to 20/05/2016	34	19	7	14	< 0.01
	20/05/2016 to 21/05/2016	38	22	6	14	< 0.01
Tajmahal Hotel, Sailiam Kawn, Serchip, N:$23^0$17'24", E:$92^0$51'41" 1.5 m (approx.) From Edge of the Pavement	16/05/2016 to 17/05/2016	37	22	<5	9	< 0.01
	17/05/2016 to 18/05/2016	33	20	6	11	< 0.01
	19/05/2016 to 20/05/2016	35	27	8	10	< 0.01
	20/05/2016 to 21/05/2016	34	21	7	8	< 0.01
Number of Sample		12	12	12	12	12
Max		38	27	9	14	< 0.01
Min		31	19	<5	8	< 0.01
98th Percentile		37	25	8	14	< 0.01

Source: JICA Study Team

(iii) Hnathial

Three ambient air quality stations were selected in the Hnathial bypass (near start point, mid-point and end point) and the results are enumerated below.

A) Particulate Matter (Size less than 10 µm) PM_{10}

The concentration of PM_{10} at the AAQM station in Hnathial ranged from 37 µg/Nm^3 to 52 µg/Nm^3 in the dry season, and ranged from 29 µg/Nm^3 to 34 µg/Nm^3 in the monsoon season.

B) Particulate Matter (Size less than 2.5 µm) $PM_{2.5}$

The concentration of $PM_{2.5}$ at the AAQM station ranged from 18 µg/Nm^3 to 32 µg/Nm^3 in the dry season, and ranged from 15 µg/Nm^3 to 22 µg/Nm^3 in the monsoon season.

C) Sulphur Dioxide (SO_2)

The concentration of SO_2 ranged from 6 µg/Nm^3 to 9 µg/Nm^3 in the dry season, and ranged from 6 µg/Nm^3 to 8 µg/Nm^3 in the monsoon season.

D) Nitrogen Oxide (NOx)

The concentration of NOx ranged from 12 µg/Nm^3 to 16 µg/Nm^3 in the dry season, and ranged from 9 µg/Nm^3 to 14 µg/Nm^3 in the monsoon season.

E) Lead

The concentration of lead in ambient air was <0.01 µg/Nm^3 for both the locations and both seasons.

Table 4.16 Air Quality in Hnathial in Dry Season

Sampling Location:	Date of Sampling	Parameters				
		Particulate Matter (PM_{10}) in µg/Nm^3	Particulate Matter ($PM_{2.5}$) in µg/Nm^3	Sulphur Dioxide (SO_2) in µg/Nm^3	Nitrogen Dioxide (NO_2) in µg/Nm^3	Lead (Pb) in µg/Nm^3
Samuel Tyre Works, Electric Veng, Hnathial. N:22^{0}58'46", E:92^{0}55'19" 1.5 m (approx.) From Edge of the Pavement	29/02/2016 to 01/03/2016	39	19	7	14	< 0.01
	01/03/2016 to 02/03/2016	37	20	6	13	< 0.01
	03/03/2016 to 04/03/2016	41	18	7	12	< 0.01
	04/03/2016 to 05/03/2016	42	21	6	13	< 0.01
Peniel Veng, Residence of Mr. T SAPTAWNA, H/№. 172, Hnathial. N:22^{0}57'39", E:92^{0}55'44" 1.5 m (approx.) From Edge of the Pavement	29/02/2016 to 01/03/2016	41	22	8	15	< 0.01
	01/03/2016 to 02/03/2016	43	24	9	16	< 0.01
	03/03/2016 to 04/03/2016	44	26	9	15	< 0.01
	04/03/2016 to 05/03/2016	46	23	8	14	< 0.01
Wayside Cottage, Kutkawk, Hnahthial. N:22^{0}55 '51", E:92^{0}55'33" 5 m (approx.) From Edge of the Pavement	29/02/2016 to 01/03/2016	52	30	7	14	< 0.01
	01/03/2016 to 02/03/2016	49	31	8	15	< 0.01
	03/03/2016 to 04/03/2016	50	32	7	14	< 0.01
	04/03/2016 to 05/03/2016	51	30	8	15	< 0.01
Number of Sample		12	12	12	12	12
Max		52	32	9	16	< 0.01
Min		37	18	6	12	< 0.01
98th Percentile		51	31	9	15	< 0.01

Source: JICA Study Team

Table 4.17 Air Quality in Hnathial in Monsoon Season

Sampling Location:	Date of Sampling	Parameters				
		Particulate Matter (PM_{10}) in µg/Nm^3	Particulate Matter ($PM_{2.5}$) in µg/Nm^3	Sulphur Dioxide (SO_2) in µg/Nm^3	Nitrogen Dioxide (NO_2) in µg/Nm^3	Lead (Pb) in µg/Nm^3
Samuel Tyre Works, Electric Veng, Hnathial.	23/05/2016 to 24/05/2016	29	19	8	14	< 0.01

Sampling Location:	Date of Sampling	Parameters				
		Particulate Matter (PM_{10}) in µg/Nm^3	Particulate Matter ($PM_{2.5}$) in µg/Nm^3	Sulphur Dioxide (SO_2) in µg/Nm^3	Nitrogen Dioxide (NO_2) in µg/Nm^3	Lead (Pb) in µg/Nm^3
N:22^{0}58'46", E:92^{0}55'19" 1.5 m (approx.) From Edge of the Pavement	24/05/2016 to 25/05/2016	32	22	7	9	< 0.01
	26/05/2016 to 27/05/2016	33	17	7	11	< 0.01
	27/05/2016 to 28/05/2016	34	17	6	9	< 0.01
Peniel Veng, Residence of Mr. T SAPTAWNA, H/№. 172, Hnathial. N:22^{0}57'39", E:92^{0}55'44" 1.5 m (approx.) From Edge of the Pavement	23/05/2016 to 24/05/2016	31	15	6	12	< 0.01
	24/05/2016 to 25/05/2016	33	18	7	11	< 0.01
	26/05/2016 to 27/05/2016	34	19	6	13	< 0.01
	27/05/2016 to 28/05/2016	32	16	<5	11	< 0.01
Wayside Cottage, Kutkawk, Hnahthial. N:22^{0}55 '51", E:92^{0}55'33" 5 m (approx.) From Edge of the Pavement	23/05/2016 to 24/05/2016	34	17	7	11	< 0.01
	24/05/2016 to 25/05/2016	31	18	8	9	< 0.01
	26/05/2016 to 27/05/2016	32	16	7	12	< 0.01
	27/05/2016 to 28/05/2016	30	16	6	11	< 0.01
Number of Sample		12	12	12	12	12
Max		34	22	8	14	< 0.01
Min		29	15	6	9	< 0.01
98th Percentile		34	19	8	13	< 0.01

Source: JICA Study Team

(iv) Lawngtlai

Two ambient air quality stations were selected in the Lawngtlai bypass (near start point and end point) and the results are enumerated below.

A) Particulate Matter (Size less than 10 µm) PM_{10}

The concentration of PM_{10} concentration at the AAQM station in Lawngtlai ranged from 55 µg/Nm^3 to 62 µg/Nm^3 in the dry season. The PM_{10} concentration at AOC Veng, Lawngtlai crossed the permissible limit of 60 µg/Nm^3 during the monitoring period of 22/02/2016 to 23/02/2016. This may be due to the dry season, vehicular movement and construction activities going on in the particular location.

On the other hand, the concentration of PM_{10} ranged from 29 µg/Nm^3 to 35 µg/Nm^3 in the monsoon season.

B) Particulate Matter (Size less than 2.5 µm) $PM_{2.5}$

The concentration of $PM_{2.5}$ at the AAQM station ranged from 32 μg/Nm^3 to 41 μg/Nm^3 in the dry season, and ranged from 18 μg/Nm^3 to 23 μg/Nm^3 in the monsoon season.

C) Sulphur Dioxide (SO_2)

The concentration of SO_2 ranged from 7 μg/Nm^3 to 9 μg/Nm^3 in the dry season, and ranged from 6 μg/Nm^3 to 8 μg/Nm^3 in the monsoon season.

D) Nitrogen Oxide (NOx)

The concentration of NOx ranged from 13 μg/Nm^3 to 16 μg/Nm^3 in the dry season, and ranged from 9 μg/Nm^3 to 14 μg/Nm^3 in the monsoon season.

E) Lead

The concentration of lead in ambient air was <0.01 μg/Nm^3 for both the locations and both seasons.

Table 4.18 Air Quality in Lawngtlai in Dry Season

Sampling Location:	Date of Sampling	Parameters				
		Particulate Matter (PM_{10}) in μg/Nm^3	Particulate Matter ($PM_{2.5}$) in μg/Nm^3	Sulphur Dioxide (SO_2) in μg/Nm^3	Nitrogen Dioxide (NO_2) in μg/Nm^3	Lead (Pb) in μg/Nm^3
Lawngtlai IV Bazar, N:$22^0$53'37", E:$92^0$89'93" 1.5 m (approx.) From Edge of the Pavement	22/02/2016 to 23/02/2016	58	36	8	15	< 0.01
	23/02/2016 to 24/02/2016	56	34	7	13	< 0.01
	25/02/2016 to 26/02/2016	57	32	9	14	< 0.01
	26/02/2016 to 27/02/2016	59	33	7	15	< 0.01
AOC Veng, Lawngtlai, N:$22^0$53'38", E:$92^0$89'93" 1.5 m (approx.) From Edge of the Pavement	22/02/2016 to 23/02/2016	62	38	9	16	< 0.01
	23/02/2016 to 24/02/2016	57	37	7	15	< 0.01
	25/02/2016 to 26/02/2016	55	36	8	15	< 0.01
	26/02/2016 to 27/02/2016	59	41	7	14	< 0.01
Number of Sample		8	8	8	8	8
Max		62	41	9	16	< 0.01
Min		55	32	7	13	< 0.01
98th Percentile		59	38	9	15	< 0.01

Source: JICA Study Team

Table 4.19 Air Quality in Lawngtlai in Monsoon Season

Sampling Location:	Date of	Parameters

	Sampling	Particulate Matter (PM_{10}) in µg/Nm^3	Particulate Matter ($PM_{2.5}$) in µg/Nm^3	Sulphur Dioxide (SO_2) in µg/Nm^3	Nitrogen Dioxide (NO_2) in µg/Nm^3	Lead (Pb) in µg/Nm^3
Lawngtlai IV Bazar, N:$22^0$53'37", E:$92^0$89'93" 1.5 m (approx.) From Edge of the Pavement	23/05/2016 to 24/05/2016	32	20	8	12	< 0.01
	24/05/2016 to 25/05/2016	30	18	7	11	< 0.01
	26/05/2016 to 27/05/2016	29	21	7	9	< 0.01
	27/05/2016 to 28/05/2016	31	20	6	10	< 0.01
AOC Veng, Lawngtlai, N:$22^0$53'38", E:$92^0$89'93" 1.5 m (approx.) From Edge of the Pavement	23/05/2016 to 24/05/2016	33	22	8	14	< 0.01
	24/05/2016 to 25/05/2016	35	21	7	9	< 0.01
	26/05/2016 to 27/05/2016	32	21	6	11	< 0.01
	27/05/2016 to 28/05/2016	30	23	7	12	< 0.01
Number of Sample		8	8	8	8	8
Max		35	23	8	14	< 0.01
Min		29	18	6	9	< 0.01
98th Percentile		32	22	8	12	< 0.01

Source: JICA Study Team

4.2.2 Ground and Surface Water Quality

Under natural conditions, the water quality reflects environmental conditions to a great extent. Hydro-geochemical factors influence color, odour, taste, temperature and the degree of mineralization of water derived from surface run off, springs, etc. Besides, human settlements, overall land use, morphology of the basin area, seasonal distribution of rainfall and winds, disposal of industrial effluents and sewage, etc. contribute a great deal in determining the quality of water. The quality of ground water is influenced by surface and sub-surface environmental conditions. The quantity and quality of water entering the underground regime is another important parameter which influences ground water quality. Rainfall absorbs atmospheric pollutants during its descent through the atmosphere.

The collected water sample was analyzed for selected physical and chemical parameters. The analyzed parameters of the physico-chemical properties of the water samples meet desirable limits as per IS 10500:2012. The odor, taste and smell are acceptable for all areas. Oil and grease and fluoride were below detectable limit. Hardness of water, determined by the dissolved salts calcium and magnesium, was found to be in the range from 18 to 56 mg/l. The water of the samples analyzed can be classified as soft water (Durfer and Backer classification of Hardness). The total dissolved solid (TDS) of water represents the amount of soluble inorganic substances in the water source. The TDS of

the water samples varied from a minimum of 80 mg/l to 510 mg/l. The iron content of the water samples was lower in the surface water sample as compared to the ground water samples. The concentration of the trace metals and soluble inorganics like sulphate and nitrate analyzed was within the permissible limits as per IS 10500:2012.

(i) Chhiathlang (Bypass One)

One surface water sample, three ground water sample and one sample from community water tank were collected from different locations of Chiahtlang. The pH ranged from 6.7 to 7.4 in the dry season and from 6.4 to 7.9 in the monsoon season which are well within the desirable limit as per the IS 10500:2012 standards. The temperature of the water was lower than the ambient temperature and ranged from 19°C to 20.1°C in the dry season and 25.1°C to 27°C in the monsoon season. The physico-chemical parameters analyzed were within the limits as per IS 10500:2012. The presence of total coliform was detected in the community water tank (Chiahtlang Sample 1) and surface water sample (Chiahtlang Sample 5).

Table 4.20 Surface Water Quality in Chhiathlang in Dry Season

LOCATION: CHHIAHTLANG			**24/2/2016 & 5/3/2016**					**LIMIT IS:10500: 2012**
SL. N0.	**Parameters**	**Unit**	**Sample 1 Water Tank**	**Sample 2 Ground Water**	**Sample 3 Ground Water**	**Sample 4 Ground Water**	**Sample 5 Surface Water**	
1	Color	Hazen unit	1	1	1	1	1	**5**
2	Odor	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	**Agreeable**
3	Taste	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	**Agreeable**
4	Turbidity in NTU	NTU	1	1	1	1	1	**1**
5	pH	value	6.7	7.1	7.1	7.4	7.4	**6.5 - 8.5**
6	Temperature (^{0}C)	Celsius	20.1^{0}C	19.6^{0}C	19^{0}C	19.5^{0}C	19^{0}C	-
7	Total Suspended Solids	mg/l	69	263	295	155	131	-
8	Total Dissolved Solids	mg/l	200	350	450	90	270	**500**
9	BOD in mg/l (5 days 20^{0}C)	mg/l	< 1	< 1	< 1	< 1	< 1	-
10	COD in mg/l	mg/l	< 1	< 1	< 1	< 1	< 1	-
11	Conductivity	µS/cm	0.18	0.41	0.56	0.03	0.42	-
12	Alkalinity	mg/l	35	60	120	45	35	**200**
13	Oil & Grease	mg/l	< 1	< 1	< 1	< 1	< 1	-
14	Total Hardness $CaCO_3$	mg/l	34	55	51	47	49	**200**
15	Chlorides as (Cl)	mg/l	12.5	22.5	15	_	5	**250**
16	Residual free Chlorine	mg/l	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	**0.2**
17	Calcium as Ca	mg/l	14.4	22.2	25.5	7.7	15.5	**75**

LOCATION: CHHIAHTLANG			24/2/2016 & 5/3/2016					LIMIT IS:10500: 2012
SL. N0.	**Parameters**	**Unit**	**Sample 1 Water Tank**	**Sample 2 Ground Water**	**Sample 3 Ground Water**	**Sample 4 Ground Water**	**Sample 5 Surface Water**	
18	Magnesium as Mg	mg/l	6.9	9.2	10.4	4.5	6.8	**30**
19	Fluoride as F	mg/l	<1	<1	<1	<1	<1	**1**
20	Nitrate as NO_3	mg/l	10	13	12	3	4	**45**
21	Sulphates as (SO_4)	mg/l	7.21	5.46	5.48	5.96	5.37	**200**
22	Iron (Fe)	mg/l	0.16	0.28	0.26	0.29	0.15	**0.3**
23	Total *Coliform* (MPN/100 ml)	MPN/100 ml	48	Absent	Absent	Absent	9	**Absent**

Note: <1 indicate No Colony developed in 1 ml. Sample
<10 indicate No Colony developed in 0.1 ml. Sample
<100 indicate No Colony developed in 0.01 ml. Sample

Source: JICA Study Team

Table 4.21 Surface Water Quality in Chhiathlang in Monsoon Season

LOCATION: CHHIAHTLANG			17/05/2016 & 18/05/2016 & 09/07/2016 & 12/07/2016					LIMIT IS:10500: 2012
SL. No.	**Parameters**	**Unit**	**Sample 1 Water Tank**	**Sample 2 Ground Water**	**Sample 3 Ground Water**	**Sample 4 Ground Water**	**Sample 5 Surface Water**	
1	Color	Hazen unit	1	1	1	1	1	**5**
2	Odor	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	**Agreeable**
3	Taste	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	**Agreeable**
4	Turbidity in NTU	NTU	1	1	1	1	1	**1**
5	pH	value	6.4	7.1	7.9	7.3	6.8	**6.5 - 8.5**
6	Temperature (^0C)	Celsius	25.1^{0}C	26.6^{0}C	27^{0}C	26.5^{0}C	26.7^{0}C	**-**
7	Total Suspended Solids	mg/l	162	120	62	75	107	**-**
8	Total Dissolved Solids	mg/l	114	84	103	58	139	**500**
9	BOD in mg/l (5 days 20^{0}C)	mg/l	< 1	< 1	< 1	< 1	< 1	**-**
10	COD in mg/l	mg/l	< 1	< 1	< 1	< 1	< 1	**-**
11	Conductivity	µS/cm	0.68	0.64	0.77	0.48	0.51	**-**
12	Alkalinity	mg/l	30	41	45	40	38	**200**
13	Oil & Grease	mg/l	< 1	< 1	< 1	< 1	< 1	**-**
14	Total Hardness $CaCO_3$	mg/l	Nil	168	8	Nil	40	**200**
15	Chlorides as (Cl)	mg/l	26	32	20	24	94	**250**
16	Residual free Chlorine	mg/l	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	**0.2**
17	Calcium as Ca	mg/l	20	24	22	14	34	**75**
18	Magnesium as Mg	mg/l	8.5	8	9	18.5	7.5	**30**
19	Fluoride as F	mg/l	BDL	BDL	BDL	BDL	BDL	**1**

LOCATION: CHHIAHTLANG			17/05/2016 & 18/05/2016 & 09/07/2016 & 12/07/2016					LIMIT IS:10500: 2012
SL. No.	**Parameters**	**Unit**	**Sample 1 Water Tank**	**Sample 2 Ground Water**	**Sample 3 Ground Water**	**Sample 4 Ground Water**	**Sample 5 Surface Water**	
20	Nitrate as NO_3	mg/l	8	9	10	4	6	**45**
21	Sulphates as (SO_4)	mg/l	4.5	3.4	6.2	4.9	4.3	**200**
22	Iron (Fe)	mg/l	0.3	0.3	0.3	0.2	0.2	**0.3**
23	Total *Coliform* (MPN/100 ml)	MPN/100 ml	Absent	Absent	Absent	Absent	300	**Absent**

Note: <1 indicate No Colony developed in 1 ml. Sample
<10 indicate No Colony developed in 0.1 ml. Sample
<100 indicate No Colony developed in 0.01 ml. Sample
Source: JICA Study Team

(ii) Serchhip (Bypass Two)

Two surface water samples, one ground water sample and one sample from community water tank were collected from different locations of Serchhip. The pH ranged from 7.4 to 7.7 in the dry season and 7.2 to 8.3 in the monsoon season which are well within the desirable limit as per the IS 10500:2012 standards. The temperature of the water ranged from 19.2°C to 20.1°C in the dry season and 26.1°C to 27.6°C in the monsoon season. Most of the physico-chemical parameters tested was well within the limits as per IS 10500:2012. Total coliform was detected in the samples collected from community water tank (Serchhip Sample 1) and surface water (Serchhip Sample 1 and Serchhip Sample 4).

Table 4.22 Surface Water Quality in Serchhip in Dry Season

LOCATION: SERCHHIP			24/2/2016					LIMIT IS:10500: 2012
SL. No.	**Parameters**	**Unit**	**Sample 1 C Water Tank**	**Sample 2 Surface Water**	**Sample 3 Potable Water**	**Sample 4 Stream Water**	**Sample 1 C Water Tank**	
1	Color	Hazen unit	1	1	1	1	1	**5**
2	Odor	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	**Agreeable**
3	Taste	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	**Agreeable**
4	Turbidity in NTU	NTU	1	1	1	1	1	**1**
5	pH	value	8.1	8.3	7.2	7.1	8.1	**6.5 - 8.5**
6	Temperature (^{0}C)	Celsius	27.6^{0}C	26.1^{0}C	27.4^{0}C	26.5^{0}C	27.6^{0}C	**-**
7	Total Suspended Solids	mg/l	55	127	35	116	55	**-**
8	Total Dissolved Solids	mg/l	108	134	89	93	108	**500**
9	BOD in mg/l (5 days 20^{0}C)	mg/l	< 1	< 1	< 1	< 1	< 1	**-**
10	COD in mg/l	mg/l	< 1	< 1	< 1	< 1	< 1	**-**
11	Conductivity	µS/cm	0.32	0.19	0.42	0.56	0.32	**-**
12	Alkalinity	mg/l	28	32	22	25	28	**200**

LOCATION: SERCHHIP			24/2/2016					LIMIT IS:10500: 2012
SL. No.	**Parameters**	**Unit**	**Sample 1 C Water Tank**	**Sample 2 Surface Water**	**Sample 3 Potable Water**	**Sample 4 Stream Water**	**Sample 1 C Water Tank**	
13	Oil & Grease	mg/l	< 1	< 1	< 1	< 1	< 1	**-**
14	Total Hardness $CaCO_3$	mg/l	44	28	24	Nil	44	**200**
15	Chlorides as (Cl)	mg/l	34	28	22	26	34	**250**
16	Residual free Chlorine	mg/l	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	**0.2**
17	Calcium as Ca	mg/l	36	32	18	14	36	**75**
18	Magnesium as Mg	mg/l	19.5	18	12.5	14.5	19.5	**30**
19	Fluoride as F	mg/l	BDL	BDL	BDL	BDL	BDL	**1**
20	Nitrate as NO_3	mg/l	10	10	8	7	10	**45**
21	Sulphates as (SO_4)	mg/l	5.9	5.5	4.9	3.6	5.9	**200**
22	Iron (Fe)	mg/l	0.2	0.3	0.3	0.3	0.2	**0.3**
23	Total *Coliform* (MPN/100 ml)	MPN/100 ml	Absent	Absent	Absent	Absent	Absent	**Absent**

Note: <1 indicate No Colony developed in 1 ml. Sample
<10 indicate No Colony developed in 0.1 ml. Sample
<100 indicate No Colony developed in 0.01 ml. Sample

Source: JICA Study Team

Table 4.23 Surface Water Quality in Serchhip in Monsoon Season

LOCATION: SERCHHIP			9/7/2016 & 17/05/2016					LIMIT IS:10500: 2012
SL. No.	**Parameters**	**Unit**	**Sample 1 C Water Tank**	**Sample 2 Surface Water**	**Sample 3 Potable Water**	**Sample 4 Stream Water**	**Sample 1 C Water Tank**	
1	Colour	Hazen unit	Clear	Clear	Clear	Clear	Clear	**5**
2	Odor	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	**Agreeable**
3	Taste	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	**Agreeable**
4	Turbidity in NTU	NTU	1	1	1	1	1	**1**
5	pH	value	8.1	8.3	7.2	7.1	8.1	**6.5 - 8.5**
6	Temperature (^0C)	Celsius	27.6^{0}C	26.1^{0}C	27.4^{0}C	26.5^{0}C	27.6^{0}C	**-**
7	Total Suspended Solids	mg/l	55	127	35	116	55	**-**
8	Total Dissolved Solids	mg/l	108	134	89	93	108	**500**
9	BOD in mg/l (5 days 20^{0}C)	mg/l	< 1	< 1	< 1	< 1	< 1	**-**
10	COD in mg/l	mg/l	< 1	< 1	< 1	< 1	< 1	**-**
11	Conductivity	µS/cm	0.32	0.19	0.42	0.56	0.32	**-**
12	Alkalinity	mg/l	28	32	22	25	28	**200**
13	Oil & Grease	mg/l	< 1	< 1	< 1	< 1	< 1	**-**
14	Total Hardness $CaCO_3$	mg/l	44	28	24	Nil	44	**200**

LOCATION: SERCHHIP			9/7/2016 & 17/05/2016					LIMIT IS:10500: 2012
SL. No.	**Parameters**	**Unit**	**Sample 1 C Water Tank**	**Sample 2 Surface Water**	**Sample 3 Potable Water**	**Sample 4 Stream Water**	**Sample 1 C Water Tank**	
15	Chlorides as (Cl)	mg/l	34	28	22	26	34	**250**
16	Residual free Chlorine	mg/l	< 1	< 1	< 1	<1	< 1	**0.2**
17	Calcium as Ca	mg/l	36	32	18	14	36	**75**
18	Magnesium as Mg	mg/l	19.5	18	12.5	14.5	19.5	**30**
19	Fluoride as F	mg/l	BDL	BDL	BDL	BDL	BDL	**1**
20	Nitrate as NO_3	mg/l	10	10	8	7	10	**45**
21	Sulphates as (SO_4)	mg/l	5.9	5.5	4.9	3.6	5.9	**200**
22	Iron (Fe)	mg/l	0.2	0.3	0.3	0.3	0.2	**0.3**
23	Total *Coliform* (MPN/100 ml)	MPN/100 ml	Absent	Absent	Absent	Absent	Absent	**Absent**

Note: <1 indicate No Colony developed in 1 ml. Sample
<10 indicate No Colony developed in 0.1 ml. Sample
<100 indicate No Colony developed in 0.01 ml. Sample
Source: JICA Study Team

(iii) Hnathial

One surface water sample and three samples from community water tank were collected from different locations of Hnanthial. The pH ranged from 6.8 to 7.7 in the dry season and 6.3 to 8.2 in the monsoon season which are well within the desirable limit as per the IS 10500:2012 standards. The temperature of the water was lower than the ambient temperature and ranged from 18.1°C to 19°C in the dry season and 26.5°C to 27.8°C in the monsoon season in the community tanks. The physico-chemical parameters analysed were within the limits as per IS 10500:2012. There was presence of total coliform in the surface water sample (Hnanthial Sample 1) and in one of the community water tank ((Hnanthial Sample 2).

Table 4.24 Surface Water Quality in Hnathial in Dry Season

LOCATION: HNATHIAL			23/2/2016					LIMIT IS:10500: 2012
SL. No.	**Parameters**	**Unit**	**Sample 1 Surface Water**	**Sample 2 C Water Tank**	**Sample 3 C Water Tank**	**Sample 4 C Water Tank**	**Sample 1 Surface Water**	
1	Colour	Hazen unit	1	1	1	1	1	**5**
2	Odour	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	**Agreeable**
3	Taste	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	**Agreeable**
4	Turbidity in NTU	NTU	1	1	1	1	1	**1**
5	pH	value	7	7.7	6.8	7.2	7	**6.5 - 8.5**
6	Temperature (^{0}C)	Celsius	18.1^{0}C	19^{0}C	18.6^{0}C	19^{0}C	18.1^{0}C	**-**
7	Total Suspended	mg/l	137	157	186	258	137	**-**

LOCATION: HNATHIAL			23/2/2016					LIMIT IS:10500: 2012
SL. No.	**Parameters**	**Unit**	**Sample 1 Surface Water**	**Sample 2 C Water Tank**	**Sample 3 C Water Tank**	**Sample 4 C Water Tank**	**Sample 1 Surface Water**	
	Solids							
8	Total Dissolved Solids	mg/l	160	230	168	140	160	**500**
9	BOD in mg/l (5 days 20^0C)	mg/l	< 1	< 1	< 1	< 1	< 1	**-**
10	COD in mg/l	mg/l	< 1	< 1	< 1	< 1	< 1	**-**
11	Conductivity	µS/cm	0.12	0.23	0.13	0.11	0.12	**-**
12	Alkalinity	mg/l	45	45	40	45	45	**200**
13	Oil & Grease	mg/l	< 1	< 1	< 1	< 1	< 1	**-**
14	Total Hardness $CaCO_3$	mg/l	56	18	36	32	56	**200**
15	Chlorides as (Cl)	mg/l	2.5	_	_	5	2.5	**250**
16	Residual free Chlorine	mg/l	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	**0.2**
17	Calcium as Ca	mg/l	18.8	21.1	17.7	18.8	18.8	**75**
18	Magnesium as Mg	mg/l	9.2	9.6	7.8	8.2	9.2	**30**
19	Fluoride as F	mg/l	<1	<1	<1	<1	<1	**1**
20	Nitrate as NO_3	mg/l	10	12	8	9	10	**45**
21	Sulphates as (SO_4)	mg/l	3.69	6.25	5.84	6.76	3.69	**200**
22	Iron (Fe)	mg/l	0.16	0.22	0.25	0.21	0.16	**0.3**
23	Total *Coliform* (MPN/100 ml)	MPN/100 ml	910	32	Absent	Absent	910	**Absent**

Note: <1 indicate No Colony developed in 1 ml. Sample
<10 indicate No Colony developed in 0.1 ml. Sample
<100 indicate No Colony developed in 0.01 ml. Sample

Source: JICA Study Team

Table 4.25 Surface Water Quality in Hnathial in Monsoon Season

LOCATION: HNATHIAL			25/5/2016 & 8/7/2016					LIMIT IS:10500: 2012
SL. No.	**Parameters**	**Unit**	**Sample 1 Surface Water**	**Sample 2 C Water Tank**	**Sample 3 C Water Tank**	**Sample 4 C Water Tank**	**Sample 1 Surface Water**	
1	Color	Hazen unit	1	1	1	1	1	**5**
2	Odor	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	**Agreeable**
3	Taste	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	**Agreeable**
4	Turbidity in NTU	NTU	1	1	1	1	1	**1**
5	pH	value	6.8	7.7	6.3	8.2	6.8	**6.5 - 8.5**
6	Temperature (^{0}C)	Celsius	26.1^{0}C	27^{0}C	26.6^{0}C	26.8^{0}C	26.1^{0}C	**-**
7	Total Suspended Solids	mg/l	116	98	108	88	116	**-**
8	Total Dissolved	mg/l	120	95	114	97	120	**500**

LOCATION: HNATHIAL			25/5/2016 & 8/7/2016					LIMIT IS:10500: 2012
SL. No.	**Parameters**	**Unit**	**Sample 1 Surface Water**	**Sample 2 C Water Tank**	**Sample 3 C Water Tank**	**Sample 4 C Water Tank**	**Sample 1 Surface Water**	
	Solids							
9	BOD in mg/l (5 days 20^0C)	mg/l	< 1	< 1	< 1	< 1	< 1	**-**
10	COD in mg/l	mg/l	< 1	< 1	< 1	< 1	< 1	**-**
11	Conductivity	µS/cm	0.42	0.37	0.29	0.81	0.42	**-**
12	Alkalinity	mg/l	32	36	28	25	32	**200**
13	Oil & Grease	mg/l	< 1	< 1	< 1	< 1	< 1	**-**
14	Total Hardness $CaCO_3$	mg/l	Nil	50	30	20	Nil	**200**
15	Chlorides as (Cl)	mg/l	18	24	24	28	18	**250**
16	Residual free Chlorine	mg/l	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	**0.2**
17	Calcium as Ca	mg/l	26	32	24	26	26	**75**
18	Magnesium as Mg	mg/l	9.5	8	10	12.5	9.5	**30**
19	Fluoride as F	mg/l	BDL	BDL	BDL	BDL	BDL	**1**
20	Nitrate as NO_3	mg/l	7	8	10	6	7	**45**
21	Sulphates as (SO_4)	mg/l	7.1	6.1	6.7	7.7	7.1	**200**
22	Iron (Fe)	mg/l	0.2	0.2	0.3	0.2	0.2	**0.3**
23	Total *Coliform* (MPN/100 ml)	MPN/100 ml	200	Absent	Absent	Absent	200	**Absent**

Note: <1 indicate No Colony developed in 1 ml. Sample
<10 indicate No Colony developed in 0.1 ml. Sample
<100 indicate No Colony developed in 0.01 ml. Sample

Source: JICA Study Team

(iv) Lawngtlai

Three ground water samples and one surface water sample was collected from different locations of Lawngtlai. The pH ranged from 6.7 to 7.3 in the dry season and from 6.5 to 7.8 in the monsoon season which are well within the desirable limit as per the IS 10500:2012 standards. The temperature of the water was slightly lower than the ambient temperature ranging from 18.6°C to 20.5°C in the dry season and 26.5°C to 27.8°C in the monsoon season. Most of the physico-chemical parameters tested was within the limits as per IS 10500:2012. The surface water sample (Lawngtlai Sample 4) showed the presence of total coliform.

Table 4.26 Surface Water Quality in Lawngtlai in Dry Season

LOCATION: LAWNGTLAI			23/2/2016 & 29/2/2016					LIMIT IS:10500: 2012
SL. No.	**Parameters**	**Unit**	**Sample 1 Surface Water**	**Sample 2 C Water Tank**	**Sample 3 C Water Tank**	**Sample 4 C Water Tank**	**Sample 1 Surface Water**	
1	Colour	Hazen unit	1	1	1	1	1	**5**
2	Odour	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	**Agreeable**

LOCATION: LAWNGTLAI			23/2/2016 & 29/2/2016					LIMIT IS:10500: 2012
SL. No.	**Parameters**	**Unit**	**Sample 1 Surface Water**	**Sample 2 C Water Tank**	**Sample 3 C Water Tank**	**Sample 4 C Water Tank**	**Sample 1 Surface Water**	
3	Taste	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	**Agreeable**
4	Turbidity in NTU	NTU	1	1	1	1	1	**1**
5	pH	value	7.1	7.3	6.7	6.9	7.1	**6.5 - 8.5**
6	Temperature (^{0}C)	Celsius	18.6^{0}C	19.2^{0}C	20.5^{0}C	19.8^{0}C	18.6^{0}C	**-**
7	Total Suspended Solids	mg/l	238	56	119	264	238	**-**
8	Total Dissolved Solids	mg/l	90	80	100	510	90	**500**
9	BOD in mg/l (5 days 20^{0}C)	mg/l	< 1	< 1	< 1	< 1	< 1	**-**
10	COD in mg/l	mg/l	< 1	< 1	< 1	< 1	< 1	**-**
11	Conductivity	µS/cm	0.94	0.93	0.93	1.57	0.94	**-**
12	Alkalinity	mg/l	45	55	45	40	45	**200**
13	Oil & Grease	mg/l	< 1	< 1	< 1	< 1	< 1	**-**
14	Total Hardness $CaCO_3$	mg/l	30	47	48	38	30	**200**
15	Chlorides as (Cl)	mg/l	5	5	7.5	5	5	**250**
16	Residual free Chlorine	mg/l	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	**0.2**
17	Calcium as Ca	mg/l	16.6	15.5	16.6	6.9	16.6	**75**
18	Magnesium as Mg	mg/l	8.5	6.9	8.6	3.5	8.5	**30**
19	Fluoride as F	mg/l	<1	<1	<1	<1	<1	**1**
20	Nitrate as NO_3	mg/l	8	9	10	7	8	**45**
21	Sulphates as (SO_4)	mg/l	7.25	6.42	5.76	5.48	7.25	**200**
22	Iron (Fe)	mg/l	0.27	0.18	0.22	0.14	0.27	**0.3**
23	Total *Coliform* (MPN/100 ml)	MPN/100 ml	Absent	Absent	Absent	151	Absent	**Absent**

Note: <1 indicate No Colony developed in 1 ml. Sample
<10 indicate No Colony developed in 0.1 ml. Sample
<100 indicate No Colony developed in 0.01 ml. Sample

Source: JICA Study Team

Table 4.27 Surface Water Quality in Lawngtlai in Monsoon Season

LOCATION: LAWNGTLAI			23/5/2016 & 7/7/2016					LIMIT IS:10500: 2012
SL. No.	**Parameters**	**Unit**	**Sample 1 Surface Water**	**Sample 2 C Water Tank**	**Sample 3 C Water Tank**	**Sample 4 C Water Tank**	**Sample 1 Surface Water**	
1	Colour	Hazen unit	1	1	1	1	1	**5**
2	Odour	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	**Agreeable**
3	Taste	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	**Agreeable**

LOCATION: LAWNGTLAI			23/5/2016 & 7/7/2016					LIMIT IS:10500: 2012
SL. No.	**Parameters**	**Unit**	**Sample 1 Surface Water**	**Sample 2 C Water Tank**	**Sample 3 C Water Tank**	**Sample 4 C Water Tank**	**Sample 1 Surface Water**	
4	Turbidity in NTU	NTU	1	1	1	1	1	**1**
5	pH	value	6.5	6.8	6.6	7.8	6.5	**6.5 - 8.5**
6	Temperature (^{0}C)	Celsius	26.6^{0}C	27.2^{0}C	26.5^{0}C	27.8^{0}C	26.6^{0}C	**-**
7	Total Suspended Solids	mg/l	92	127	126	156	92	**-**
8	Total Dissolved Solids	mg/l	78	94	87	102	78	**500**
9	BOD in mg/l (5 days 20^{0}C)	mg/l	< 1	< 1	< 1	< 1	< 1	**-**
10	COD in mg/l	mg/l	< 1	< 1	< 1	< 1	< 1	**-**
11	Conductivity	µS/cm	0.53	0.37	0.28	0.64	0.53	**-**
12	Alkalinity	mg/l	26	30	25	34	26	**200**
13	Oil & Grease	mg/l	< 1	< 1	< 1	< 1	< 1	**-**
14	Total Hardness $CaCO_3$	mg/l	<1	<1	4	<1	<1	**200**
15	Chlorides as (Cl)	mg/l	28	24	58	26	28	**250**
16	Residual free Chlorine	mg/l	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	**0.2**
17	Calcium as Ca	mg/l	16	10	22	14	16	**75**
18	Magnesium as Mg	mg/l	8	9	7	11	8	**30**
19	Fluoride as F	mg/l	BDL	BDL	BDL	BDL	BDL	**1**
20	Nitrate as NO_3	mg/l	12	10	10	5	12	**45**
21	Sulphates as (SO_4)	mg/l	6.5	6.8	5.4	7.9	6.5	**200**
22	Iron (Fe)	mg/l	0.2	2	0.3	0.2	0.2	**0.3**
23	Total *Coliform* (MPN/100 ml)	MPN/100 ml	Absent	Absent	Absent	400	Absent	**Absent**

Note: <1 indicate No Colony developed in 1 ml. Sample
<10 indicate No Colony developed in 0.1 ml. Sample
<100 indicate No Colony developed in 0.01 ml. Sample

Source: JICA Study Team

4.2.3 Noise

Noise can be defined as an unwanted sound. It interferes with speech and hearing and if intense enough can damage hearing or is otherwise annoying. The definition of noise as unwanted sound implies that it has an adverse effect on human beings and their environment. Noise can also disturb natural wildlife and ecological system.

Ministry of Environment, Forest and Climate Change has notified the ambient standards in respect of noise and these standards are given in the table below. To understand the noise environment in the study area, a noise survey was conducted using Lutron SLM 4013. The sound levels in the study area are given in the tables below. The ambient standards in respect of noise both for Leq_{day} and Leq_{night} with respect to noise applicable for Commercial Area were considered in the present study since most of the start/end points of bypasses can be categorized as Commercial Area.

Table 4.28 Ambient Standard for Noise

Area Code	Category of Area	Leq. Limits in dB(A)	
		Day Time	Night Time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone	50	40

Note: 1. Day time is reckoned in between 6:00 a.m and 10:00 p.m. 2. Night time is reckoned is between 10:00 p.m and 6.00 a.m. 3. Silence Zone is defined as areas upto 100 m around such premises as hospitals, educational, institutions and Courts. The Silence Zones are to be declared by the competent authority.

Source: Pollution Control Acts, Rules and Notifications Issued Thereunder, Central Pollution Control Board, Delhi, May, 1998.

(i) Chhiathlang

In the dry season, the maximum Leq was 61.5 and minimum was 54.7 during day time. During night time the maximum and minimum Leq are 47.8 and 43.0 respectively. In the monsoon season, the maximum Leq was 63.2 and minimum was 55.3 during day time. During night time the maximum and minimum Leq are 47.2 and 42.9 respectively. In both seasons, the ambient sound levels are within the limits notified by Ministry of Environment, Forest and Climate Change.

Table 4.29 Noise Level in Chhiathlang in Dry Season

Sl. No.	Sampling Location	GPS Coordinates	Sampling Date	Ambient Noise Level Leq.dB(A)					
				Day Time (06:00AM to 10:00PM)			Night Time (10:00PM to 06:00AM)		
				L_{min}	L_{max}	L_{eq}	L_{min}	L_{max}	L_{eq}
1	CHHIATLANG 1, Tourist Lodge	N:23º23'41" E:92º50'53"	1/03/2016 to 2/03/2016	**50.3**	**65.4**	**61.5**	**35.5**	**48.9**	**44.2**
2	CHHIATLANG 2, Tetei's Tea Stall	N:23º22'53" E:92º50'40"	1/03/2016 to 2/03/2016	**51.8**	**68**	**61.4**	**40.8**	**47.8**	**45.4**
3	CHHIATLANG 1, Tourist Lodge	N:23º23'41" E:92º50'53"	2/03/2016 to 3/ 03/2016	**47.6**	**58.2**	**54.7**	**37.5**	**47.9**	**44.0**
4	CHHIATLANG 2, Tetei's Tea Stall	N:23º22'53" E:92º50'40"	2/03/2016 to 3/ 03/2016	**49.3**	**68**	**60.3**	**41.8**	**52.0**	**47.8**
5	CHHIATLANG 1, Tourist Lodge	N:23º23'41" E:92º50'53"	4/03/2016 to 5/03/2016	**45.8**	**58.5**	**55.9**	**38.8**	**46.0**	**43.0**
6	CHHIATLANG 2, Tetei's Tea Stall	N:23º22'53" E:92º50'40"	4/03/2016 to 5/03/2016	**47.2**	**64**	**58.7**	**40.9**	**51.7**	**46.8**
7	CHHIATLANG 1, Tourist Lodge	N:23º23'41" E:92º50'53"	5/03/2016 to 6/03/2016	**46.1**	**60.7**	**57.5**	**39.4**	**47.1**	**44.2**

8	CHHIATLANG 2, Tetei's Tea Stall	N:23º22'53" E:92º50'40"	5/03/2016 to 6/03/2016	**46.7**	**68**	**59.6**	**41.2**	**49.8**	**46.3**
			Minimum	**45.8**	**58.2**	**54.7**	**35.5**	**46.0**	**43.0**
			Maximum	**51.8**	**68.0**	**61.5**	**41.8**	**52.0**	**47.8**

Source: JICA Study Team

Table 4.30 Noise Level in Chhiathlang in Monsoon Season

Sl. No.	Sampling Location	GPS Coordinates	Sampling Date	Ambient Noise Level Leq.dB(A)					
				Day Time (06:00AM to 10:00PM)			Night Time (10:00PM to 06:00AM)		
				L_{min}	L_{max}	L_{eq}	L_{min}	L_{max}	L_{eq}
1	CHHIATLANG 1, Tourist Lodge	N:23º23'41" E:92º50'53"	16/05/2016 to 17/05/2016	**51.2**	**64.5**	**63.2**	**36.5**	**44.9**	**43.8**
2	CHHIATLANG 1, Tourist Lodge	N:23º23'41" E:92º50'53"	17/05/2016 to 18/05/2016	**48.2**	**56.5**	**55.3**	**38.6**	**46.2**	**45.1**
3	CHHIATLANG 1, Tourist Lodge	N:23º23'41" E:92º50'53"	19/05/2016 to 20/05/2013	**46.2**	**56.6**	**55.8**	**39.2**	**43.9**	**42.9**
4	CHHIATLANG 1, Tourist Lodge	N:23º23'41" E:92º50'53"	20/05/2016 to 21/05/2016	**47.5**	**61.2**	**58.3**	**39.3**	**44.9**	**43.1**
5	CHHIATLANG 2, Tetei's Tea Stall	N:23º22'53" E:92º50'40"	16/05/2016 to 17/05/2016	**52.9**	**62.5**	**60.3**	**37.2**	**45.9**	**44.4**
6	CHHIATLANG 2, Tetei's Tea Stall	N:23º22'53" E:92º50'40"	17/05/2016 to 18/05/2016	**48.9**	**60.1**	**58.6**	**38.8**	**47.1**	**43.3**
7	CHHIATLANG 2, Tetei's Tea Stall	N:23º22'53" E:92º50'40"	19/05/2016 to 20/05/2013	**47.6**	**60.9**	**58.1**	**41.5**	**45.4**	**43.9**
8	CHHIATLANG 2, Tetei's Tea Stall	N:23º22'53" E:92º50'40"	20/05/2016 to 21/05/2016	**47.2**	**60.2**	**58.3**	**40.3**	**47.5**	**47.2**
			Minimum	**46.2**	**56.5**	**55.3**	**36.5**	**43.9**	**42.9**
			Maximum	**52.9**	**64.5**	**63.2**	**41.5**	**47.5**	**47.2**

Source: JICA Study Team

(ii) Serchhip

In the dry season, the maximum Leq was 64.5 and minimum was 61.7 during day time, and the maximum and minimum Leq are 52.7 and 49.6 during night time. The ambient sound levels are within the limits notified by Ministry of Environment, Forest and Climate Change. In the monsoon season, the maximum Leq was 72.1 and minimum was 59.5 during day time. During night time the maximum and minimum Leq are 53.1 and 42.1 respectively. The sampling locations are in the commercial area with activity during the daytime so the ambient sound level are found to be higher.

Table 4.31 Noise Level in Serchhip in Dry Season

Sl. No.	Sampling Location	GPS Coordinates	Sampling Date	Ambient Noise Level Leq.dB(A)	
				Day Time (06:00AM to 10:00PM)	Night Time (10:00PM to 06:00AM)

				L_{min}	L_{max}	L_{eq}	L_{min}	L_{max}	L_{eq}
1	SERCHHIP 1, Aircel Mawiteii Store	N:23º20'51" E:92º50'58"	07/03/2016 to 08/03/2016	**54.6**	**65.7**	**62.2**	**42.3**	**53.7**	**49.6**
2	SERCHHIP 2, Hotel Zamela Rooftop	N:23º30'90" E:92º85'67"	07/03/2016 to 08/03/2016	**55.7**	**70.6**	**63.5**	**45.8**	**58.5**	**52.5**
3	SERCHHIP 3, Taj Mahal Hotel	N:23º17'24" E:92º51'41"	07/03/2016 to 08/03/2016	**53.5**	**68.6**	**62.2**	**46.5**	**58.5**	**52.5**
4	SERCHHIP 1, Aircel Mawiteii Store	N:23º20'51" E:92º50'58"	08/03/2016 to 09/03/2016	**53.4**	**66.5**	**61.7**	**44.2**	**53.7**	**50.4**
5	SERCHHIP 2, Hotel Zamela Rooftop	N:23º30'90" E:92º85'67"	08/03/2016 to 09/03/2016	**57.5**	**68.1**	**63.8**	**45.8**	**56.5**	**51.6**
6	SERCHHIP 3, Taj Mahal Hotel	N:23º17'24" E:92º51'41"	08/03/2016 to 09/03/2016	**55.7**	**71.6**	**63.0**	**47.2**	**54.5**	**51.1**
7	SERCHHIP 1, Aircel Mawiteii Store	N:23º20'51" E:92º50'58"	10/03/2016 to 11/03/2013	**54.5**	**68.5**	**61.9**	**44.6**	**54.1**	**51.1**
8	SERCHHIP 2, Hotel Zamela Rooftop	N:23º30'90" E:92º85'67"	10/03/2016 to 11/03/2013	**55.9**	**72.0**	**64.5**	**46.5**	**58.5**	**52.5**
9	SERCHHIP 3, Taj Mahal Hotel	N:23º17'24" E:92º51'41"	10/03/2016 to 11/03/2013	**57.3**	**69.6**	**62.9**	**46.5**	**58.5**	**52.5**
10	SERCHHIP 1, Aircel Mawiteii Store	N:23º20'51" E:92º50'58"	11/03/2016 to 12/03/2016	**55.2**	**70.5**	**62.6**	**46.2**	**56.1**	**52.2**
11	SERCHHIP 2, Hotel Zamela Rooftop	N:23º30'90" E:92º85'67"	11/03/2016 to 12/03/2016	**56.9**	**71.0**	**64.2**	**47.2**	**53.1**	**50.7**
12	SERCHHIP 3, Taj Mahal Hotel	N:23º17'24" E:92º51'41"	11/03/2016 to 12/03/2016	**58.1**	**68.6**	**62.7**	**49.3**	**55.8**	**52.7**
			Minimum	**53.4**	**65.7**	**61.7**	**42.3**	**53.1**	**49.6**
			Maximum	**58.1**	**72.0**	**64.5**	**49.3**	**58.5**	**52.7**

Source: JICA Study Team

Table 4.32 Noise Level in Serchhip in Monsoon Season

Sl. No.	Sampling Location	GPS Coordinates	Sampling Date	Ambient Noise Level Leq.dB(A)					
				Day Time (06:00AM to 10:00PM)			Night Time (10:00PM to 06:00AM)		
				L_{min}	L_{max}	L_{eq}	L_{min}	L_{max}	L_{eq}
1	SERCHHIP 1, Aircel Mawiteii Store	N:23º20'51" E:92º50'58"	16/05/2016 to 17/05/2016	**55.2**	**70.7**	**67.2**	**43.2**	**52.4**	**50.1**
2	SERCHHIP 1, Aircel Mawiteii Store	N:23º20'51" E:92º50'58"	17/05/2016 to 18/05/2016	**53.8**	**65.4**	**59.5**	**37.8**	**46.3**	**45.1**
3	SERCHHIP 1, Aircel Mawiteii Store	N:23º20'51" E:92º50'58"	19/05/2016 to 20/05/2013	**55.5**	**65.5**	**60.8**	**40.7**	**46.8**	**42.1**
4	SERCHHIP 1, Aircel	N:23º20'51" E:92º50'58"	20/05/2016 to 21/05/2016	**56.5**	**68.3**	**61.6**	**45.8**	**55.5**	**52.8**

	Mawiteii Store								
5	SERCHHIP 2, Hotel Zamela Rooftop	N:23º30'90" E:92º85'67"	16/05/2016 to 17/05/2016	**56.8**	**69.5**	**67.1**	**46.8**	**57.3**	**53.1**
6	SERCHHIP 2, Hotel Zamela Rooftop	N:23º30'90" E:92º85'67"	17/05/2016 to 18/05/2016	**58.2**	**66.5**	**60.2**	**46.3**	**57.2**	**52.7**
7	SERCHHIP 2, Hotel Zamela Rooftop	N:23º30'90" E:92º85'67"	19/05/2016 to 20/05/2013	**56.9**	**70.5**	**65.5**	**45.3**	**57.2**	**53.1**
8	SERCHHIP 2, Hotel Zamela Rooftop	N:23º30'90" E:92º85'67"	20/05/2016 to 21/05/2016	**55.8**	**70.2**	**60.5**	**46.5**	**53.4**	**51.4**
9	SERCHHIP 3, Taj Mahal Hotel	N:23º17'24" E:92º51'41"	16/05/2016 to 17/05/2016	**54.2**	**73.5**	**72.1**	**47.3**	**57.8**	**51.6**
10	SERCHHIP 3, Taj Mahal Hotel	N:23º17'24" E:92º51'41"	17/05/2016 to 18/05/2016	**54.5**	**68.5**	**67.1**	**46.5**	**55.5**	**52.3**
11	SERCHHIP 3, Taj Mahal Hotel	N:23º17'24" E:92º51'41"	19/05/2016 to 20/05/2013	**56.8**	**67.5**	**65.2**	**47.2**	**47.3**	**46.8**
12	SERCHHIP 3, Taj Mahal Hotel	N:23º17'24" E:92º51'41"	20/05/2016 to 21/05/2016	**57.8**	**67.6**	**64.5**	**42.9**	**44.7**	**45.3**
			Minimum	**53.8**	**65.4**	**59.5**	**37.8**	**44.7**	**42.1**
			Maximum	**58.2**	**73.5**	**72.1**	**47.3**	**57.8**	**53.1**

Source: JICA Study Team

(iii) Hnathial

In the dry season, the maximum Leq was 62.1 and minimum was 55.3 during day time. During night time the maximum and minimum Leq are 53.4 and 43.2 respectively. The ambient sound levels are within the limits notified by Ministry of Environment, Forest and Climate Change. In the monsoon season, the maximum Leq was 68.7 and minimum was 59.2 during day time. During night time the maximum and minimum Leq are 48.4 and 40.2 respectively. The sampling locations are in the commercial area with activity during the daytime so the ambient sound level are found to be higher.

Table 4.33 Noise Level in Hnathial in Dry Season

Sl. No.	Sampling Location	GPS Coordinates	Sampling Date	Ambient Noise Level Leq.dB(A)					
				Day Time (06:00AM to 10:00PM)			Night Time (10:00PM to 06:00AM)		
				L_{min}	L_{max}	L_{eq}	L_{min}	L_{max}	L_{eq}
1	HNAHTHIAL 1, Wayside Cottage	N:22º55 '51" E:92º55'33"	29/02/2016 & 01/03/2016	**42.5**	**62.4**	**55.3**	**34.6**	**51.0**	**46.0**
2	HNAHTHIAL 2, Samuel Tyre Works	N:22º58'45" E:92º55'19"	29/02/2016 & 01/03/2016	**40.2**	**70.2**	**59.6**	**32.5**	**53.0**	**46.0**
3	HNAHTHIAL 3, Peniel Veng	N:22º57'39" E:92º55'44"	29/02/2016 & 01/03/2016	**41.2**	**68.0**	**59.3**	**39.5**	**49.5**	**44.7**
4	HNAHTHIAL 1, Wayside Cottage	N:22º55 '51" E:92º55'33"	01/03/2016 & 02/03/2016	**44.0**	**65.0**	**57.5**	**32.0**	**46.5**	**43.2**
5	HNAHTHIAL	N:22º58'45"	01/03/2016 &	**40.6**	**71.2**	**61.9**	**34.6**	**56.3**	**49.7**

	2, Samuel Tyre Works	E:92º55'19"	02/03/2016						
6	HNAHTHIAL 3, Peniel Veng	N:22º57'39" E:92º55'44"	01/03/2016 & 02/03/2016	**42.6**	**70.2**	**61.7**	**30.2**	**54.5**	**46.6**
7	HNAHTHIAL 1, Wayside Cottage	N:22º55 '51" E:92º55'33"	03/03/2016 & 04/03/2016	**46.4**	**68.2**	**59.9**	**34.0**	**48.6**	**45.9**
8	HNAHTHIAL 2, Samuel Tyre Works	N:22º58'45" E:92º55'19"	03/03/2016 & 04/03/2016	**41.8**	**68.7**	**60.0**	**35.5**	**55.3**	**49.8**
9	HNAHTHIAL 3, Peniel Veng	N:22º57'39" E:92º55'44"	03/03/2016 & 04/03/2016	**43.1**	**69.2**	**61.5**	**31.6**	**55.5**	**47.4**
10	HNAHTHIAL 1, Wayside Cottage	N:22º55 '51" E:92º55'33"	04/03/2016 & 05/03/20	**45.2**	**67.0**	**58.9**	**35.0**	**49.6**	**45.1**
11	HNAHTHIAL 2, Samuel Tyre Works	N:22º58'45" E:92º55'19"	04/03/2016 & 05/03/20	**48.4**	**72.6**	**62.1**	**32.2**	**52.3**	**48.0**
12	HNAHTHIAL 3, Peniel Veng	N:22º57'39" E:92º55'44"	04/03/2016 & 05/03/20	**40.6**	**71.2**	**61.2**	**33.4**	**62.1**	**53.4**
			Minimum	**40.2**	**62.4**	**55.3**	**30.2**	**46.5**	**43.2**
			Maximum	**48.4**	**72.6**	**62.1**	**39.5**	**62.1**	**53.4**

Source: JICA Study Team

Table 4.34 Noise Level in Hnathial in Monsoon Season

Sl. No.	Sampling Location	GPS Coordinates	Sampling Date	Ambient Noise Level Leq.dB(A)					
				Day Time (06:00AM to 10:00PM)			Night Time (10:00PM to 06:00AM)		
				L_{min}	L_{max}	L_{eq}	L_{min}	L_{max}	L_{eq}
1	HNAHTHIAL 1, Wayside Cottage	N:22º55 '51" E:92º55'33"	23/05/2016 & 24/05/2016	**43.5**	**60.5**	**59.3**	**35.9**	**41.6**	**40.2**
2	HNAHTHIAL 1, Wayside Cottage	N:22º55 '51" E:92º55'33"	24/05/2016 & 25/05/2016	**45.2**	**62.3**	**61.4**	**32.5**	**47.2**	**44.6**
3	HNAHTHIAL 1, Wayside Cottage	N:22º55 '51" E:92º55'33"	26/05/2016 & 27/05/2016	**46.2**	**64.5**	**63.7**	**34.6**	**46.2**	**44.8**
4	HNAHTHIAL 1, Wayside Cottage	N:22º55 '51" E:92º55'33"	27/05/2016 & 28/02/2016	**44.6**	**64.6**	**63.9**	**35.4**	**47.7**	**44.5**
5	HNAHTHIAL 2, Samuel Tyre Works	N:22º58'45" E:92º55'19"	23/05/2016 & 24/05/2016	**41.8**	**70.3**	**68.7**	**34.3**	**41.4**	**40.4**
6	HNAHTHIAL 2, Samuel Tyre Works	N:22º58'45" E:92º55'19"	24/05/2016 & 25/05/2016	**42.5**	**65.8**	**63.4**	**35.2**	**48.2**	**47.4**
7	HNAHTHIAL 2, Samuel Tyre Works	N:22º58'45" E:92º55'19"	26/05/2016 & 27/05/2016	**42.8**	**66.5**	**63.2**	**36.4**	**48.5**	**47.2**
8	HNAHTHIAL 2, Samuel Tyre Works	N:22º58'45" E:92º55'19"	27/05/2016 & 28/02/2016	**49.3**	**68.5**	**59.5**	**33.2**	**53.1**	**47.6**

9	HNAHTHIAL 3, Peniel Veng	N:22º57'39" E:92º55'44"	23/05/2016 & 24/05/2016	**42.9**	**65.2**	**63.4**	**39.6**	**46.4**	**44.7**
10	HNAHTHIAL 3, Peniel Veng	N:22º57'39" E:92º55'44"	24/05/2016 & 25/05/2016	**43.5**	**65.3**	**59.2**	**32.5**	**52.3**	**48.4**
11	HNAHTHIAL 3, Peniel Veng	N:22º57'39" E:92º55'44"	26/05/2016 & 27/05/2016	**42.6**	**66.2**	**64.2**	**32.5**	**47.9**	**46.5**
12	HNAHTHIAL 3, Peniel Veng	N:22º57'39" E:92º55'44"	27/05/2016 & 28/02/2016	**41.5**	**68.3**	**67.2**	**33.5**	**48.5**	**46.5**
			Minimum	**41.5**	**60.5**	**59.2**	**32.5**	**41.4**	**40.2**
			Maximum	**49.3**	**70.3**	**68.7**	**39.6**	**53.1**	**48.4**

Source: JICA Study Team

(iv) Lawngtlai

In the dry season, the maximum Leq was 65.4 and minimum was 61.5 during day time, and the maximum and minimum Leq are 56.8 and 48.2 during night time. Since the study point (start and end point of the area) was near busy commercial area the ambient sound level are slightly higher at Lawngtlai 2 AOC Veng during daytime and night time. In the monsoon season, the maximum Leq was 68.4 and minimum was 56.3 during day time. During night time the maximum and minimum Leq are 54.5 and 43.4 respectively. Since the study point (start and end point of the area) was near busy commercial area the ambient sound level are slightly higher at Lawngtlai 2 AOC Veng during daytime and night time.

Table 4.35 Noise Level in Lawngtlai in Dry Season

Sl. No.	Sampling Location	GPS Coordinates	Sampling Date	Ambient Noise Level Leq.dB(A)					
				Day Time (06:00AM to 10:00PM)			Night Time (10:00PM to 06:00AM)		
				L_{min}	L_{max}	L_{eq}	L_{min}	L_{max}	L_{eq}
1	LAWNGTLAI 1, Lawngtlai Bazar	N:22º31'41" E:92º53'49"	22/02/2016 & 23/02/2016	**54.3**	**70.0**	**61.5**	**46.2**	**50.7**	**48.2**
2	LAWNGTLAI 2, AOC Veng	N:22º32'20" E:92º53'11"	22/02/2016 & 23/02/2016	**56.3**	**70**	**63.6**	**47.4**	**52.9**	**50.1**
3	LAWNGTLAI 1, Lawngtlai Bazar	N:22º31'41" E:92º53'49"	23/02/2016 & 24/02/2016	**54.7**	**72**	**64.0**	**48.9**	**56.0**	**52.4**
4	LAWNGTLAI 2, AOC Veng	N:22º32'20" E:92º53'11"	23/02/2016 & 24/02/2016	**60.1**	**72.6**	**65.4**	**49.1**	**55.8**	**52.4**
5	LAWNGTLAI 1, Lawngtlai Bazar	N:22º31'41" E:92º53'49"	25/02/2016 & 26/02/2016	**52.4**	**68.4**	**62.2**	**45.1**	**54.3**	**50.5**
6	LAWNGTLAI 2, AOC Veng	N:22º32'20" E:92º53'11"	25/02/2016 & 26/02/2016	**57.7**	**70**	**64.3**	**50.2**	**59.9**	**55.3**
7	LAWNGTLAI 1, Lawngtlai Bazar	N:22º31'41" E:92º53'49"	26/02/2016 & 27/02/2016	**53.6**	**72**	**64.8**	**50.3**	**56.7**	**54.1**

8	LAWNGTLAI 2, AOC Veng	N:22º32'20" E:92º53'11"	26/02/2016 & 27/02/2016	**59.4**	**66.9**	**64.0**	**51.7**	**61.4**	**56.8**
			Minimum	**52.4**	**66.9**	**61.5**	**45.1**	**50.7**	**48.2**
			Maximum	**60.1**	**72.6**	**65.4**	**51.7**	**61.4**	**56.8**

Source: JICA Study Team

Table 4.36 Noise Level in Lawngtlai in Monsoon Season

Sl. No.	Sampling Location	GPS Coordinates	Sampling Date	Ambient Noise Level Leq.dB(A)					
				Day Time (06:00AM to 10:00PM)			Night Time (10:00PM to 06:00AM)		
				L_{min}	L_{max}	L_{eq}	L_{min}	L_{max}	L_{eq}
1	LAWNGTLAI 1, Lawngtlai Bazar	N:22º31'41" E:92º53'49"	23/05/2016 & 24/05/2016	**54.1**	**60.4**	**56.3**	**45.2**	**50**	**47.2**
2	LAWNGTLAI 1, Lawngtlai Bazar	N:22º31'41" E:92º53'49"	24/05/2016 & 25/05/2016	**55.7**	**62.3**	**58.2**	**43.5**	**47.0**	**46.0**
3	LAWNGTLAI 1, Lawngtlai Bazar	N:22º31'41" E:92º53'49"	26/05/2016 & 27/05/2016	**54.3**	**62.1**	**58.1**	**40.3**	**47**	**48.5**
4	LAWNGTLAI 1, Lawngtlai Bazar	N:22º31'41" E:92º53'49"	27/05/2016 & 28/02/2016	**54.5**	**62.8**	**61.2**	**40.8**	**46**	**43.4**
5	LAWNGTLAI 2, AOC Veng	N:22º32'20" E:92º53'11"	23/05/2016 & 24/05/2016	**55.3**	**67.2**	**64.7**	**47.2**	**51**	**50.1**
6	LAWNGTLAI 2, AOC Veng	N:22º32'20" E:92º53'11"	24/05/2016 & 25/05/2016	**60.5**	**70.6**	**68.4**	**40.4**	**47**	**43.6**
7	LAWNGTLAI 2, AOC Veng	N:22º32'20" E:92º53'11"	26/05/2016 & 27/05/2016	**57.5**	**65.6**	**64.3**	**41.3**	**49**	**46.2**
8	LAWNGTLAI 2, AOC Veng	N:22º32'20" E:92º53'11"	27/05/2016 & 28/02/2016	**58.7**	**70.3**	**63.3**	**52.7**	**55**	**54.5**
			Minimum	**54.1**	**60.4**	**56.3**	**40.3**	**46.0**	**43.4**
			Maximum	**60.5**	**70.6**	**68.4**	**52.7**	**55.0**	**54.5**

Source: JICA Study Team

4.2.4 Vibration

Generally, ground-borne vibration from highway traffic is not an environmental concern unless there is a significant discontinuity in the road surface. Vehicles travel on properly maintained roadways does not generate vibration of concern. Because the net average of vibration signal is zero, the root mean square (rms) amplitude is used to describe the "smoothed" average vibration amplitude. Decibel notation is frequently used to compress the range of rms value used to describe vibration, and rms velocity values used in evaluating human responses are typically expressed in terms of the metric of VdB (velocity level in decibels) The term "VdB" is used to indicate velocity decibel values. The corresponding VdB values of in/sec (rms= root mean square) using a 0 VdB reference value of 1×10^{-6} cm/sec (rms) (equal to $.394 \times 10^{-6}$ in/sec (rms). When measuring vibration in velocity relative to a chosen reference level, use the term VdB.

$VdB=20\ Log_{10}(Vm/Vr)$
where:
Vm = measured vibration velocity
Vr = international reference 1×10^{-6} cm/sec (rms) or $.394 \times 10^{-6}$ in/sec(rms)
$=20*LOG_{10}(Vm/0.394*10^{-6})$
Reference 0 VdB = 0.394×10^{-4} in/sec (rms)
$= 1 X 10^{-6}$ cm sec (rms)

(i) Chhiathlang

Vibration survey was implemented at two points and the results of two seasons are as follows.

Table 4.37 Vibration Level in Chhiathlang in Dry Season

Sampling Station	Start Point E: $23^0$23'41", N: $92^0$50'53" 2 m (approx.) (From Edge of the Pavement)				End Point E:$23^0$22'42", N: $92^0$50'36" 1.5 m (approx.) (From Edge of the Pavement)			
Date of Sampling	01/03/2016 & 02/03/2016	02/03/2016 & 03/03/2016	04/03/2016 & 05/03/2016	05/03/2016 & 06/03/2016	01/03/2016 & 02/03/2016	02/03/2016 & 03/03/2016	04/03/2016 & 05/03/2016	05/03/2016 & 06/03/2016
Duration	Day Time 6hr – 22hr		Night Time 22hrs- 6 hrs		Day Time 6hr – 22hr		Night Time 22hrs- 6 hrs	
Unit	mm/sec (rms)	VdB	mm/sec (rms)	VdB	mm/sec (rms)	VdB	mm/sec (rms)	VdB
Maximum	1.95	106	1.5	104	1.98	106	1.50	104
Minimum	< 0.01	< 60	< 0.01	< 60	< 0.01	< 60	< 0.01	< 60

Source: JICA Study Team

Table 4.38 Vibration Level in Chhiathlang in Monsoon Season

Sampling Station	Start Point E: $23^0$23'41", N: $92^0$50'53" 2 m (approx.) (From Edge of the Pavement)				End Point E:$23^0$22'53", N: $92^0$50'38" 1.5 m (approx.) (From Edge of the Pavement)			
Date of Sampling	16/05/2016 & 17/05/2016	17/05/2016 & 18/05/2016	19/05/2016 & 20/05/2016	20/05/2016 & 21/05/2016	16/05/2016 & 17/05/2016	17/05/2016 & 18/05/2016	19/05/2016 & 20/05/2016	20/05/2016 & 21/05/2016
Duration	Day Time 6hr – 22hr		Night Time 22hrs- 6 hrs		Day Time 6hr – 22hr		Night Time 22hrs- 6 hrs	
Unit	mm/sec (rms)	VdB	mm/sec (rms)	VdB	mm/sec (rms)	VdB	mm/sec (rms)	VdB
Maximum	1.88	105	0.11	81	1.87	105	0.15	84
Minimum	< 0.01	< 60	< 0.01	< 60	< 0.01	< 60	< 0.01	< 60

Source: JICA Study Team

(ii) Serchhip

Vibration survey was implemented at two points and the results of two seasons are as follows.

Table 4.39 Vibration Level in Serchhip in Dry Season

Sampling Station	Start Point AircelMawiteii Store, New Serchhip	End Point Tajmahal Hotel, SailiamKawn, Serchip

	N:23^{0}20'51", E:92^{0}50'58" 1.5 m (approx.) (From Edge of the Pavement)				N:23^{0}17'24" E:92^{0}51'41" 1.5 m (approx.) (From Edge of the Pavement)			
Date of Sampling	07/03/2016 to 08/03/2016	08/03/2016 to 09/03/2016	10/03/2016 to 11/03/2016	11/03/2016 to 12/03/2016	07/03/2016 to 08/03/2016	08/03/2016 to 09/03/2016	10/03/2016 to 11/03/2016	11/03/2016 to 12/03/2016
Duration	Day Time 6hr – 22hr		Night Time 22hrs- 6 hrs		Day Time 6hr – 22hr		Night Time 22hrs- 6 hrs	
Unit	mm/sec (rms)	VdB	mm/sec (rms)	VdB	mm/sec (rms)	VdB	mm/sec (rms)	VdB
Maximum	2.35	107	0.02	66	1.98	106	0.02	66
Minimum	< 0.01	< 60	< 0.01	< 60	< 0.01	< 60	< 0.01	< 60

Source: JICA Study Team

Table 4.40 Vibration Level in Serchhip in Monsoon Season

Sampling Station	Start Point AircelMawiteii Store, New Serchhip N:23^{0}20'51", E:92^{0}50'58" 1.5 m (approx.) (From Edge of the Pavement)				End Point Tajmahal Hotel, SailiamKawn, Serchip N:23^{0}17'24" E:92^{0}51'41" 1.5 m (approx.) (From Edge of the Pavement)			
Date of Sampling	16/05/2016 & 17/05/2016	17/05/2016 & 18/05/2016	19/05/2016 & 20/05/2016	20/05/2016 & 21/05/2016	16/05/2016 & 17/05/2016	17/05/2016 & 18/05/2016	19/05/2016 & 20/05/2016	20/05/2016 & 21/05/2016
Duration	Day Time 6hr – 22hr		Night Time 22hrs- 6 hrs		Day Time 6hr – 22hr		Night Time 22hrs- 6 hrs	
Unit	mm/sec (rms)	VdB	mm/sec (rms)	VdB	mm/sec (rms)	VdB	mm/sec (rms)	VdB
Maximum	2.12	107	0.08	78	1.98	106	0.05	74
Minimum	< 0.01	< 60	< 0.01	< 60	< 0.01	< 60	< 0.01	< 60

Source: JICA Study Team

(iii) Hnathial

Vibration survey was implemented at two points and the results of two seasons are as follows.

Table 4.41 Vibration Level in Hnathial in Dry Season

Sampling Station	Start Point Wayside Cottage, Kutkawk, Hnahthial.. E:22^{0}58'45", N: 92^{0}55'18" 1.5 m (approx.) (From Edge of the Pavement)				End Point (Highway Inn Hnahthial) E:22^{0}55'50", N: 92^{0}55'33" 2 m (approx.) (From Edge of the Pavement)			
Date of Sampling	29/02/2016 & 01/03/2016	01/03/2016 & 02/03/2016	03/03/2016 & 04/03/2016	04/03/2016 & 05/03/2016	29/02/2016 & 01/03/2016	01/03/2016 & 02/03/2016	03/03/2016 & 04/03/2016	04/03/2016 & 05/03/2016
Duration	Day Time 6hr – 22hr		Night Time 22hrs- 6 hrs		Day Time 6hr – 22hr		Night Time 22hrs- 6 hrs	
Unit	mm/sec (rms)	VdB	mm/sec (rms)	VdB	mm/sec (rms)	VdB	mm/sec (rms)	VdB
Maximum	1.60	104	0.5	94	1.74	105	0.38	92
Minimum	< 0.01	< 60	< 0.01	< 60	< 0.01	< 60	< 0.01	< 60

Source: JICA Study Team

Table 4.42 Vibration Level in Hnathial in Monsoon Season

Sampling Station	Start Point Samuel Tyre Works, Electric Veng, Hnahthial N:22^{0}58'46", E:92^{0}55'19" 1.5 m (approx.) (From Edge of the Pavement)				End Point (Highway Inn Hnahthial) E:22^{0}55'50", N: 92^{0}55'33" 2 m (approx.) (From Edge of the Pavement)			
Date of Sampling	23/05/2016 & 24/05/2016	24/05/2016 & 25/05/2016	26/05/2016 & 27/05/2016	27/05/2016 & 28/05/2016	23/05/2016 & 24/05/2016	24/05/2016 & 25/05/2016	26/05/2016 & 27/05/2016	27/05/2016 & 28/05/2016
Duration	Day Time 6hr – 22hr		Night Time 22hrs- 6 hrs		Day Time 6hr – 22hr		Night Time 22hrs- 6 hrs	
Unit	mm/sec (rms)	VdB	mm/sec (rms)	VdB	mm/sec (rms)	VdB	mm/sec (rms)	VdB
Maximum	1.92	106	0.28	89	1.58	104	0.56	95
Minimum	< 0.01	< 60	< 0.01	< 60	< 0.01	< 60	< 0.01	< 60

Source: JICA Study Team

(iv) Lawngtlai

Vibration survey was implemented at two points and the results of two seasons are as follows.

Table 4.43 Noise Level in Lawngtlai in Dry Season

Sampling Station	Lawngtlai Bazar, E:22^{0}31'40", N: 92^{0}53'49" 1.5 m (approx.) (From Edge of the Pavement)				AOC Veng E:22^{0}32'19", N: 92^{0}53'11" 1.5 m (approx.) (From Edge of the Pavement)			
Date of Sampling	22/02/2016 & 23/02/2016	23/02/2016 to 24/02/2016	25/02/2016 to 26/02/2016	26/02/2016 to 27/02/2016	22/02/2016 & 23/02/2016	23/02/2016 to 24/02/2016	25/02/2016 to 26/02/2016	26/02/2016 to 27/02/2016
Duration	Day Time 6hr – 22hr		Night Time 22hrs- 6 hrs		Day Time 6hr – 22hr		Night Time 22hrs- 6 hrs	
Unit	mm/sec (rms)	VdB	mm/sec (rms)	VdB	mm/sec (rms)	VdB	mm/sec (rms)	VdB
Maximum	1.85	105	0.02	66	1.68	104	0.02	66
Minimum	< 0.01	< 60	< 0.01	< 60	< 0.01	< 60	< 0.01	< 60

Source: JICA Study Team

Table 4.44 Vibration Level in Lawngtlai in Monsoon Season

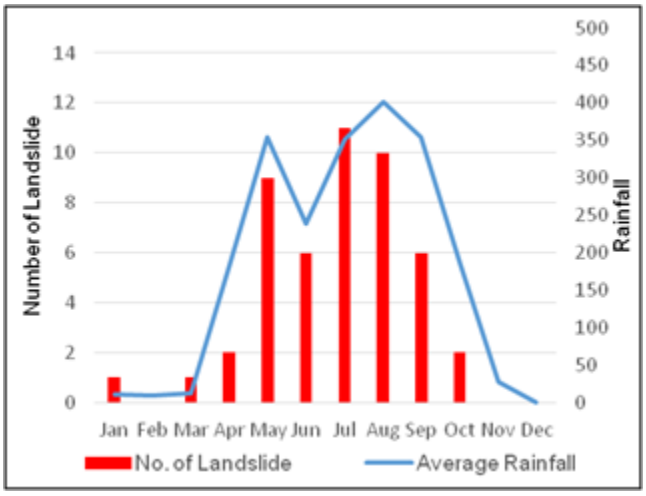
Sampling Station	AOC Veng E:22^{0}32'19", N: 92^{0}53'12" 1.5 m (approx.) (From Edge of the Pavement)				Lawngtlai Bazar, E:22^{0}31'41", N: 92^{0}53'50" 1.5 m (approx.) (From Edge of the Pavement)			
Date of Sampling	23/05/2016 & 24/05/2016	24/05/2016 & 25/05/2016	26/05/2016 & 27/05/2016	27/05/2016 & 28/05/2016	23/05/2016 & 24/05/2016	24/05/2016 & 25/05/2016	26/05/2016 & 27/05/2016	27/05/2016 & 28/05/2016
Duration	Day Time 6hr – 22hr		Night Time 22hrs- 6 hrs		Day Time 6hr – 22hr		Night Time 22hrs- 6 hrs	
Unit	mm/sec (rms)	VdB	mm/sec (rms)	VdB	mm/sec (rms)	VdB	mm/sec (rms)	VdB
Maximum	1.98	106	0.43	93	1.86	105	0.78	98
Minimum	< 0.01	< 60	< 0.01	< 60	< 0.01	< 60	< 0.01	< 60

Source: JICA Study Team

4.2.5 Hazards

With the inherently weak geology of fractured rock, the steep, unstable slopes are further weakened by water flows during monsoons and result in landslides. Deforestation due to felling of trees for timber, animal fodder and removal of vegetation for jhum cultivation are also contributing to soil erosions and destabilization of slopes.

In addition to the field identification of landslide, information on past landslide disaster in and around Mizoram states has been collected to ascertain the trend of natural hazard in area. The number of landslide reported in newspapers and academic paper from 1992 to 2015 is summarized in Figure below, which clearly indicates elevated risk of landslide in monsoon season. In September 2014, a large landslide occurred near PWD office at Laipuitang in Aizawl and killed 17 people and destroyed 15 structures including PWD office buildings. These disasters often cause severe disruption in the lifeline, which deprive the local population along NH54 of supply of essential commodities.



Source: JICA Study Team

Figure 4.9 Frequency of Landslide in Mizoram

In September 2014, a large landslide occurred near PWD office at Laipuitang in Aizawl and killed 17 people and destroyed 15 houses including PWD office buildings. As above, landslide has often occurred in this area and clearly tends to increase in monsoon season from May to September.

4.3 Socio-Economic Conditions

4.3.1 Mizo People

Mizoram name derived from Mi (Peoples), Zo (Hills) & Ram (Land) thus Mizoram implies '*land of the hilly peoples*'. The meaning itself shows social structure of the Mizoram state. The Mizos are broadly divided into 5 major tribes and 11 minor tribes. The 5 major tribes are Lushai, Ralte, Hmar, Paite and Pawi. Mizo is the official language and most widely used language for verbal interactions, but English being important for education, administration, formalities and governance, is also widely used. The Duhlian dialect, also known as the Lusei, was the first language of Mizoram and has come

to be known as Mizo language. All the tribes still have their own unique dialects which are slightly different from the dominant Mizo (Duhlian), but they can understand each other without problems. As per 2011 census, total population of Mizoram is 1,097,206. Out of these, the number of male and female are 555,339 and 541,867 respectively. The Lushai tribes constituted the majority of the Mizo population. Population density of Mizoram is 52 per km^2. The literacy rate in Mizoram is 91.3% as per 2011 census. District-wise and Tribe-wise population of Mizoram is shown below. Out of 8 districts, districts where four bypasses are located are highlighted in below table.

Table 4.45 District-wise Population and Literacy Rate

District	Population			Density (per Sq Km)	Sex Ratio	Literacy %
	Male	Female	Total			
Mamit	44,567	41,190	85,757	28	924	60
Kolasib	42,456	40,598	83,054	60	956	94.54
Aizawl	201,072	202,982	404,054	113	1009	98.50
Champhai	63,299	62,071	125,370	39	981	93.51
Serchhip	32,824	32,051	64,875	46	976	98.76
Lunglei	79,252	74,842	154,094	34	944	89.40
Lawngtlai	60,379	57,065	117,444	46	945	66.41
Saiha	28,490	27,876	56,366	40	978	88.41
Total	**552,339**	**538,675**	**1,091,014**	**52**	**875**	**91.85**

Source: 2011 Census

The population of four towns where the bypasses are located is shown below.

Table 4.46 Population of Bypass Areas

Town	No. of Household	No. of Population
Chhiathlang	815	4,071
Serchhip	4,085	21,158
Hnathial	1,548	7,187
Lawngtlai	3,910	20,830

Source: 2011 Census

The Mizo ancestors had no written language and the British missionaries, F.W. Savidge and J.H. Lorrain, created the Mizo alphabets based on the Roman scripts. The arrival of these two missionaries marked the formal origin of education in Mizoram. After only two and half months, Savidge started the first school on 1st April, 1894. They also prepared a Grammar and Dictionary of the Lushai language (Duhlian dialect) in 1898, which became the foundation of Mizo language. Today, Mizoram enjoys one of the highest rate of literacy in India, at 91.3%

The Mizo ancestors had no written language and were completely devoted to animism, worshipping all sorts of objects and natural phenomena. The British has to simply modernise them. The first missionary who came to Lushai hill was Rev. William Williams, a Welsh missionary for investigative visit for a week. On 11th January, 1894, F.W. Savidge and J.H. Lorrain arrived at Aizawl and this marked the origin of formal Christianity in Mizoram.

The majority of the Mizo people are Christian. The major Christian denominations are Presbyterian,

Baptist, United Pentecostal Church, Roman Catholic, the Salvation Army, Congregational Church of India (Maraland), Seventh-day Adventist, among others. There are other religions like Buddhism, Hinduism, Muslim and Sikh. There are few people who practice Judaism claiming to be one of the lost Judaic tribe group Bnei Menashe and a modernized traditional Mizo religion called Hnam sakhua, which put a particular emphasis on Mizo culture and seeks to revive traditional Mizo values. There are also few tribal religions such as Lalchhungkua, Lalhnam and Nunna Lalchhungkua.

The Mizo celebrate many festivals among which the Chapchar kut and the Pawl kut are the most important. Chapchar kut is celebrated in the month of March and it is a spring festival. Pawl kut is a harvest festival celebrated in the months of December and January. They also celebrated Mim kut in the month of September. This festival is for the dead members of the family and they used to prepare foods for them. The Mizo people celebrated the festivals with many dances among which Cheraw is the most colorful dance. All the festivals are connected with agricultural activities.

Table 4.47 Composition of Various Mizo Tribes in the State

Tribe	Number	Percentage (%)
Lushai	646,117	77
Chakma	71,283	8.5
Pawi	42,230	5
Lakher	36,018	4.3
Any Kuki tribes	21,040	2.5
Hmar	18,155	2.2

Source: 2001 Census[4]

4.3.2 Mizo Economy

As per the data available, the Net State Domestic Product (NSDP) for the year 2012-13 was about Rs 7,556 Crores, and the Per Capita Income (PCI) during the same period was Rs. 63,413. It has also been observed that during the period 2004-05 to 2012-13 the economy of the state grew at a compound annual growth rate of 9.3%, with Primary Sector growing at 7.6%, Secondary Sector at 7.9% and the Tertiary Sector at 10.3%. During the same period the per capita income of the state grew at 6.8%.

Table 4.48 Economic Growth of Mizoram

Sector	CAGR (2004-05 to 2012-13)
Agriculture & Allied – P (Primary Sector)	7.64%
Industry - S (Secondary Sector)	7.87%
Services – T (Tertiary Sector))	10.30%
NSDP (Net State Domestic Product)	9.30%
PCI (Per Capita Income)	6.77%

Note: CAGR – Compound Annual Growth Rate

[4] 2001 Census is the latest data available as per-tribe population data is not included in 2011 Census.

The main occupation of the people is agriculture. About 80% of the population are agriculturist. Rice is the main crop of Mizoram and besides rice, maize, potato, ginger, tumeric, black pepper, chilies and a variety of fruits are grown. In Mizoram, the ownership of land is vested with the government, which issues periodic pattas to individual cultivators. The Village Council distributes the plots of land among the villagers for cultivation every year. The agricultural system practiced is of the primitive type of 'jhum' or 'slash and burn', a practice that has been regarded as detrimental to the top layer of the soil, rendering it to become loose and soft and susceptible to frequent soil erosion. The government is attempting to bring about a change to the practice of 'jhum' by introducing 'terrace cultivation' which is ideal for the hill slope. The main horticulture crops are fruit crops like Mandarin orange, banana, passion fruit, grapes, hatkora, pineapple, papaya, etc. and flowers like anthurium, bird of paradise, orchid, rose and other subsidiary seasonal flowers. People have also started extensive cultivation of oil palm, medicinal and aromatic plants. Anthurium is being sent for sale to places to major cities like Kolkata, Delhi, Mumbai and Hyderabad. The arecanut fibre, which is plentiful in the state, is very good for making disposable plates and saucers.

CHAPTER 5 ANALYSIS OF ALTERNATIVES

5.1 Analysis of Alternative for Widening and Improvement of NH54

The analysis of alterntives has been carried out in two stages. First, alternatives for widening of NH54 between Aizawl and Tuipang was carried out during the feasibility study in Phase I. The scope for alternative was limited due to hilly nature of the terrain and the nature of the project, which essentially aims to improve and widen existing road. In developing a proposed preliminary road design, three concepts of alternatives have been as shown below.

Table 5.1 Concepts of Alternatives

No.	Option	Contents
0	Zero-Option (without project)	Existing road and slope conditions will persist. Poor pavement condition will lead to more vehicular emissions with detrimental impacts on health and ecosystem. Also, continuation of uncontrolled encroachment will increase the risk of traffic accident in built-up areas. Poor road network continues to be a bottleneck of economic development and also undermine positive benefits of ongoing Kaladan Multimodal Transport Project, which provides additional network from Mizoram to Haldia/Kolkata ports through NH54 and Kaladan River in Myanmar.
1	Applying the same design standard across the whole stretch based on the IRC	The same standard for widening/improvement will be applied across the whole stretch irrespective to geological condition and socio-economic conditions. While the positive impact of widening is significant, the project will trigger significantly more resettlement compared with option 2. Also, geometric improvement of many hair-pin curves will trigger more cutting and filling, increasing impacts on forest and leads to higher project implementation cost. The number of traffic accident will also increase due to the increased speed of vehicles passing through built-up areas.
2	Selective widening considering social impacts	The level of widening will be minimized in heavily built-up area to reduce the scale of resettlement. This option is desirable from socio-economic point of view, but the positive impact in terms of improvement of the road network in the region may be slightly limited compared with option 1.
3	New bypass to avoid densely built-up areas	A new bypass will be constructed in densely built-up areas to avoid resettlement. The option will minimize the scale of resettlement, but the impact on forest and agricultural land (jhum) will be significant as the new road will be constructed in open forest. The bypass will be required in the longer-term to accommodate project increase in traffic demand in the future, but its environmental impact as well as economic feasibility will have to be studied in more details.

Source: JICA Study Team

The illustrative images of widening concepts are shown below.

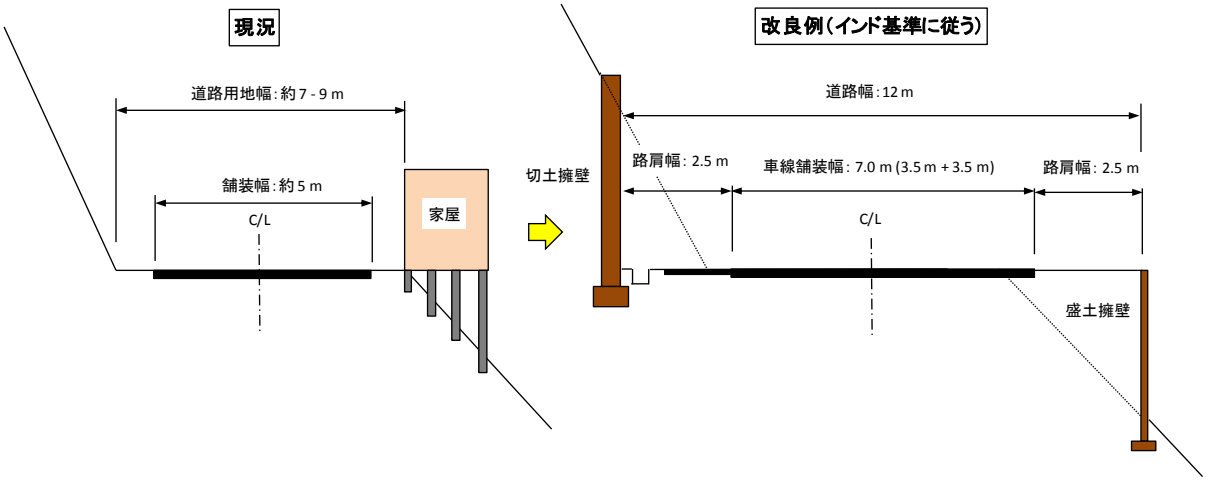


Figure 5.1 Alternative One (Widening based on IRC Standard)

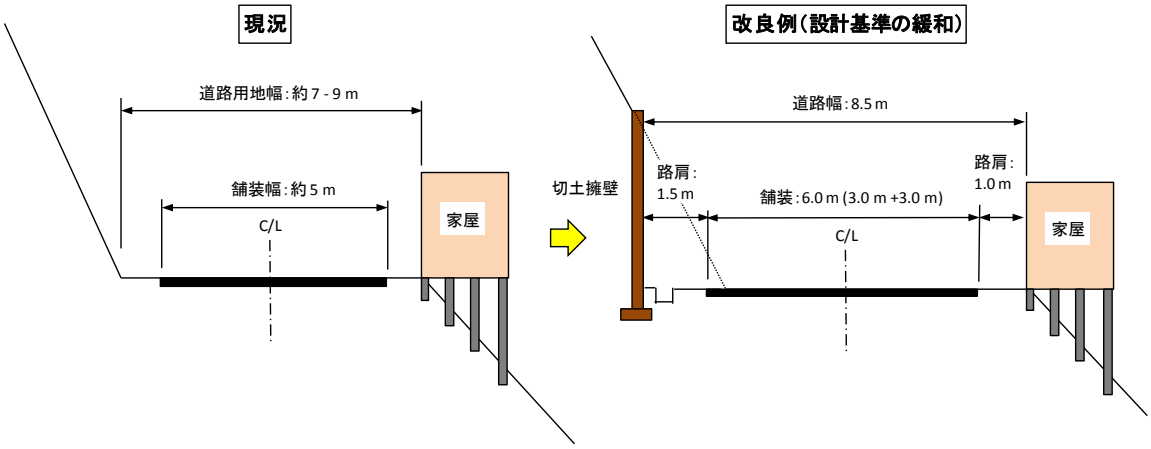


Figure 5.2 Alternative Two (Limited Widening)

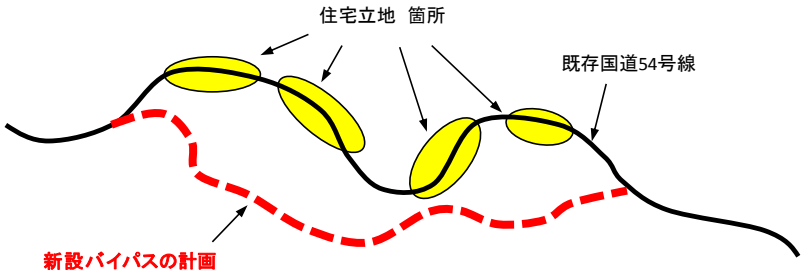


Figure 5.3 Alternative Three (New Bypass)

A comparison of three options is provided in below.

Table 5.2 Review of Alternatives

Alternative	Zero Option	One	Two	Three
General Objective	No project. Continue business as usual without intervention.	Follow Indian standard and ensure road capacity will be sufficient over the long-run	Minimize the scale of resettlement	Avoid resettlement
Resettlement	N/A	× Trigger significant resettlement. Preliminary assessment suggests that expansion beyond 15m can result in resettlement of more than 5,000 households.	△ ROW 12m will be adopted in general, except for hair pin curves. Impact will be reduced compared with Option One. 1,937 households will be affected in total.	◎ Minimum impact (some 200 households to be relocated)
Impact on natural environment	△ No immediate impact, but slope failure and soil erosion without proper management will eventually degrade natural environment	◎ Limited impact as the engineering work will be limited in the side of existing road	◎ Limited impact as the engineering work will be limited in the side of existing road	× A more detailed analysis is needed to assess potential impact for new bypass to be constructed in open forest
Social Impact	△ No immediate impact, but frequent slope failure and landslide will hamper the movement of goods and people along NH54.	○ Widening will create a positive impact but greater traffic volume in major towns/villages result in traffic jams, which may offset some positive impacts.	○ Widening will create a positive impact but greater traffic volume in major towns/villages result in traffic jams, which may offset some positive impacts.	◎ The positive impact will be biggest as the road is widened without causing traffic jam in major towns.
Pollution	× No immediate impact, but poor road and growing level of congestion will lead to elevated pollution level in the long-run, particularly in	△ The option leads to least level of congestion and thus least to relatively small increase in vehicular emissions.	△ More congestion will be expected compared with option one, but still leads to better situation compared with without project scenario.	◎ Traffic will not pass through densely built up area and thus the health impact associated with greater vehicular emission

Alternative	Zero Option	One	Two	Three
	built-up area			will be minimized.
Traffic Safety	× Likely to deteriorate further as no safety measures will be implemented.	○ Proper safety measures inc. traffic signs will be required as the speed of vehicles passing through built-up area is likely to increase.	○ Proper safety measures inc. traffic signs will be required as the speed of vehicles passing through built-up area is likely to increase.	◎ The traffic does not pass through densely built-up area and thus the risk of accident will be reduced.
Construction cost	N/A	△ Require significant cost associated with land acquisition and resettlement.	◎ The cost associated with land acquisition and resettlement will be less than option one.	× While the cost associated with resettlement will be least among three options, cost of constructing new bypass will be significant.
Overall Evaluation (Ranking in bracket)	**4**	**3**	**1**	**2**
	Given the vulnerability of existing road against landslide and the importance as the key infrastructure in the state, it is not recommended to keep the condition as it is.	The option will trigger significant resettlement. Given the limited availability of open and flat land, preparation of new resettlement site will be necessary.	The scale of widening is compromised in some areas, but this level of widening will be sufficient for caring existing and projected traffic volume in mid-terms.	The scale of resettlement will be minimum, but the high cost associated with bypass construction will undermine economic viability of the project.

Note: ◎: most desirable, best among the option; ○: desirable but better option is available; △: other option is preferable; × should be avoided

Source: JICA Study Team

Option two has been identified as the most viable option for this project. However, considerable expectation for new bypasses has been observed during consultation meetings, particularly from residents in large village in which widening is likely to trigger significant resettlement. After a review of likely resettlement impact, future traffic volume and economic viability of the project in the long-term, and feasibility from engineering g point of view, four major villages with over 4,000 population, namely: Chhiahtlang, Serchhip, Hnathial and Lawngtlai, have been selected for bypass construction.

5.2 Analysis of Alternative for NH54 Bypasses

The scope of bypasses in the DPR was not clearly mentioned. The alignments of the four bypasses in DPR were given tentatively without much description of profile and detailed cross sections, especially for Chhiahtlang and Serchhip Bypasses. Therefore, JICA Study Team conducted Alternative Route Study for these four bypasses before conducting detailed topographic survey for preliminary design. Based on the results of the Alternative Route Study, which included detailed examination of the routes on site by the team members, optimum route for each bypass is established.

5.2.1 Data Used and Site Investigation

Wide area satellite images were used to produce digital terrain model with detailed contour lines by photogrammetry along all four bypass routes. At least two alternate horizontal alignments were designed based on the produced contour maps. All the data were created in the same coordinate system of WGS-84 (World Geodetic System) with UTM (Universal Transverse Mercator) Zone of 46N (93degree E) for this reason.

Site investigations were carried out by 9 members of JICA Study Team to confirm design controls and other site conditions along the route corridor by walking along the proposed routes of all four bypasses. All the sections of bypasses were not accessible, but it was investigated from as close location as possible. The proposed alternative routes were investigation based on the handheld GPS for verification of correct location at site. A series of geo-tagged photographs along the routes were also recorded for verification of control points later during detailed analysis.

5.2.2 Major Features of Alternatives of Four Bypasses

Major general features of the alternatives in each bypass are summarized below.

Table 5.3 Major Features of Alternatives of Four Bypasses

No.	Name	Alternative Routes		
		Route	Length (km)	Major Features
1	Chhiahtlang Bypass	Alternate-1 (DPR)	2.584	Houses on valley side near end of bypass

		Alternate-2	2.578	Houses on hill side near end of bypass
2	Serchhip Bypass	Alternate-1 (DPR)	12.422	Follow lower side of hill, but relatively steep terrain. Straight alignment of the bridge near end section (longest bridge length at this location)
		Alternate-2	11.629	Follow upper side of hill than Alternative-1, which is relatively gentle. Straight alignment of the bridge near end section (moderate bridge length at this location)
		Alternate-3	11.708	Follow upper side of hill than Alternative-1, which is relatively gentle. Straight alignment of bridge near end section (shortest bridge length at this location) but longer approach to reduce bridge length
		Alternate-4	12.164	Follow upper side of hill than Alternative-1, which is relatively gentle. Curve bridge alignment to reduce bridge cost but end approach pass through difficult terrain condition.
3	Hnathial Bypass	Alternate-1 (DPR)	6.799	Follow upper side of hill but affects lots of houses
		Alternate-2	6.974	Follow lower side of hill to avoid houses
4	Lawngtlai Bypass	Alternate-1 (DPR)	1.870	Follow lower side of hill but passes through middle of landslide area
		Alternate-2	2.110	Follow upper side of hill avoiding landslide from upper side

Source: JICA Study Team

5.2.3 Alternatives and Control Points in Bypass-1 (Chhiahtlang Bypass)

Basically, the alignment is same as that of the DPR except for the short end section. Minor modifications were done to follow the contours. Major control points in this bypass are as follows;

1. Large cemetery area near Km0+200

   The DPR alignment passes along the existing road near the cemetery area at Km0+200. In order to pass the bypass route below the cemetery area, alternative to start the bypass alignment about 200m ahead was also checked. But the topographic condition was found to be very steep and this alternative was abandoned.

2. Large cemetery area near Km2+100

   Another large cemetery area exists near Km2+100, where another existing road passes from the left of the cemetery. In order to avoid the cemetery area completely, relatively large hill cutting will be required on the left side, but there is no problem of slope stability.

3. Houses on both side of existing road at end section

   The bypass alignment ends utilizing the existing road at this section where houses exist on both sides of the existing road. Two alternatives, one passing from the hill side (Alternative-1) and the other passing from the valley side (Alternative-2) are considered to check the number of houses affected in each alternative. Widening of valley side only (Alternative 2) will result in resettlement of 19 households while widening of both sides are likely to result in resettlement of over 35 households. For other bypasses, no significant differences have been identified in terms of involuntary resettlement.

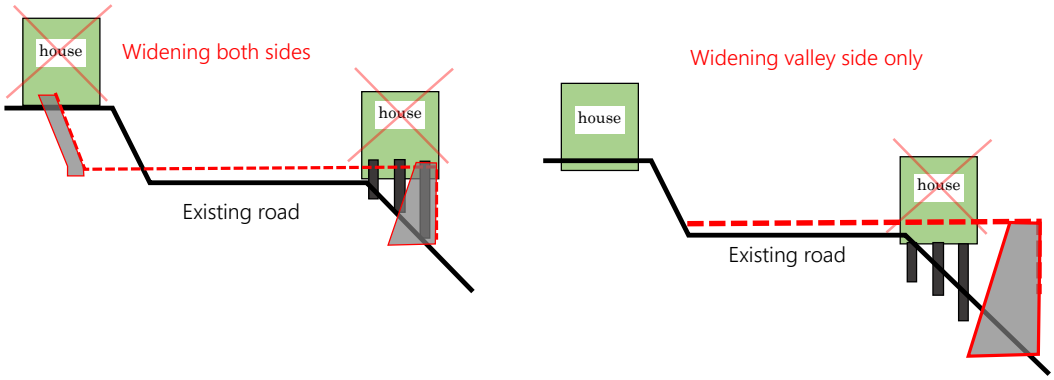


Figure 5.4 Comparison of Community Road Widening Option

In order to avoid the houses in this stretch, another alternative was also checked at site such that the end of the bypass is extended for about 400m further south. But there exists large slope failure area and many houses are also located below the existing NH54, which will require relocation otherwise. Therefore, the alternative to extend the end point of the bypass was abandoned.

Table 5.4 Control Points in Bypass-1

Control Point	Site Photo
1. Large cemetery area near Km0+200	

Control Point	Site Photo
2. Large cemetery area near Km2+100	
3. Houses on both side of existing road at end section	

Source: JICA Study Team

5.2.4 Alternatives and Control Points in Bypass-2 (Serchhip Bypass)

Four alternative routes were considered for this. The initial section from Km0+000 to about Km9+700 has basically two alternatives. Alternative-1 (DPR alignment) passes through relatively lower side of the hill, but the slope condition is very steep at several locations. All other alternatives in this section have a common alignment which passes through relatively upper side of the hill with gentle slope conditions. The end section after Km9+700 has four alternatives based on the location of the bridge crossing near Km10+500.

Three alternatives, Alternative-1, 2 and 3 pass the river at almost same location with a straight bridge alignment. Alternative-1 (DPR alignment) crosses the river at relatively higher elevation and hence the length of the bridge is longest for this alternative. Alternative-2 crosses the river at moderate elevation and the length of the bridge is also moderate among the three alternatives. The end approach section for this alternative has better alignment than other two alternatives. Alternative-3 is also basically similar to Alternative-2, but the bridge crossing was targeted at relatively lower elevation to reduce the length of the bridge as far as possible. But this resulted in higher length of end approach section and the alignment

has more curvatures than Alternative 1 and 2.

The last alternative, Alternative-4 was studied to select different location of river crossing to further reduce the total length of the bridge and to construct the superstructure of the bridge at lower elevation with direct support system, which would result in lower bridge cost. The end approach section passes through the other side of the hill, which has very steep topographic conditions with several steep stream crossings. The end approach alignment is also poor and longest compared to all other alternatives.

In the DPR, the alignment was not modified to fine tune with the terrain, therefore, a large quantities of earthwork is resulted.

The major control points identified during site investigation are listed below.

Table 5.5 Major Control Points in Alternatives of Bypass-2

S.N.	Control Points	Description	Remarks
1	CP1	Saddle point on the hill	DPR alignment causes large cutting depth
2	CP2	Bridge in DPR	Avoided in Alternative-2, 3, 4
3	CP3	Steep slope in DPR	Steep slope in DPR is avoided by passing through CP4
4	CP4	Gentle slope in Alternative-2, 3, 4	
5	CP5	DPR alignment crossing Monument	Avoided in Alternative-2, 3, 4
6	CP6	Steep slope in DPR	Steep slope in DPR is avoided by passing through CP7
7	CP7	Gentle slope in Alternative-2, 3,4	
8	CP8	Steep slope in DPR	Steep slope in DPR is avoided by passing through CP9
9	CP9	Gentle slope in Alternative-2,3,4	
10	CP10	Bridge location in Alternative 1,2,3	Straight, but longer bridge
11	CP11	Alternative bridge location in Alternative-4	Lower bridge at curve
12	CP12	Houses affected by Alternative-4	Avoided in Alternative-2, 3, 4

Source: JICA Study Team

Table 5.6 Control Points in Bypass-2

Control Point	Site Photo
CP1	

Control Point	Site Photo
CP2	
CP3/CP4	
CP5	

Control Point	Site Photo
CP6	
CP7	
CP8/CP9	

Control Point	Site Photo
CP10	
CP11	
CP12	

Source: JICA Study Team

5.2.5 Alternatives and Control Points in Bypass-3 (Hnathial Bypass)

Two alternative routes were studied for this bypass. Alternative-1 (DPR alignment) passes relatively along upper side of the hill, closer to the exiting NH54. Therefore, this alternative requires relocation of

a large number of houses and a football ground. Therefore, another alternative was studied, which passes relatively lower side of the hill avoiding houses and the football ground.

In addition, the DPR alignment was not modified to fine tune with the terrain, therefore, a large quantities of earthwork is resulted. The major control points identified during site investigation are as listed below.

Table 5.7 Major Control Points in Alternatives of Bypass-3

S.N.	Control Points	Description	Remarks
1	CP1	Houses affected in DPR	Avoided by alignment of Alternative-2
2	CP2	Houses affected in DPR	
3	CP3	Houses affected in DPR	
4	CP4	Houses affected in DPR	
5	CP5	Houses affected in DPR	
6	CP6	Football ground affected in DPR	
7	CP7	Excessive hill cutting	Excessive cutting due to straight alignment in DPR is avoided in Alternative-2 by applying curves with permissible radii

Source: JICA Study Team

Table 5.8 Control Points in Bypass-3

Control Point	Site Photo
CP1	

Control Point	Site Photo
CP2	
CP3	
CP4	

Control Point	Site Photo
CP5	
CP6	
CP7	

Source: JICA Study Team

5.2.6 Alternatives and Control Points in Bypass-4 (Lawngtlai Bypass Link)

Two alternative routes were studied for this bypass. The Lawngtlai Bypass would include a part of

Kaladan Multi-Modal road in the initial section, which will not connect with NH54 in the south. Therefore, a link road is designed to connect from the Kaladan Multi-Modal road to the existing NH54 after the Lawngtali town so that it would serve as Lawngtlai Bypass for the traffic along NH54.

Major control point in this bypass is that Alternative-1 (DPR alignment) passes through the middle of landslide area around Km1+100. Therefore, another alternative was studied so that it would pass through top avoiding the landslide area. In order to pass the alignment above the landslide area, yet maintaining the maximum vertical gradient of 7%, the alignment of Alternative-2 needs to start about 250m prior to the starting point of Alternative-1, making it longer in length.

Table 5.9 Control Points in Bypass-4

Control Point	Site Photo
landslide area around Km1+100	

Source: JICA Study Team

5.3 Results of Alternative Analysis

Alternative analysis was conducted to find the optimum route for each bypass with the following conditions:

1. The base case with Alternative-0 is also studied with the condition that the existing NH54 for the studied stretches are widened to 12m without bypass.
2. Geometric data of the alternative alignment (horizontal and vertical), environmental factors, spoil volume, houses to be compensated and total construction cost were used for the analysis.
3. In the analysis of Bypass-4 (Lawngtlai Bypass link), the base case of Alternative-0 is considered with the total length from where the Kaladan Multi-Modal Road starts before Lawngtlai town to the end of Bypass-4. Therefore, in Alternative-1 and Alternative-2, the total construction cost is inclusive of 4.4km of construction cost for the initial section of Kaladan Multi-Modal Road with assumed average cost of Rs.10 crore/km.

The results with ranking on each item and overall ranking is given below.

Table 5.10 Summary Results of Alternative Analysis

Bypass No.	Bypass Name	Items for Analysis	Ranking for each Alternative				
			Alternate-0	Alternate-1	Alternate-2	Alternate-3	Alternate-4
1	Chhiahtlang Bypass	Geometry	3	1	1	--	--
		Spoil volume	1	3	2	--	--
		House compensation	3	1	1	--	--
		Construction cost	1	2	3	--	--
		OVERALL RANKING	**3**	**2**	**1**	--	--
2	Serchhip Bypass	Geometry	4	5	1	2	3
		Spoil volume	1	5	1	1	1
		House compensation	5	1	1	1	1
		Construction cost	1	5	2	4	3
		OVERALL RANKING	**5**	**4**	**1**	**2**	**3**
3	Hnathial Bypass	Geometry	3	1	2	--	--
		Spoil volume	1	3	1	--	--
		House compensation	3	2	1	--	--
		Construction cost	1	3	2	--	--
		OVERALL RANKING	**3**	**2**	**1**	--	--
4	Lawngtlai Bypass	Geometry	3	2	1	--	--
		Spoil volume	1	3	1	--	--
		House compensation	3	2	1	--	--
		Construction cost	1	3	2	--	--
		OVERALL RANKING	**3**	**2**	**1**	--	--

The highlighted cells are for the Optimum Route, which is Alternative-2 for each bypass.
Source: JICA Study Team

Based on the results of the alternative analysis the conclusions are made as shown below.

Table 5.11 Conclusions from Alternative Analysis

No.	Bypass Name	Route	Length (km)	Conclusion
1	Chhiahtlang Bypass	Alternate-0	2.200	Though Alternative-2 is ranked 1st in the analysis, both alternative routes are basically similar except the end section. Therefore, it will be further studied after detailed topographic survey results are available.
		Alternate-1	2.584	
		Alternate-2	2.578	
2	Serchhip Bypass	Alternate-0	9.700	Alternative-2 is selected as optimum route due to better alignment, less spoil volume and compensation of houses and least cost among 4 alternatives.
		Alternate-1	12.422	
		Alternate-2	11.629	
		Alternate-3	11.708	
		Alternate-4	12.164	
3	Hnathial Bypass	Alternate-0	10.000	Alternative-2 is selected as optimum route due to less spoil volume, compensation of houses and construction cost.
		Alternate-1	6.799	
		Alternate-2	6.794	
4	Lawngtlai Bypass	Alternate-0	5.800	Alternative-2 is selected as optimum route due to better alignment, less spoil volume, compensation of houses and construction cost.
		Alternate-1	6.270	
		Alternate-2	6.100	

Source: JICA Study Team

CHAPTER 6 SCOPING

6.1 Procedure of Scoping

In order to assess the likely significant environmental and social impacts, potential environmental and social impacts of the project were preliminary identified based on the project description and overall environmental and social conditions in and around project area. The preliminary assessment also builds on the feasibility study of widening of NH54 between Aizawl and Tuipang, which was carried out in 2015. The impacts of pollution, natural environment and social environment, health and safety, emergency risk, and others were classified as A to D in accordance with the following criteria, assuming no specific measures toward the impacts are taken:

A-: Significant negative impact A+: Significant positive impact

B-: Some negative impact B+: Some positive impact

C: Impacts are not clear, need more investigation

D: No impact or impacts are negligible, no further study required

6.2 Results of Scoping

Results of the scoping for environmental and social impact assessment are shown in Table 6.1. Scoping was conducted toward the construction of four bypasses. A separate description is added where likely environmental and social impact are considerably different across different bypasses. The positive and negative impacts associated with the proposed project vary temporally and therefore, impacts were evaluated for three different stages, which are: pre-construction; construction; and operation. In the table below, they are referred to as P, C and O respectively.

Table 6.1 Scoping Matrix for NH54 Bypass Construction

Sl.	Item	Scoping Result			Rational of Assessment
		P	C	O	
Natural Environment					
1.1	Climate/ Meteorological Phenomena	D	D	D	P: No impact is expected as no engineering work is carried out at this stage.
					C/O: The impacts on micro-climate and micro meteorological phenomena are negligible because the project-related structures will not disturb wind path.
1.2	Topography	D	A-	D	P: No impact is expected as no engineering work is carried out at this stage.
					C: Changes in topographic conditions are expected due to the requirement of cutting filling work. Balancing the volume of cutting and filling is recommended to minimize the volume of spoil soil.
					O: Topographic condition will be stable after the completion of construction work which include slope protection and slope stabilization.
1.3	Geology	D	D	D	P/C/O: No impact is expected as the project does not alter geological condition of the area.

1.4	Soil Erosion	D	A-	B+/B-	P: No impact is expected as no engineering work is carried out at this stage.
					C: Soil erosion is expected particularly during the monsoon period. Construction work should avoid the monsoon period.
					O: Poor condition of drainage causes soil erosion in existing road. The project is expected to improve the condition and thus reduce the risk of soil erosion, but measures for slope protection and stabilization and prevent soil erosion, particularly during the monsoon period, must be in place and regularly monitored.
1.5	Hydrology	D	B-	B-	P: No impact is expected as no engineering work is carried out at this stage.
					C: Construction work may cause minor, temporary impacts on hydrology.
					O: Cutting and/or filling may result in changes in local hydrology. New drainage and culvert will be installed, taking into account the likely water flow in the area.
1.6	Groundwater	D	D	D	P: No impact is expected as no engineering work is carried out at this stage.
					C: The project does not envision the use of groundwater and thus no impact is expected.
					O: No impact is expected during the operation stage.
1.7	Ecosystem, Flora, Fauna and Biodiversity, Forest	D	A-	B-	P: No impact is expected. No unique/endangered species have been identified during assessment.
					C: The project will not affect pristine ecosystem as the work will be carried out along the existing road. However, construction work will affect mountain ecosystem and local flora and fauna including jhum and plantation.
					O: Increases in traffic volume will have negative impact ecosystem and flora and fauna along the road.
1.8	Protected Areas	C	C	C	P/C: The bypasses do not traverse or border with national parks or protected forest. Meanwhile, potential indirect impacts on nearby protected area will need to be assessed continuously.
					O: Increases in emissions due to greater traffic volume will negatively affect forest and surrounding ecosystem. Monitoring shall be carried out to check the impact of increased emissions on forest/plantation and measures (e.g. additional plantation) shall be undertaken to mitigate negative impacts as necessary.
1.9	Coastal Zone	D	D	D	P/C/O: No impacts are expected, because the alignment is far away from the coastal zone and the planned alignment will not pass the tidelands and the mangrove forests which are peculiar to the coastal region.
1.10	Landscape	D	D	D	P: No impact is expected since the project at this stage does not alter existing condition.
					C: Changes in landscape during the construction work will be minor and temporary.
					O: Improved road network facilitates access to scenic places and tourist attractions, thereby positively contributing tourism in the region.
1.11	Natural Disaster	D	B-	B-	P: No impact is expected since the project at this stage does not alter existing condition.
					C: Many areas of the road are prone to landslide and thus appropriate measures should be in place during the construction work to avoid accidents. Construction during the monsoon period is risky and should be avoided.

					O: Slope protection/stabilization measures and drainage are expected to significantly reduce the risk of natural disaster.
Living Environment (Pollution Control)					
2.1	Air Pollution	D	B-	B-	P: No impact is expected since the project at this stage does not alter existing condition.
					C: Some negative impacts are expected due to operation of construction equipment and vehicles. One of these is the dust incidental to earthwork especially during the dry season.
					O: Air pollution is expected to increase due to increase traffic volume on the road. Relevant data (e.g. actual/projected traffic volume) shall be shared with relevant State authority so that mitigation measures can be developed.
2.2	Offensive Odor	D	D	D	P/C/O: No impact is expected as the project does not involve the use of chemical and other materials that may cause offensive odor.
2.3	Water Pollution	D	B-	B-	P: No impact is expected since the project at this stage does not alter existing condition.
					C: Turbid water due to the earthworks 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 Contamination	D	D	D	P/C: No impact is expected.
					O: Some wastewater will be generated from maintenance activities along the road, the impacts on bottom sediment from the wastewater will be negligible.
2.5	Soil Contamination	D	D	D	P: No impact is expected as no engineering activity will be carried out at this stage
					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 except for the risk of accidental spillage of oil and lubricant, which will be managed by proper safety measures.
2.6	Ground Subsidence	D	D	D	P/C/O: No impact is expected
2.7	Noise/ Vibration	D	B-	B-	P: No impact is expected.
					C: Noise and vibration are generated by 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 in part 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/C/O: No impact is expected.
2.9	Wastes/Hazardous Materials	D	B-	B-	P: No impact is expected.
					C: Waste from construction workers' camps are expected to be generated. 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: Bypass construction is likely to result in involuntary resettlement of 20 households, majority of which will take place in BP1. Minimizing the resettlement should be the priority for road design.
					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-	D	P: Land acquisition and involuntary resettlement are likely to cause changes in existing land use pattern.
					C: The project will be carried out along the existing road, and as such, changes in land use associated with construction work are relatively minor, and land clearance for construction yards and workers' camps is temporary.
					No impact is expected as sufficient slope protection/ stabilization measures to protect land use.
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 obstruct there utilization by the local people for other purposes.
					O: No impact is expected as use of local resources is not expected during operation.
3.4	General, Regional /City Plans	D	D	D	P: No impact is expected.
					C: No impact is expected.
					O: Better infrastructure network may trigger influx of outsiders and economic development in the region.
3.5	Social Institutions and Local Decision-making Institutions	D	D	D	P/C/O: No impact is expected as there will be no change in social institutions and local decision-making institutions such as village councils and women groups
3.6	Social Infrastructure and Services	D	A-	B+	P: No impact is expected at this stage while community center and public hall may be used as a venue for consultation for EIA/RAP.
					C: Access to social infrastructure and services, such as water point in BP1, 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: The project is expected to improve access to social infrastructure and services by providing better road network.
3.7	Local Economy and Livelihood	A-	A-	B+	P: Loss of income source and livelihood due to involuntary resettlement are expected to negatively affect the local economic and livelihood.
					C: Loss of income source and livelihood due to involuntary resettlement are expected to negatively affect the local economic and livelihood. On the other hand, construction work will have positive impact on local economy by creating employment and business opportunities in the project area.
					O: The project will have positive impact on local economy as improved road network ensures more stable supply of essential goods. In the long-term, this will lead to regional economic development with more job and business opportunities.
3.8	Unequal Distribution of Benefit and Damage	A-	A-	B-/B+	P: Land acquisition and involuntary resettlement will lead to unequal distribution of benefits and damage between groups who are directly affected by the project and who are not.

					C: While resettling households bear much of the damage, others may even enjoy benefits from new business opportunities created by construction work, resulting in unequal distribution of benefit and damage.
					O: No impact is expected.
3.9	Local Conflicts of Interest	C	C	C	P/C/O: Local conflict may emerge between resettled PAH and other resident, etc.
3.10	Water Usage, Water Rights and Communal Rights	D	D	D	P/C/O: No impact is expected as rain water is used for both household and agricultural use.
3.11	Cultural and Historical Heritage	C-	D	D	P/C/O: No impact is expected as the project will not affect cultural and historical heritages
3.12	Religious Facilities	A-	A-	B-	P: Local graveyard is located near the proposed bypass alignment (BP1), and a memorial stones located at the existing road (BP2) may be affected. Small religious facilities in built-up areas may also be affected.
					C: Roadside religious facilities may be affected by noise and vibration during construction and operation due to construction work and greater traffic volume.
					O: Facilities may be affected due to increased traffic volume
3.13	Sensitive Facilities (ex. hospital, school, precision machine factory)	B-	B-	B-	P: Pre-school near the starting point of BP1 may be affected.
					C: Noise and vibration during construction work may affect school and hospitals but the impacts are expected to be minor.
					O: Greater traffic volume is expected to increase noise and vibration level, but adequate mitigation measures will be implemented.
3.14	Poor People	A-	A-	D	P: Given the limited coping capacity of the poor, it is necessary to assess their vulnerability and develop appropriate mitigation measures to be included in rehabilitation plan.
					C: The poor may bear disproportionally higher burden due to their limited coping capacity, although they can be benefited from employment opportunities during construction work.
					P: No impact is expected. In the long-term, economic development in the region is likely to benefit the poor.
3.15	Ethnic Minorities/ Indigenous People	A-	A-	D	P/C/O: The project area is inhabited by several Mizo tribes and they co-exit peacefully without conflicts. All subtribes speak Mizo and therefore communication barrier does not exit either. Preparation of RAP and rehabilitation plan will take into account Mizo culture and customs.
3.16	Gender	D	C-	B+	P: No impact is expected.
					C: Equal opportunity should be sought for employment during construction work. Prevailing social and cultural norms must be carefully studied to avoid gender-related conflict.
					O: Better road condition is expected to reduce the burden of girls and women who carry water and fuel wood and improve their safety.
3.17	Children's Rights	B-	B-	D	P: Children's right to go to school may be compromised.
					C/O：Child labor is unlawful according to article 24 of Indian Constitution, but it still exists in the region.
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 the health risk, particularly that of STD 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 impact 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 Environment Management Plan.
					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 as the project at this stage does not alter existing condition.
					C: Increase of risks of accidents associated with construction activities is expected due to the operation of heavy equipment and vehicles.
					O: Risks of accidents is expected to increase due to greater traffic volume and speed. On the other hand, installment of accident-prevention measures (such as mirrors at curves) will reduce the risk of accidents.
4.2	GHG emissions	D	B-	B+/B-	P: No impact is expected.
					C: CO_2 emissions will increase due to the clearance of forest for bypass construction. 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: Loss of forest cover will result in an increase in GHG emissions. The GHG emission will also increase due to an increase in traffic volume. The project is expected to improve the resilience of road against climate change by factoring long-term climate change (changes/increase in precipitation etc.) into the road design.

Note A-: Significant negative impact A+: Significant positive impact
B-: Some negative impact B+: Some positive impact
C: Impacts are not clear, need more investigation
D: No impact or impacts are negligible, no further study required
P: Pre-project Stage; C: Construction Stage: O: Operation Stage

Source: JICA Study Team

CHAPTER 7 ASSESSMENT OF IMPACTS AND MITIGATION MEASURES

The proposed project will have both positive and negative impacts on the surrounding environment during different stages of the project planning and implementation. This chapter assesses the nature, type and magnitude of the potential negative impacts on the various relevant environmental and social components along the project area as identified during the Scoping stage (see Chapter 6). For the assessment of impacts, the baseline information has been supplemented by the field visits and the primary surveys of the various environmental components carried out during the study. Below table shows the TOR to assess each environmental items.

Table 7.1 TOR for Impact Assessment

Category	Item	Assessment Item	Measure
Natural Environment	Climate	1) Data collection of climate in the survey area	1) Existing information (statistical data from State Government)
	Topography and Geology	1) Selection of candidates for disposal	1) Measurement Survey
	Soil Erosion	1) Data collection of soil in the survey area	1) Existing information
	Hydrology	1) Data collection of rivers in the survey area	1) Existing information 2) Site visit
	Groundwater	1) Utilization of groundwater	1) Hearing investigation
	Ecosystem, Flora, Fauna and Biodiversity	1) Current situation of flora and fauna in the survey area	1) Existing information 2) Baseline survey (by project)
	Protected Areas /Forest	1) Current situation of protected areas /forest in the survey area	1) Existing information from State Government
Living Environment	Air Quality	1) Environmental Standard in India 2) Current situation of air quality 3) Existence of sensitive facilities (e.g. school, church, etc.)	1) Existing information 2) Baseline survey (by project) 3) Site visit /Hearing survey
	Water Quality	1) Environmental Standard in India 2) Current situation of water quality (groundwater and surface water)	1) Existing information 2) Baseline survey (by project)
	Soil Contamination	1) Waste from the project which can be pollution source	1) Sample of similar projects
	Noise and Vibration	1) Environmental Standard in India 2) Current situation of noise and vibration 3) Existence of sensitive facilities (e.g. school, church, etc.) 4) Future prediction	1) Existing information 2) Baseline survey (by project) 3) Site visit /Hearing survey 4) Future prediction based on traffic demand
	Waste /Hazardous materials	1) Waste and hazardous materials which can be generated 2) Selection of candidates for disposal	1) Measurement Survey 2) Site visit /Hearing survey
Social Environment	Involuntary Resettlement	1) Number of affected households 2) Demand of affected persons	1) Baseline survey (by project) 2) Consultation meetings /Hearing survey

Category	Item	Assessment Item	Measure
	Land Use	1) Land use in the survey area	1) Site visit 2) Hearing survey
	Utilization of Local Resources and Local Economy and Livelihood	1) Volume of local resources, and impact on local economy and livelihood	1) Site visit
	General, Regional /City Plans	1) Current situation in the survey area	1) Hearing survey
	Social Institutions and Local Decision-making Institutions	1) Current situation in the survey area	1) Hearing survey
	Social Infrastructure and Services	1) Current situation in the survey area	1) Hearing survey 2) Site visit
	Unequal Distribution of Benefit and Damage	1) Current situation in the survey area	1) Hearing survey
	Religious and Sensitive Facilities	1) Current situation in the survey area	1) Hearing survey 2) Site visit
	Poor People	1) Current situation in the survey area	1) Baseline survey (by project)
	Ethnic Minorities/ Indigenous People	1) Current situation in the survey area	1) Baseline survey (by project)
	Gender	1) Current situation in the survey area	1) Baseline survey (by project)
	Public Health and Occupational Health and Safety (OHS)	1) Countermeasure examples	1) Sample of similar projects
Others	Accidents	1) Countermeasure examples	1) Sample of similar projects
	GHG emissions	1) Current situation in the survey area	1) Existing information

Source: JICA Study Team

7.1 Natural Environment

(1) Climate

Pre-Construction and Construction Phase

No change in the macroclimate i.e. precipitation, temperature and wind is envisaged. However, there will be localized, temporary impact due to vegetation removal and the creation of paved surface for road. There may be an increase in daytime temperature around alignment due to loss of vegetation. The impact will be more prominent at locations where the cutting of trees is in clusters.

Operation Phase

During operation phase, increased traffic plying will lead to increase in temperature levels locally along the carriageway though it will be insignificant and temporary.

(2) Topography and geology

Pre-Construction and Construction Phase

The change in topography (that of existing) is envisaged to in section where new bypasses are constructed in hilly and mountaneous slopes. The change in topography will also happen due to operation of borrow areas. The construction of material handling yards and labor camps will also alter the existing topography temporarily.

Operation Phase

During the operation phase, there will be probable induced developments in the form of commercial establishments along the new bypasses. During monsoon, the change in topography will also be visible due to landslide and damage to side slope and breast wall. The benefits in the form of land leveling and tree plantations in the vicinity of the project road shall enhance the local aesthetics.

Mitigation Measures

During construction phase, the existing vegetation including shrubs and grasses along the alignment (except within the strip directly under embankment or cutting) will be properly maintained. The borrow areas shall be operated and closed as per the specifications for road and bridge construction standard. The borrow areas shall be filled with the rejected waste/material, spoil and then finally a layer of topsoil shall be spread over it before carrying out plantation and turfing.

During operation phase, maintenance of embankment will be carried out to avoid soil erosion. The slope protection/ retaining wall if damaged due to land slide will be repaired promptly. The slope protection will also be established/strengthened regularly through plantation of shrubs and vegetation.

(3) Soil Erosion

Pre-Construction and Construction Phase

Site preparation will involve demolition of building, clearing of brushwood, tree removal and temporary re-routing of utilities. This brings risks of erosion to the exposed ground and topsoil. The soil erosion in construction stage may take place at the slope of the embankments, construction sites of cross drainage structures, at borrow areas and at construction sites which will be cleared.

Operation Phase

The soil erosion in operation stage may take place during operation at side slopes of road and near the interchanges. The risk is higher during monsoon.

Mitigation Measures

To control roadside soil erosion, turfing with grasses and shrubs will be carried out in accordance with

the recommended practice in IRC guidelines. At the locations of steep slopes near crossings of highway with major rivers suitable protection measures such as stone pitching will be adopted. The surface area of erodible earth material exposed by clearing and grubbing, excavation, borrow and fill material operations shall be limited to the extent practicable. The contractor will provide immediate permanent erosion control measures to prevent soil erosion that will adversely affect construction operations, damage adjacent properties or cause contamination of nearby streams or other watercourses, village ponds or water bodies etc. The green belt will be developed simultaneously along with construction activities to control the erosion process. In addition, gabion and apron concrete will be installed at the outlet of culverts to avoid soil erosion due to water runoff.

During the operation phase, the slope protection measures like sodding, turfing shall be done and monitored regularly. The green belt will be monitored and replantation for the loss of plants species will be done immediately. The side ditch on road is designed as concrete lined ditch for all section of cut side to prevent damage from water runoff.

(4) Hydrology

Pre-Construction and Construction Phase

Potential impact on hydrology will be minor, as the project does not involve diversion or re-routing of existing water resources. However, the existing drainage will be slightly obstructed during the construction period, but for a limited period. Hence, change in natural drainage pattern is very insignificant from the present state of the project.

Operation Phase

The projects may marginally lead to increased run-off during operational stages due to increase in impervious surface and sediment will be accumulation in nearby water bodies.

Mitigation Measures

The new drainage system is designed by based on hydrological calculation result. Based on obtained location of water crossing and water discharge, dimension and locations for drainage system are determined. For cross drainage structure, appropriate culvert type is selected by taking account of economy, construction workability, and maintenance ability. Comparison of different culvert types is shown below. In principle, pipe culvert is used where the water discharge is comparably small. BOX culvert is proposed where the water discharge is comparable large. The size is determined to satisfy the water discharge obtained by hydrological calculation.

(5) Groundwater

No tunnel is proposed in this project and as such, the project will not affect groundwater level or quality in the area. If contractor propose to use water from under surface water source, however, permission from the Water Resource Department and Local Administration is mandatory. The contractor is expected to properly manage effluents and waste water during the construction stage to avoid potential influence to the groundwater.

(6) Ecosystem, Flora, Fauna and Biodiversity

Being part of India-Burma biodiversity hotspot, Mizoram is known for its rich biodiversity. Meanwhile, no pristine ecosystem remains in the areas along NH54, the main road network of the State, due to human activities. As such, there are significant differences in the level of biodiversity and richness of flora/faunal community between in the area the proximity of NH54 and in Natural Park and Protected Areas of the State. Even in sections where the bypasses pass through hilly and mountaneous slopes, the areas are not pristine forest but mostly jhum field, fallow or plantation. Natural vegetation grow in fallow area but they are to be burned in the next cycle of jhum farming.

Flora and fauna assessment were carried out for all the four areas where the bypasses are proposed for two seasons. Floral/Vegetation assessment carried out through quadrate methods: for trees 10mx10m, for shrubs 5mx5m and for Herbs 1m x1m square shaped quadrates were used. Quadrates were laid randomly in the corridors upside and downside of the road. All species in the quadrates were recorded & ecological parameters such as density and frequency were calculated. Faunal species were recorded with the visual observation during site visits, secondary data from the forest department and local information from peoples. Faunal species were recorded with the visual observation during site visits, secondary data from the forest department and local information from peoples. There is no unique faunal community within the project area. No endangered or threatened fauna species were reported in the area.

The main impact on flora involves the removal of trees and grubbing of vegetative cover for construction and a clear zone within the Right of Way (ROW) and for spoil bank.

<u>Mitigation Measures</u>

In the process of finalizing ROW, efforts to minimize the scale of forest clearing and impacts associated with construction activity shall be made. The contractor shall review/renew relevant permit as necessary and fully cooperate with inspection by relevant authority.

During the construction stage, signboards will be used to make sure that workers will be aware of the vulnerable and other important species. Relevant information (e.g. encounter with vulnerable species during engineering work) shall be shared with State Environment and Forest Department with which the project authority will discuss potential measures to promote conservation and monitoring of ecosystem shall be carried out.

The tree cleared due to construction work will be replaced and compensated according to the Compensatory Afforestation Policy under the Forest Conservation Act, 1980. Apart from trees earmarked for feeling, no additional tree clearing within the ROW will be allowed. All construction workers should adhere to this rule. It is recommended that the two or more trees will be planted for a loss of one tree. The site of compensatory afforestation will be specified by the Forest Department during the process of obtaining forest clearance. As per its guidance, the project proponent will plant

saplings (types and number to be specified) at designated location (either degraded forest or vacant/abandoned jhum area).

(7) Protected Areas/Forest

Pre-Construction and Construction Phase

The project road does not traverse or border with national park, wildlife sanctuary or reserved forest. As discussed above, however, three wildlife sanctuaries are located near the area (but more than 10km away). The conditions of these WLS should be monitored periodically so that potential indirect impacts to these sites can be identified and mitigation measures can be developed.

Operation Phase

Increases in traffic volume are likely to have negative impact on forest ecosystem.

Mitigation Measures

At the planning stage, efforts to avoid or minimize the number of trees to be cut have been done as part of the design for widening of the road. For greening the slope as part of slope protection, use species that indigenous breed in the project area to minimize impacts on existing ecosystem.

During the operation stage, monitoring shall be carried out to check the impact of increased emissions on forest/plantation and measures (e.g. additional plantation) shall be undertaken to mitigate negative impacts as necessary. All data related to increased traffic volume and emissions shall be shared with relevant state authorities. In addition, improved road network may trigger poaching. At the moment, educational activities and removal of traps by rangers are undertaken to reduce poaching. While NHIDCL is not responsible for the control of poaching, a proposal shall be made to relevant authority regarding the potential increase in poaching and the necessity of adequate management system, such as restriction of precious wildlife trade.

Deforestation is one of the main causes of climate change. The project clears forest in hilly and mountainous slopes to construct new bypasses, which results in GHG emissions. The loss of forest also means the loss of long-term carbon sequestrating capacity. Given that more than 20% of the entire Mizoram state is jhum field, which is regularly burned yearly with considerable GHG emissions, the impact of the project in terms of GHG emission volume will be minor. Yet, as per the requirement of Forest Act, the project will undertake reforestation to compensate the loss of forest. Indeed, it is planned that more trees will be planted than cut due to the project, and therefore, the project will result in net increase in carbon sequestration capacity in the State in the long-term. The detailed terms and conditions of reforestation will be finalized in consultation with the Environment and Forest Department of the State.

7.2 Living Environment

(1) Air Quality

Being on hill, towns and villages along NH54 generally have good ambient air quality. The project road alignment also has no polluting industry along it. There is congestion due to traffic in major the built up area. This leads to vehicular exhaust emissions and deterioration for which the proposed bypasses will have positive impact.

Pre-Construction and Construction Phase

The short-term and localized degradation of air quality will occur from dust generation due to procurement and transport of raw materials from quarries and borrow pits, site clearance, use of heavy vehicles, machinery/ equipment, stone crushing handling and storage of aggregates and generation of fine particulate matter (smoke) in asphalt processing. Dust would be generated from haulage of materials and detouring of traffic on non-permanent, temporary pavement etc.

Hot mix plants contribute substantially to the deterioration of air quality due to emissions of oxides of Sulphur, Hydrocarbons and particulate matter. During the construction period, temporary impacts include generation of Odor from construction activities as well as from construction camps. During construction of road, the movement of different types of construction machinery and vehicle will be increased. This in other way increases the fuel consumption.

From the results of the ambient air quality monitoring conducted along the road, it is noticed that the monitoring parameters are within the standards as prescribed by the Central Pollution Control Board. The concentration of the air pollutants will further increase during construction period but for limited period only. The impacts on air quality during construction will be mostly localized and concentrated within the ROW. The impacts due to dust generation may felt downwind of the site rather than the site itself due to local wind pattern.

Operation Phase

The project road is mostly passing through the rural areas with alluvial soil. Dust generation due to movement of vehicles is envisaged along the project road, but not in significant amount. Due to increase in speed and volumes of vehicular traffic on the project corridor, marginal increase in the air pollutant levels is expected. The increase in the pollution levels is assessed through air quality modelling using CALINE 4 (California LINE Source Dispersion Model), version 4. This is the standard modeling program used to assess air pollution impacts due to transportation. It is based on the standard Gaussian diffusion equation which is the basis for U.S. EPA's various dispersion models.

CALINE4 requires input of traffic characteristics like volume, emission factors, receptor locations, chainage length etc.The model has been extensively tested for its predictive capability for traffic related air quality impacts. Given source strength, meteorology, site geometry and site characteristics the model can reliably predict pollutant concentrations for receptors located within 300 meters of the

roadway, the most important region for estimating the impacts of road project due to the low elevation emissions.

To account for the effect of the diurnal variations in model inputs (vehicular emissions and meteorological conditions), the averaging time for model predictions has been restricted to 60 minutes. The averaging time is so selected because the primary meteorological factors that influence the air quality predictions i.e. wind speeds and directions do not remain steady for longer time periods. Also, during the peak traffic hours, traffic volumes typically show significant variations over periods longer than one hour.

Model predictions have been carried out for CO and NOx pollutants. HC was not modelled since its limits are not specified for ambient levels in the Environment Protection Act. In the absence of Indian standards for HC, the predictions could not have been interpreted meaningfully. Further the SPM contributions are dominated by background concentrations as well as traffic induced re-suspension, both of which are difficult to quantify.

Due to averaging time of 60 minutes, the project impacts on air quality are essentially assessed based on one hourly standard for CO. NOx levels however have been developed for peak traffic conditions and compared with WHO standard of 400 μg/m3 for hourly average. Due to non-availability of hourly variations of meteorological conditions over 24 hours, daily average levels could not be predicted for comparison with the relevant standards of NOx. Further scale up factors for estimating 24 hourly average concentrations for 1 hour are not reported. In any case such an exercise requires that the wind is blowing in the same direction for all 24 hours - which is not a practical assumption.

The peak hourly estimated traffic volumes for the years 2020 and 2035 have been considered to project future air quality scenarios to provide an indication of long-term variations in air quality. A longer time horizon has not been considered because of uncertainty in ascertaining the emission factors for various categories of vehicles due to the probable change in technology and fuel use.

The Peak Hourly Traffic Projections for the years 2020 and 2035 used for model prediction are tabulated below.

Table 7.2 Predicted Peak Hourly Traffic Volume

Locations	Cars/ Jeep/ Taxi	2 W	3 W	Bus	LCV	Trucks	Total
2020							
Kwalzin (km 20)	207	128	11	7	91	24	476
Sercchip (km 107)	51	67	17	8	34	0	177
Hirakundi (km 160)	59	86	0	0	21	0	167
Tuipang (km 329)	42	50	38	0	29	0	159
2035							
Kwalzin (km 20)	557	346	29	18	246	88	1285
Sercchip (km 107)	137	182	46	23	91	0	478

Locations	Cars/ Jeep/ Taxi	2 W	3 W	Bus	LCV	Trucks	Total
Hirakundi (km 160)	161	234	0	0	59	0	453
Tuipang (km 329)	112	135	101	0	79	0	427

The vehicular emission norms Bharat Stage – III standards as specifiedby CPCB have been used to provide the emission factors for the different vehicle types. These Emission factors are as specified below.

Table 7.3 Emission Factors In Gm/Km/Vehicle*

Type of Vehicles	Average Tailpipe Emissions (g/km)	
	CO	NOx
2 Wheeler	1.0	1.0
3 – wheelers	1.0	1.0
Passenger Cars	2.3	0.35
Heavy Diesel Vehicles	2.1	5.0

Source: CPCB Emission Standards for Vehicular Exhaust, Bharat Stage-III
* to be multiplied by 1.6 for converting into gm/mile for use in CALINE4 model.

The air quality scenarios were developed for all stability classes using the representative wind speeds (minimum wind speed in the respective stability) for the particular stability class. The meteorological data considered for the modelling studies is given below.

Table 7.4 Meteorological Data Considered for Modelling

Stability Class	Wind Speed (m/sec)
A	1.0
B	2.0
C	3.0
D	5.0
E	2.0
F	2.0

For model computations, the receptor locations have been chosen to account for its location with respect to center of the road. The Ground Level Concentrations (GLC) are computed for distances viz: 50, 100, 150, 200, 250 and 300 m from centre of the road. The scenarios were modelled for cross wind direction.

The predicted CO & NOx maximum concentrations were observed at a distance of 50 m from the center of the road under stability class A. The maximum concentration of were observed at Kwalzin due to high traffic at this location in both the predicted years. The trend in the predicted concentrations follows that of the increase in traffic volume during the respective years. On

comparison with the hourly standard for CO of 4000 μg/m^3, it is seen that no violations of CO standard are expected due to the project. The CO levels in fact will remain well below the standards. The project therefore has no adverse impact on ambient air quality in terms of CO. When compared to WHO standard of 400 μg/m^3 for NOx, it is observed that no violations of are expected due to the project. The project therefore has no adverse impact on ambient air quality in terms of NOx concentrations.

Mitigation Measures

The hot mix plants, crushers and the batching plants will be sited at least 500 m in the downwind direction from the nearest settlement. All precautions to reduce the level of dust emissions from the hot mix plants, crushers and batching plants will be taken up. The hot mix plant will be fitted with dust extraction system. Asphalt and concrete plants will be operated in conformity with government pollution control legislation, and located away from the settlements as far as possible. All vehicles, equipment and machinery used for construction will be regularly maintained to ensure that the pollution emission levels conform to the SPCB norms. Regular monitoring of particulate Matter at crusher sites, during the construction, will be conducted. Regular water sprinkling will be done on the cement and earth mixing sites, asphalt mixing site and temporary service and access roads. After compacting the earthwork, water will be sprayed to prevent dust emission. The vehicles delivering construction material will be covered to avoid spilling. Planting of trees/vegetation on the periphery of the construction site will be taken up.

During the operation stage of the project, vehicular emissions of critical pollutants (RSPM, CO, HC, SO_2, and NOx) will be monitored and roadside tree plantation will be maintained. Over the long-term, projected increase in traffic volume, particularly ones of heavy trucks, may pose health threat in roadside community. The peak hourly estimated traffic volumes for the years 2020 and 2035 have been considered to project future air quality scenarios to provide an indication of long-term variations in air quality. The future level of air pollution, modeled based on the projected increase in traffic volume indicates that the level of pollution (CO and NOx levels) will remain below the standard during the projected period (2035). Nevertheless, mitigation measures such as introducing speed limit and other measures to control congestion in built-up area may be necessary in the longer term. Also, local communities should be well informed of the risk of air pollution. Awareness raising campaign may include distribution of facemask to mitigate risk of air pollution and other information kit.

(2) Water Quality

Pre-Construction and Construction Phase

The bypasses may marginally lead to increased run-off during construction stages, which will increase sediment accumulation in nearby water bodies. Though most of the natural watercourses are perennial in nature, the impacts due to the increased run-off would be negligible due to the project road. During construction, the disposal of solid and liquid waste from labor camps, fuel and lubricant spills or leaks from construction vehicles, pollution from fuel storage and distribution sites and that from hot-mix

plants is likely to affect water quality unless adequate mitigation measures are designed. The existing drainage will be slightly obstructed during the construction period, but for a limited period. Hence, change in natural drainage pattern is very insignificant from the present state of the project.

Use of water for construction activities such as compaction, suppression, concrete work may pose pressure on local water supplies; the demand would be met from surface water bodies like ponds, canal and rivers. Municipal water supply will be used only for drinking purposes (for construction camps), if available and if permitted by the local municipal authority. No local/municipal water supply would be used for construction purpose.

Operation Stage Impacts

In the operation stage, pollutants from vehicles, and accidental fuel spills may make their way into the receiving environment. The major pollutants of concern are suspended solids, oil and grease, lead etc. All the rivers present at this road section are non-perennial surface water bodies. No adverse direct impact on the water quality (both underground and surface water bodies) is expected during the operation period. The change in natural drainage pattern is very insignificant from the present state of the project.

Mitigation Measures

To avoid contamination of the various water bodies and drainage channels, construction work close to water bodies will be avoided during monsoon period. All necessary precautions will be taken to construct temporary or permanent devices to prevent water pollution due to increased siltation and turbidity. All wastes arising from the project will be disposed off, as per the State Pollution Control Board norms, so as not to block the flow of water in the channels. The wastes will be collected, stored and taken to approve disposal sites.

To avoid contamination of the water body and drainage channels from fuel and lubricants, the vehicles and equipment will be properly maintained and re-fuelled only at designated places. The slopes of embankment leading to water bodies will be modified and re-canalized so that contaminants do not enter the water body. Oil and grease traps will be provided at fuelling locations, to prevent contamination of water.

(3) Soil Contamination

Pre-Construction and Construction Phase

The contamination of soil during construction stage is primarily due to construction and allied activities. The soil contamination may take place due to solid waste from the labor camps set- up during construction stage. This impact is significant at locations of construction camps; stockyards, hot mix plants, etc. The sites where construction vehicles are parked and serviced are likely to be contaminated because of leakage or spillage of fuel and lubricants. The contamination of soils can also occur at the site of hot-mix plants from leakage or spillage of asphalt or bitumen. At the site of batching plants, because of spillage of cement, leakage of curing agents the soil contamination can

occur. The contamination of soil may take place due to dumping of solid waste in unscientific manner, leaching of fuel/oil & grease from workshops, petrol stations and DG sets.

Operation Stage Impacts

During the operation stage, soil pollution due to accidental vehicle spills or leaks is a low probability but potentially disastrous to the receiving environment, should they occur. These impacts can belong term and irreversible depending upon the extent of spill.

Mitigation Measures

At construction yards, the vehicles/equipment will be maintained and re-fuelled in such a fashion that oil/diesel spillage does not occur and contaminate the surrounding soil. It will be ensured that the fuel storage and re-fuelling sites are kept away from drainage channels and important water bodies. At the washdown and re-fuelling areas, "Oil Water Separators" shall be provided. All spills and discarded petroleum products shall be disposed off in accordance to the Hazardous Waste Management and Handling Rules. Fuel storage and re-fuelling areas will be located at least 500 m from all water bodies near the road alignment. The fuel storage and re-fuelling areas shall not be located on agricultural lands or productive lands to avoid topsoil contamination. The earthwork will be carried out strictly in accordance with the design so that no excess earth is borrowed. The construction waste generated will be reused in the construction of highway.

In the operation stage, the petrol pumps & vehicle washing area located along the ROW will be monitored regularly for any spillages and corrective remedial measures like spread of sand, provision of oil & greases separators for passing wash water of petrol pumps & vehicle washing area before diverting it to water bodies shall be done regularly. The solid waste generated from the way side amenities will include Municipal Waste both organic and inorganic, hazardous waste (like used batteries), will be treated in accordance with Municipal Solid Waste (Management & Handling) Rule and Hazardous Waste (Management, Handling & Transboundary Movement) Rules.

(4) Noise and Vibration

Pre-Construction and Construction Phase

The short-term impact of noise and vibration will occur for local residents near the construction area. Most of the construction area are far from residential area excluding start/end points, then only the persons who live near start/end points may be affected. Bypass construction includes civil work (e.g. drilling and filling), pavement work, drainage work, bridge work and slope protection work, however, significant construction works (e.g. civil work, slope protection work, etc.) will not be implemented. Therefore the prediction targets on only pavement work.

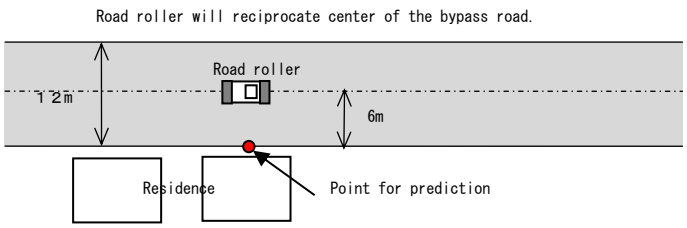
Method of prediction and evaluation

Prediction of noise during construction were calculated based on propagation theory and compared with environmental standard in India. Prediction of vibration were calculated by Bornitz formula.and compared with Vibration Regulation Law in Japan because there is no related regulations in India.

Condition of prediction

Prediction condition for noise and vibration are shown in below table.

Table 7.5 Prediction Condition for Noise and Vibration by Construction Machines

Item	Condition	Remarks
Target	Pavement Work	
Construction Machine	Roller	
Construction Condition	Velocity 5 km/hour Frequency 10 times/day	
"A" weighted sound power level	104dB (Road Roler)	Source: Acoustical Society of Japan (ASJ) Prediction Model 2007 for Construction Noise Report
Vibration Level at Standard Position	59dB (Asphalt pavement work, upper and under layer)	Source: Environmental Impact Assessment Technique for Road Project edition of FY 2012 (National Institute for land and infrastructure management)
Attenuation Coefficient of Ground Vibration	0.01	
Construction Location		

Source: JICA Study Team

Result of prediction

Result of prediction and evaluation are described as follows. Both impacts of noise and vibration will fall within the standards.

Table 7.6 Prediction Result for Noise and Vibration by Construction Machines

Item	Prediction Result	Evaluation Criteria
Noise (LAeq)	53.9dB	65dB (Day time)
Vibration (L_{10})	57.7dB	70dB

Source: JICA Study Team

Most of the construction area are passing in the forest far from residential area. Therefore, it is necessary to consider the impact of noise and vibration for sensitive facilities near start/end points. Regarding the start point of Chhiathlang bypass, one elementary school is located 50 m to the south and one church named Presbyterian Kohhran Chhiahtlang is located 170 to the south. These facilities are not remarkably close to the construction site, but it is necessary to consider the time of class or event.

Operation Stage Impacts

Noise and vibration from vehicles passing by new bypasses and its impact for to local residents near bypasses will occur.

Method of prediction and evaluation

Prediction of noise during operation were calculated based on ASJ-RTN Model 2013 by Acoustical Society of Japan which was developed based on energy and compared with noise standard in India.

Prediction of vibration were calculated based on the proposed formula by Public Works Research Institute in Japan based on the results of driving tests and compared with The limit value of request to road manager defined in Vibration Regulation Law in Japan.

Condition of prediction

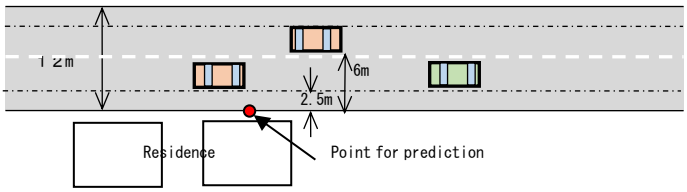
Prediction condition for noise and vibration are shown in below table.

Table 7.7 Prediction Condition for Noise and Vibration during Operation

Item	Condition	Remarks
Basic Information	Two-lane	Width 2.5＋3.5＋3.5＋2.5=12.0m
Design Speed	40km/h	
Running Condition	Non-steady	
"A" weighted sound power level	Large Vehicle: $88.8+10\cdot\log_{10}V$ Compact Vehicle: $82.3+10\cdot\log_{10}V$	Source: Acoustical Society of Japan (ASJ) Prediction Model 2013 for Road Traffic Noise Report
Natural Frequency of Ground	8 Hz	*Assumption
Target Year	2040	
Volume of Traffic	Volume of Traffic for Bypass (2040)	

Line	Standard	Bus	Auto Rickshaw	Two-wheeled	Compact (Commerce)	Truck
Chhiahtlang (No.1)	2052	38	29	885	580	63
Serchhip (No.2)	2049	0	264	988	649	131
Hnathial (No.3)	1469	0	99	754	542	115
Lawngai (No.4)	1783	0	169	654	592	145

Running Location



Source: JICA Study Team

Result of prediction

Result of prediction and evaluation are described as follows. Both impacts of noise and vibration will fall within the standards.

Table 7.8 Prediction Result for Noise and Vibration by Construction Machines

Item	Prediction Result		Evaluation Criteria
Noise (LAeq)	Chhiahtlang bypass (No.1)	64.4dB	65dB (Day time)
	Serchhip bypass (No.2)	64.6dB	
	Hnathial bypass (No.3)	63.5dB	
	Lawngai bypass (No.4)	64.3dB	
Vibration (L_{10})	Chhiahtlang bypass (No.1)	42.9dB	70dB
	Serchhip bypass (No.2)	43.4dB	
	Hnathial bypass (No.3)	42.3dB	
	Lawngai bypass (No.4)	43.3dB	

Source: JICA Study Team

Mitigation Measures

The high noise and vibration levels may cause discomfort to local residents and workers. Following mitigation measures shall be adopted to keep the noise and vibration levels under control.

- 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 minimum;
- Workers in the vicinity of high noise levels must wear ear plugs, helmets and should be engaged in diversified activities to prevent prolonged exposure to noise levels of more than90dB(A);
- In construction sites within 150 m of human settlements, noisy construction will be stopped between 10 PM and 6 AM except in case of laying of cement concrete pavement for which lower working temperature is a requirement;
- Hot mix plant, batching or aggregate plants shall not be located within 500 m of sensitive land use as schools;
- Phase demolition, earthmoving and ground-impacting operations so as not to occur in the same time period. Unlike noise, the total vibration level produced could be significantly less when each vibration source operates separately
- Careful planning of machinery operation and scheduling of operations can reduce the noise levels. Use of equipment, emitting noise not greater than 90 dB(A) for the eight-hour operations shift and locating of construction yards at a distance of at least 500 m from any residential areas can be adhered to;
- Use of air horns should be minimized on the highway during nighttime. During daytime use of horns should be restricted at few sensitive locations. This can be achieved through the use of sign boards along the roadside

Since there is no target level set in India, the tentative target vibration levels from traffic are set in accordance with the Japanese target level as shown in Table below.

Table 7.9 Tentative Target Vibration Level from Traffic

Construction Equipment	Daytime (L_{10})	Nighttime (L_{10})
Target Level (dB)*	65	60

* Applied "Residential Area"

Source: The Vibration Regulation Law (Japan) (Law No. 64 of 1976, Latest Amendment by Law No.75 of 1995)

(5) Wastes/Hazardous Materials

Types of construction waste to be generated include asphalt chunks, chunks of concrete, surplus soil, construction scrap materials and organic waste generated by construction workers. The amount and percentage composition of construction waste will depend on the final design and the schedule of the

construction, and thus generic mitigation measures proposed in EMP should be updated once the final ROW drawing is completed.

In addition, a Waste Management Plan needs to be prepared and approved by relevant local authorities in accordance with Construction and Demolition Waste Management Rules, 2016 which was notified by Ministry of Environment, Forests and Climate Change on 29 March 2016. According to the Rules, large waste generators (who generate more than 20 tons or more in one day or 300 tons per project in a month) shall 1) submit waste management plan and get appropriate approvals from the local authority before starting construction or demolition or remodeling work; 2) have environment management plan to address the likely environmental issues from construction, demolition, storage, transportation process and disposal / reuse of Waste; 3) shall segregate the waste into four streams such as concrete, soil, steel, wood and plastics, bricks and mortar; and 4) shall pay relevant charges for collection, transportation, processing and disposal as notified by the concerned authorities.

Based on the preliminary design for NH54 Bypass, the necessary volume of spoil bank has been calculated as below.

Table 7.10 Required Volume for Spoil Bank

Bypass Name	Item	Volume of Generated Soil	Coefficient of Compaction	Volume of Compacted Soil	Required Volume of Spoil Bank
		Cu.m		Cu.m	Cu.m
Chhiahtlang Bypass	Cut Soil	127,499	0.9	114,749	77,238
	Fill Soil			37,511	
Serchhip Bypass	Cut Soil	743,768	0.9	669,391	481,306
	Fill Soil			188,085	
Hnahthial Bypass	Cut Soil	379,505	0.9	341,555	252,047
	Fill Soil			89,508	
Lawngtlai Bypass	Cut Soil	247,013	0.9	222,312	154,547
	Fill Soil			67,765	

Source: JICA Study Team

Followings are assumed conditions for suitable locations for that.

- ❖ To find out suitable place along NH-54 Bypass with following condition;
  - Ground shape with concavity topography
  - Less ground gradient than 22 degree which is assumed as average angle of spoil bank slope with necessary steps
  - No built-up area
  - No national sanctuary area
- ❖ To be able to construct the spoil bank in less than 30m height

The proposed location of the spoil bank is presented in section 2.2.5. Local communities are also encouraged to use residual soil for community development, for example for ground leveling and

creating of playground. The proper measure will be applied to each spoil bank to prevent soil erosion (and damage to jhum field), which was one of the key concerns raised during consultation meetings.

Regarding domestic wastes from workers' camps, Solid Waste Management Rules, 2016 will be adhered to. Solid Management Rules, 2016, mandates waste generators to segregate waste into three streams – Biodegradables, Dry (Plastic, Paper, metal, Wood, etc.) and Domestic Hazardous waste (diapers, napkins, mosquito repellants, cleaning agents etc.) before handing it over to the collector.

7.3 Socio-Economic Environment

(1) Involuntary Resettlement

As per the preliminary ROW design, the project will affect 257 households (1,485 persons). Out of those, 20 households (133 persons), which include 4 house cum shops, will be resettled. Two rounds of consultation showed their strong support to the project. Also, it was confirmed that they prefer cash compensation over land-for-land compensation. The proposed compensation package is presented in Entitlement Matrix in section 8.11.

(2) Land Use

The construction of bypass and spoil bank will cause changes in land use pattern, affecting existing agricultural and plantation activities. For sections where the proposed alignment passes through forest, jhum area and plantation, engineering work should be scheduled in a way that minimize disruption of access by local people. At the same time, proper management of effluent and soil erosion shall be carried out to avoid negative impact on such resources.

(3) Utilization of Local Resources and Local Economy and Livelihood

Significant volume of local resources such as sand may be used for construction work. This could cloud out the use of such resources for other purposes in the short-term. In the long-term, the better road network may attract new business, possibly from outside the state with detrimental impact on local business/traders. While the project overall will have significant positive impacts on the local and regional economy, the better transport network may put some groups at risk at least in the short and medium-term. These potential high-risk groups should be identified in the preparation of R&R plan to ensure that they will not be in a disadvantaged position due to the project.

(4) General, Regional /City Plans

The project will create new opportunities for village and district-level development planning. In particular, the construction of spoil bank will create large area of flat land where such surface is a scarce commodity. The development of spoil bank, therefore, should be coordinated with the village/district's development plan so that the land will benefit the community. Similarly, development of resettlement site should be well coordinated with village development plan to ensure proper supply of basic utilities and integration of new sites with the existing village area.

(5) Social Institutions and Local Decision-making Institutions

Different tribes of Mizo people co-exist across the project area without tribe-rooted conflicts. Being a tribal state, district and village council and traditional community leaders have significant influence on decision-making process in the area. As such, their support and cooperation is critical in smooth implementation of the project, particularly activities related to resettlement. The implementation of EMP as well as RAP/R&R should be built on existing social institutions and will be best guided by local people, rather than outside experts.

(6) Social Infrastructure and Services

Where the prosed bypasses will be constructed by widening the existing community road, construction activity is likely to cause temporary disturbance to their access to social infrastructure and service and therefore, schedule and timing of the engineering activity should be developed in consultation with the local community. When road blockage is necessary, e.g. for blasting, the local community should be informed in advance so that they can make alternate plan accordingly.

There is a small pre-school near the starting point of BP1, but it can be shifted since there is an open space behind it. Also, one water point and two public toilets exist near the ending point of BP1, and one water pump, one public toilet, and one memorial stone near the ending point of BP2 will be affected. They will be relocated prior to the commencement of construction work to minimize disturbance to the local community.

(7) Unequal Distribution of Benefit and Damage

Roadside or near-road location offers critical advantages for local business (tea stalls, restaurant, petty shops). Resettlement to inner part o 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. Sound arbitration and conflict resolution mechanism by local leaders should be in place for smooth implementation of RAP and R&R activity.

(8) Religious and Sensitive Facilities

A local cemetery is located near the proposed alignment of bypass one. While the alignment is design so as not to affect the cemetery itself, extra efforts should be paid to minimize negative impact during the construction, including noise and vibration and disruption of access by local people. More stringent standard for noise and vibration and air quality should be adopted where sensitive facilities such as school and hospitals are located.

One pre-school is located near the starting point of BP1. While there is enough empty space to set back the pre-school, construction work in this section should avoid the school terms/hours as much as possible. One memorial stone (commemorating the inauguration of the road) will be affected near the

end point of bypass two. While the stone itself does not have significant religious or cultural importance, it should be relocated to an appropriate location.

(9) Poor People

The baseline survey has identified gap between official poverty level and poverty level as reported by the people. R&R activity should take into account the limited coping capacity of the local community and develop measures that leads to sustainable income generation of the affected people, rather than one-off payment of compensation and assistance.

(10) Ethnic Minorities/ Indigenous People

In the state of Mizoram, the tribal (Scheduled Tribe: ST) population constitutes about 95% of the total population. Overwhelming majority of the affected people also belong to ST, and hence they are not minority. While tribal groups in project area holds traditional culture, including shifting cultivation in forest called jhum, they freely interact and share their sources of water, folklore, food, infrastructure and other belongings with the non-ST and other tribal population within and outside community. ST population in project area is not isolated from outside.

(11) Gender

In general, tribal and non-tribal women in North East States enjoy a relatively higher position in the society than what their non-tribal counterparts do, which is reflected in their high literacy rate. Mizo women are largely involved in household work, collection of forest produce, firewood collection, cultivation and other agricultural activities and thus they will be affected in a way that is different from their male counterpart. In order to ensure that affected women will not be disadvantaged, a dedicated chapter on gender issue is included in women in which options to facilitate women's participation in project implementation and various opportunities to be created by the project is discussed. In particular, women shall have preferential access to specific types of project-related job opportunities, including light-duty work and part-time jobs that do not interfere with women's responsibility at home. In addition, efforts should be made ensure participation of women in consultation meetings to be carried out during the implementation of RAP.

(12) Public Health and Occupational Health and Safety (OHS)

The health and safety measures at design, construction and operation phase are given below.

Table 7.11 Health and Safety Measures

Construction Stage	
Health hazard to workers due to bad water and sanitation	● At every workplace, good and sufficient potable water (as per IS) supply shall be ensured to avoid water-borne diseases and to secure the health of workers. ● Adequate drainage, sanitation and waste disposal shall be provided at workplaces. ● Preventive Medical care shall be provided to workers.

Health/ social hazard, sexual harassment to female workers	Segregation of male and female areas in labor camp shall be executed.
Hygiene at Construction Camps	● The Contractor during the progress of work will provide, erect and maintain necessary (temporary) living accommodation and ancillary facilities for labour to standards and scales approved by the resident engineer. ● There shall be provided within the precincts of every workplace, latrines and urinals in an accessible place, and the accommodation, separately for each for these, 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 must 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 off in a lined landfill sites. Construction camps are to be sited 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 whole of the 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 measure shall be adopted with garland of trees around the periphery. The quarry dust and waste shall be used for refilling. The remaining portion should be covered with trees. If the quarry site is porous, it shall be used by 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 has to comply with all regulation regarding safe scaffolding, ladders, working platforms, gangway, stairwells, excavations, trenches and safe means of entry and egress.
Risk from Explosives	● Except as may be provided in the contract or ordered or authorized by the Engineer, the Contractor shall not 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 make full liaison with and inform well in advance and obtain such permission as is required from all Government Authorities, public bodies and private parties whatsoever concerned or affected or likely to be concerned or affected by blasting operations.
Malaria risk	● The Contractor shall, at his own expense, conform to all anti-malarial instructions given to him by the Engineer, including filling up any borrow pits which may have been dug by him
Operation Phase	
Safety Measures	● 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

	discoursed.

Source: JICA Study Team

7.4 Other Issues

(1) Accidents

Construction Phase Impacts

During the construction stage, dismantling of structure, cutting of trees, haulage material obstructing vision, spillage of lubricants on road making it slippery is generally the cause of road accidents. Similarly, in operation stage, increase in traffic and increase in speed would tend to increase in accidents. It is likely that there will be some concern of safety for highway users during construction period, as haulage of material and other equipment would restrict movement of vehicles. Highway patrolling system with ambulance facility and crane will render assistance to users in distress and disabled vehicles which in-turn will improve the safety level.

Operation Phase Impacts

In operation stage, increase in traffic and increase in speed would tend to increase in accidents. In-spite of these, the social benefits from the project are quite significant.

Mitigation Measures

In pre-construction and construction phase, it is necessary to take mitigation measures not to cut off the view by trucks for material transportation and cause traffic jams which may lead accidents. On the purpose of this, stuffs for construction will be informed about the location of hospitals and first aid kit will be prepared. Other safety measures are described as follows.

- Placement of guides
- Familiarization for construction stuffs with work method
- Meeting of prediction for safety
- Installation of facilities for fall prevention
- Preparation of first aid kit

Traffic safety facilities are to be provided on roads or roadside to secure safety of all road users as well as nearby residents. Given the road function of rural roads and usage situation of the target roads, facilities listed below are considered for application to the Project.

Table 7.12 Traffic Safety Facilities to be Applied for NH54 Bypass

No.	Item	Remarks / Related Code
1	Traffic Sign	IRC67-2001, IRC7-1971, IRC-SP-31-1992
2	Road Marking	IRC35-1997, IRC-SP-31-1992, IRC2-1968
3	Road Delineator	IRC79-1981
4	Guard Rail	
5	Street Furniture (Blinker, Road Stud/Cats Eye)	MoRTH's Research Project R-63

Source: JICA Study Team

Traffic signs are to be installed to promote road safety and efficiency by providing the orderly movement of all road users in both urban and non-urban areas. Road signs notify road users of regulations and provide warning and guidance needed for safe, uniform and efficient operations. IRC: 67-2012 stipulates three types of traffic signs, namely, 1) Mandatory/Regulatory Signs, 2) Cautionary/Warning Signs, and 3) Informatory/Guide Signs. The traffic signs to be installed for this project in accordance with IRC: 67-2012 is shown below.

Table 7.13 Suggestion of Traffic Signs for NH54 Bypass

Item	Type of Traffic Signs	Location of Installation
90 cm equilateral triangle	 T-Intersection Major Road Ahead  Side Road	- Installation at front side of intersection and side road
90 cm equilateral triangle	 Reverse Bend  Hand Curve	- Installation at front side of reverse bend and hand curve
90 cm equilateral triangle	 Narrow Bridge Ahead	- Installation at front side of bridge
60 cm circular	 Maximum Speed Limit	- Installation at start and end point of bypass - Installation every 2 km
80 cm x 60 cm rectangular	 Flag Type Direction Sign	- Installation at front side of intersection

Source: IRC: 67-2012 Code of Practice for Road Signs (Third Recision)

Road markings perform important functions of guiding and controlling traffic on roads. They serve as a psychological barrier and signify the delineation of traffic hazards for safe movement of traffic. Traffic markings also channelize, ensure smooth and orderly flow of traffic. Therefore, suitable road

markings shall be provided on roads in accordance with IRC: 35-1997. Road markings for NH54 are proposed based on the DPR, as shown below.

Table 7.14 Road Markings proposed in DPR for NH54

Item	NH54-S1	NH54-S2	NH54-S3
Road Marking	Edge line marking (yellow continuous, thermoplastic paint) and center line marking (white broken) are to be provided. No detailed quantities are available in Report.	Center line marking (thermoplastic paint) is to be provided. Detailed quantities are as follows: Road Marking: 28,215 sqm (250 sqm/km)	Center line marking (thermoplastic paint) is to be provided. Detailed quantities are as follows: Road Marking: 31,131 sqm (253.92 sqm/km)

Summarized by JICA Study Team

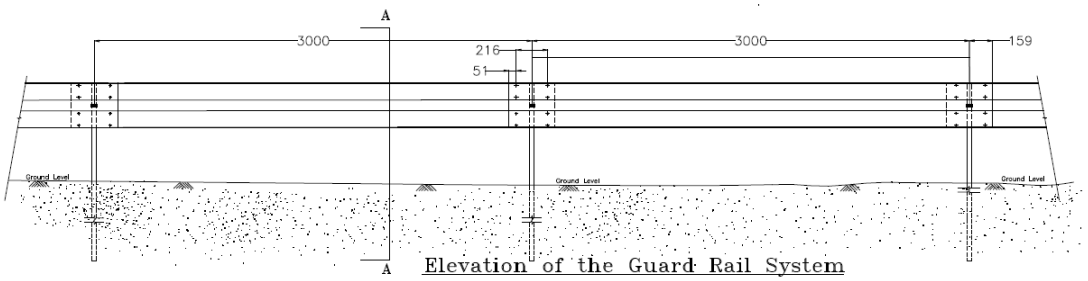
Retro-reflective road delineators are to be installed to provide visual assistance for drivers to obtain information on the alignment of the road ahead particularly at night. These are effective at locations involving change in horizontal/vertical geometry and during severe weather condition of heavy rain, fog or snow. IRC: 79-1981 stipulates the standards for the post type delineators with retro-reflective units.

The length of guard rails is considered based on the drawings of each Bypass. The length of guard rails and image are shown in below.

Table 7.15 Guard Rails Estimated for NH54 Bypass

SOR No.	Item	Unit	Chhiahtlang Bypass	Serchhip Bypass	Hnahthial Bypass	Lawngtlai Bypass
8.23-A	Type - A, "W" : Metal Beam Crash Barrier (Providing and erecting a "W" metal beam crash barrier comprising of 3 mm thick corrugated sheet metal beam rail, 70 cm above road/ground level, fixed on ISMC series channel vertical post, 150 x 75 x 5 mm spaced 2	metre	1,200	3,150	1,200	1,250

Source: JICA Study Team



Source: Detailed Project Report for National Highway No.54 Section-3

Figure 7.1 Typical Guard Rail

Street furniture known as road studs, blinker or cat's eye include equipment installed on road or roadside to assist visibility of road alignment/structures. They are retro-reflective safety devices used in road marking. Generally, it consists of two pairs of reflective glass spheres set into a white rubber dome, mounted in a cast-iron housing. This is the kind that marks the center of the road, with one pair

of devices showing in each direction. A single-ended form has become widely used in other colors at road margins and as lane dividers. Street furniture are suggested to be installed at center and both side of road of location as follows. Space of street furniture is 2 m from each other.

- Sharp outer curve
- Near houses
- Section in parallel with other road
- Center and both side

The quantity of street furniture are estimated as shown below.

Table 7.16 Street Furniture Estimated for NH54

SOR No.	Item	Unit	Chhiahtlang Bypass	Serchhip Bypass	Hnahthial Bypass	Lawngtlai Bypass
8.35	Road Markers/Road Stud with Lense Reflector (Providing and fixing of road stud 100x 100 mm, die cast in aluminium, resistant to corrosive effect of salt and grit, fitted with lense reflectors, installed in concrete or asphaltic surface by drilling hole 30 mm upto a depth of 60 mm and bedded in a suitable bituminous grout or epoxy mortar, all as per BS 873 part 4:1973)	each	1,650	7,200	3,600	1,650

Source: JICA Study Team

(2) GHG emissions

There is a possibility of increased GHG emission due to the operation of heavy vehicles as well as traffic jams incidental to the construction works, this impact will be temporary. On the other hand, it is expected that the GHG emission will be increase due to increase traffic volume. The increase will be mitigated by keeping good road conditions which will reduce consumption of extra fuel and congestion, thereby mitigating GHG emissions over time.

Deforestation is one of the main causes of climate change. The project clears forest in hilly and mountainous slopes to construct new bypasses, which results in GHG emissions. The loss of forest also means the loss of long-term carbon sequestrating capacity. Given that more than 20% of the entire Mizoram state is jhum field, which is regularly burned yearly with considerable GHG emissions, the impact of the project in terms of GHG emission volume will be minor. Yet, as per the requirement of Forest Act, the project will undertake reforestation to compensate the loss of forest. Indeed, it is planned that more trees will be planted than cut due to the project, and therefore, the project will result in net increase in carbon sequestration capacity in the State in the long-term. The detailed terms and conditions of reforestation will be finalized in consultation with the Environment and Forest Department of the State.

CHAPTER 8 ENVIRONMENT MANAGEMENT AND MONITORING PLAN

8.1 Overview

Descriptions of environment management measures during different stages of the project are provided in this chapter.

8.1.1 Pre-construction Stage

Required management measures during the pre-construction stage include the clearance of the ROW, plantation of trees, the measures for protecting/replacing community resources such as electric poles, public urinals and water points that are likely to be impacted. Their enhancement shall also be completed before construction work starts so that the community can start using these when the construction activity begins.

8.1.2 Construction Stage

This will be most crucial and active stage for the Environmental Management Plan (EMP). In addition to the monitoring of the construction activity itself to ensure that the environment is not damaged beyond permissible limits, mitigation and enhancement measures, such as proper treatment of spoil soils to prevent soil erosion, will be undertaken. In addition, the provision of proper risk management with respect to construction activities such as accidental spillage is critical at this stage to avoid damage to flora and fauna, jhum land and other sensitive resources. Typical locations of concerns include the locations of hot-mix plants (spillage of fuel, bitumen etc.) and labor camp sites.

8.1.3 Operation Stage

The operation stage will essentially entail monitoring activity along the project area. In addition to checking the efficacy of the protection/ mitigation/ enhancement measures implemented, this will help verify the predictions made as a part of the impact assessment. As such, it will complete a very important feedback loop for the project.

8.2 Environment Management Plan

The detailed measures adopted and/or to be adopted during different stages of the project to mitigate negative impacts and enhance positive aspects are shown in Table 8.1 to 8.3. The responsibility for implementation and supervision of EMPs are vested with three agencies, namely Contractors, PIU, and Supervision consultants (SC). The Contractors herein mean the agency hired for execution of the construction works for the respective contract packages. PIU would be implementation agency. The Figure below indicates implementation structure of the EMP.

It has been proposed that Executive Engineer (environment) will be in charge for the implementation of EMP for this project. Such an engineer will be assisted by Assistant Engineer (Environment), who will be assisted by a Junior Engineer as well as Supervision consultant (and Environment Specialist) and contractor. The construction supervision consultant are expected to have in-house capacity to advise on and supervise the implementation of the EMP including suggesting enhancement design options and modifications, as necessary. For this purpose, the supervision consultant will employ a full-time environmental specialist.

The NGO will be one of the stakeholders in the entire project cycle with primary responsibility of facilitating the implementation of Resettlement Action Plan and helping NHIDCL/State Government in mitigating the adverse impacts of the project. They can also play a role in successful implementation of EMP, for example by supporting afforestation activity and awareness-raising campaign for traffic safety and risk of HIV/AIDS, among others. Compensatory forestation and maintenance and protection of vegetation will be required as part of environmental mitigation and enhancement works. Likewise, spoil soils shall be used, where possible, to create community assets such as playground as per request of the community. In these types of works, the project may engage NGO such as Young Mizo Association (YMA) to liaise with local community for effective implementation of the project.

Table 8.1 Environmental Management Plan for Pre-Construction Stage

Sl. No	Environmental Impact	Mitigation Measures	Location	Time Frame	Responsibility	
					Implementation	Supervision
Social Environment						
P1	Involuntary Resettlement	● All requirements of the RAP as applicable shall be completed before start of construction works. The activities broadly include acquisition of land and structures, relocation of utilities, payment of compensation and provision assistance	All areas (involuntary resettlement takes place in Bypass 1 and 2)	Before construction begins	Government of Mizoram, District Revenue authorities, Village Councils, NGO	PIU, SC
P2	Land Use ■ Deforestation	● Minimize the scale of vegetation clearing / damage to jhum field by factoring vegetation/forest cover in the final design of the bypass route alignment process ● Removal of trees to be carried out after forest clearance is obtained ● Reforestation/replantation of trees at a term as instructed by the Forest Department ● Activity shall be supervised to avoid poaching of animals	All areas	Before construction begins (Reforestation /plantation may extend to during/after construction)	PIU, Contractor, Forest Dept.	PIU, SC, Forest Dept.
	■ Setting up construction camp	● Construction camps shall be located reasonably away from the nearest built-up area to avoid nuisance ● Sewage system for a construction workers' camp shall be designed, built and operated to prevent pollution to ground or adjacent water body. Garbage bins shall be provided in the camps and regularly emptied and the garbage disposed of in a hygienic manner, to the satisfaction of the relevant norms and the Engineer. ● All relevant provisions of the Factories Act, 1948 and the Building and other Construction Workers (regulation of Employment and Conditions of Service) Act, 1996 shall be adhered to.	All construction campsite identified by the contractor and approved by SC	During Establishment, Operation and Dismantling of Such Camps	Contractor	PIU, SC

	■ Setting up hot-mix plant	● Hot mix plants and batching plants shall be located sufficiently away from habitation and agricultural operations. ● Where possible such plants will be located at least 1,000 m away from the nearest habitation.	All hot-mix and batching plants	During Erection, Testing, Operation and Dismantling of Such Plants	Contractor	PIU, SC
	■ Finalize the location of soil dumping site	● Location of dumping sites shall be finalized in consultation with relevant village authorities. The site and its design shall meet following conditions: i) dumping does not impact natural drainage courses; ii) no endangered/rare flora is impacted by such dumping	All areas identified as potential dumping sites	During mobilization	Contractor	PIU, SC
P3	Identification of hazard-prone locations	● The contractor shall identify locations sensitive to landslides (in addition to the ones that area already identified) and shall duly report these to the Supervision Consultant (SC) and to PIU.	All areas	During mobilization	Contractor	PIU, SC
P4	Local Economy and Livelihood	● Implementation of Income Restoration Plan	PAPs	Before construction work begins	State Gov.	State Gov.
P5	Unequal distribution of benefits and damage	● Implementation of Income Restoration Plan	PAPs	Before construction work begins	State Gov.	State Gov.
P6	Religious facilities	● Select the route that minimizes the impact	All areas	Detailed Design	NHIDCL	State Gov.
P7	Sensitive Facilities	● Select the route that minimizes the impact	All areas	Detailed Design	NHIDCL	State Gov.
P8	Poor People	● Implementation of Income Restoration Plan	PAPs	Before construction work begins	State Gov.	State Gov.
P9	Minority/Indigenous People	● Implementation of Income Restoration Plan	PAPs	Before construction work begins	State Gov.	State Gov.
P10	Children's Right	● Provide assistance to children who need to commute longer to school	Children in education	Before construction work begins	State Gov.	State Gov.

Source: JICA Study Team

Table 8.2 Environmental Management Plan for Construction Stage

Sl. No	Environmental Impacts/Issues	Mitigation Measures	Location	Time Frame	Responsibility	
					Implementation	Supervision
Natural Environment						
C1	Topography	● Treat residual soil properly	Soil dumping site	Construction state	Contractor and Supervision Consultant	PIU
C2	Soil Erosion	● The depth of borrow pits shall be restricted so that sides of the excavation shall have a slope not steeper than 1:4 from the edge of the final section of the bank, if applicable	On approved locations of borrow pits.	Construction Stage	Contractor and Supervision Consultant	PIU
		● 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
		● Construction equipment and vehicles shall be restricted to move only within designated area to avoid compaction of productive soil	All areas	Construction Stage	Contractor and Supervision Consultant	PIU
		● Pitching shall be done for slope stabilization as per the IRC guidelines, if applicable	At the places of embankments	Construction Stage	Contractor and Supervision Consultant	PIU
C3	Hydrology	● Construction vehicles and equipment shall be operated and maintained in such a manner so that soil contamination due to its spillage shall be minimum ● Fuel storage shall only be done on vacant area and will be kept away from drainage channels and natural water bodies	Near Labor camp and sites of installation of construction machineries.	Construction Stage	Contractor and Supervision Consultant	PIU

C4	Ecosystem, Flora, Fauna, Biodiversity and Forest	● Three trees shall replace each tree cut for the purpose (as suggested by Environment and Forest Dept. Mizoram). ● The Engineer shall approve such felling only when the NHIDCL receives a "clearance" for such felling from the MOEF, as 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 and Supervision Consultant Forest Dept.	PIU
		● During construction, at any point of time, if a rare/ threatened/endangered flora species is found, it shall be conserved in a suitable manner in consultation with authorities. The Engineer shall approve detailed conservation processes, plans and designs as well as associated modification in the project design.	Throughout the project area.	Construction Stage	Contractor and Supervision Consultant	PIU
C5	Natural Disaster	● Prepare for fire and water disasters ● Prepare first aid kit and keep contact information of local hospitals	All area	During construction	Contractor and Supervision Consultant	PIU
Living Environment						
C6	Air Quality	● 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. ● Only unleaded petrol and low sulfur diesel or sulfur free diesel shall be used as fuel for vehicles, equipment and machinery.	Wherever the hot mix plant and batching plant is set up.	Construction Stage	Contractor and Supervision Consultant	PIU
		● The asphalt plants, crushers and batching plants shall not be sited at least 500 m in leeward direction from nearest human settlement	Locations near Settlement	Construction Stage	Contractor and Supervision Consultant	PIU

		● Regular monitoring or air quality parameters during the construction period as envisaged in the Environmental Monitoring Plan.	Locations given in Environmental Monitoring Plan.	Construction Stage	Contractor and Supervision Consultant	PIU
		● The dust generated by vehicles on site shall be arrested using a water tanker fitted with sprinkler capable of applying water uniformly with a controllable rate of flow to variable widths of surface but without any flooding.	Wherever the plants are setup and sensitive locations as suggested in monitoring plan.	Construction Stage	Contractor and Supervision Consultant	PIU
C7	Water Quality	● Construction vehicles/ equipment shall be operated and maintained in such a manner to avoid contamination of water bodies due to oil spillage ● Fuel storage shall only be done on vacant area and will be kept away from drainage channels and natural water bodies	Near labor camp and sites of installation of Construction machineries.	Construction Stage	Contractor and Supervision Consultant	PIU
		Contamination of stagnant water body by fecal matters from labor camp	● Labor camp shall not be allowed near any of the water bodies ● The proper sanitation facilities shall be provided	Preapproved locations away from the water bodies	Construction Stage	Contractor and Supervision Consultant
		Deposition of dust in open wells near construction site	● The mouth/opening of the well shall be covered with suitable material when construction activity is taking place so as to prevent dust entering in the well	All the wells along the bypass route	Construction Stage	Contractor and Supervision Consultant
		●				P

C8	Noise and Vibration	● The plants and equipment used for construction shall conform to CPCB norms. ● 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. ● All equipment and plants shall strictly be placed away from educational institutes and hospitals. ● Regular monitoring of noise parameters (Leq) during the construction period as envisaged in the Environmental Monitoring Plan.	Wherever the plants are setup.	Construction Stage	Contractor and Supervision Consultant	PIU
		● Blasting as per Indian Explosives act will be carried out. ● People living near such blasting operation sites shall be informed before the operational hours. ● Workers at blasting sites shall be provided with earplugs.	At the sites where the blasting is required and in quarry sites	Construction Stage	Contractor and Supervision Consultant	PIU

C9	Waste/Hazardous Material	● Waste Management Plan to be prepared and approved prior to the commencement of construction work as per Construction and Demolition Waste Management Rules, 2016 ● Debris generated due to the dismantling of the existing pavement structure and the cutting of the hillside for the widening (where section of existing community road is used for new bypass) shall be suitably reused in the construction, such as for fill materials for embankments ● Debris and other material obtained from existing embankment shall be dumped in approved landfill site identified by concerned agency. All spoils shall be disposed of and the site shall be fully cleaned before hand over ● Construction waste including non-bituminous and bituminous waste shall be dumped in approved landfill site identified by State Pollution Control Board (SPCB) or competent authority. All spoils shall be disposed of and the site shall be fully cleaned before hand over ● Solid waste from construction workers' camp will be segregated as per Solid Waste Management Rules, 2016	Solid waste dump site identified and approved by SPCB or competent authority Throughout the area	Construction Stage	Contractor and Supervision Consultant	PIU
		● Demolish all buildings to ensure that waste and effluents pollute local environment	Construction camp	Upon completion of construction work	Contractor and Supervision Consultant	PIU
Social Environment						
C10	Land Use	●				
C11	Utilization of Local Resources	● Use drinking water in a way not to pressure local water availability	Construction site and camp	During construction	Contractor and Supervision Consultant	PIU
C12	Social Infrastructure and Services	● Schedule construction work to minimize disturbance ● Avoid disturbance to hospitals and schools	Local community	During construction	Contractor	Engineer

		● Prepare traffic plan and submit to engineer and inform the local people	Local community	During construction	Contractor	Engineer
C13	Local Economy, Livelihood	● Schedule construction work to minimize disturbance	Local community	During construction	Contractor	Engineer
C14	Unequal distributions of benefits and damage	● Schedule construction work to minimize disturbance ●	Local community	During construction	Contractor	Engineer
C15	Religious facilities	● Avoid impacts to major religious events, particularly Sunday mass	Local community	During construction	Contractor	Engineer
C16	Sensitive facilities	● Schedule construction work to minimize disturbance	Local community	During construction	Contractor	Engineer
C17	Poor people	● Implementation of IRP	PAP	Prior to construction work	State Gov.	State Gov.
C18	Ethnic minorities/indigenous people	● Implementation of IRP	PAP	Prior to construction work	State Gov.	State Gov.
C19	Gender	● Promote women's participation in construction work ● Separate camp area for men and women	Construction site and camp	During construction	Contractor and Supervision Consultant	PIU
C20	Children's right	● Never allow child labor	Construction site and camp	During construction	Contractor and Supervision Consultant	PIU
C21	Public Health	● Reclamation measure shall be adopted with garland 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
		Prepare and distribute brochures /information kit on HIV/AIDS to construction workers and truck drivers	All construction sites and workers' camp	During construction	Contractor and Supervision Consultant	PIU

C22	Occupational Health	● 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 has to comply with all regulation 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
		● Adequate precautions will be taken to prevent danger from electrical equipment. No material or 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 Indian Standards (IS) codes, will be free from patent defect, 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.	All construction Site	Construction stage	Contractor and Supervision Consultant	PIU

		● All workers employed on mixing asphaltic material, cement, lime mortars, concrete etc., will be provided with protective footwear and protective goggles. Workers, who are engaged in welding works, would 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 chemical shall be strictly in accordance with the manufacturer's instructions. The Engineer shall be given at least 6 working day's notice of the proposed use of any herbicide or toxic chemical. 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. This should comply with Hazardous Material Act.	All construction sites	Construction stage	Contractor and Supervision Consultant	PIU
		● Nobody below the age of 18 years and no woman shall be employed on 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. ● Facemasks will be supplied for use by the workers when paint is applied in the form of spray or a surface having lead paint dry rubbed and scrapped	All construction sites	Construction stage	Contractor and Supervision Consultant	PIU
Others						

C23	Accident	● 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, particularly in section where the bypass intersects with existing 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
		● 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 has to comply with all regulation 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
		● Adequate precautions will be taken to prevent danger from electrical equipment. No material or 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 Indian Standards (IS) codes, will be free from patent defect, 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.	All construction Site	Construction stage	Contractor and Supervision Consultant	PIU

		● Except as may be provided in the contract or ordered or authorized by the Engineer, the Contractor shall not use explosives. Where the use of explosives is so provided or ordered or authorized, the Contractor shall comply with the requirements of the following Sub-Clauses of this Clause besides the law of the land as applicable. ● 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 make full liaison with and inform well in advance and obtain such permission as is required from all Government Authorities, public bodies and private parties whatsoever concerned or affected or likely to be concerned or affected by blasting operations.	Place of use of Explosives	Construction stage	Contractor and Supervision Consultant	PIU
		● 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 has to comply with all regulation 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

		● Adequate precautions will be taken to prevent danger from electrical equipment. No material or 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 Indian Standards (IS) codes, will be free from patent defect, 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.	All construction Site	Construction stage	Contractor and Supervision Consultant	PIU
		● 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 areas where bypass intersects with existing 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. ● Special consideration shall be given in the preparation of the traffic control plan to the safety of pedestrians and workers at night. ● The Contractor shall ensure that the running surface is always properly maintained, particularly during the monsoon so that no disruption to the traffic flow occurs. As far as possible idling of engines shall be avoided to curb pollution.	Near built-up areas	During Construction.	Contractor	Engineer
C24	Climate Change	● Reforestation	Location As designated by Forest Dept.	From before the construction work	Contractor and Supervision Consultant	Forest Dept.

Source: JICA Study Team

Table 8.3 Environmental Management Plan for Operation Stage

Sl. No	Environmental Impacts/Issues	Mitigation Measures	Location	Time Frame	Responsibility	
					Implementation	Supervision
Natural Environment						
O1	Soil erosion	● Prevent soil erosion by proper slope protection and turfing	All area	Continue from construction stage	Contractor and Supervision Consultant	PIU
O2	Hydrology	● Install Gabion and Apron concrete at Calvert	All area	Continue from construction stage	Contractor and Supervision Consultant	PIU
O3	Ecosystem, forest	● Trees planted for reforestation shall be maintained for a period of three years. Maintenance works include, watering of the saplings, replacement of the bamboo fence (if applicable) every year for three years and other necessary measures for survival of the sapling. ● Monitoring of flora and fauna along the highway shall be carried out to assess conditions of ecosystem against the baseline. Condition of nearby protected area shall be collected from Environment Department for checking any indirect impacts due to greater traffic volume.	All area and as per the monitoring plan	Immediately from the planting of sapling, and as per monitoring plan	PIU, NGO	PIU
O4	Natural disaster	● Prevent soil erosion by proper slope protection and turfing	All area	Continue from construction stage	Contractor and Supervision Consultant	PIU
Living Environment						
O5	Air Quality	● Monitoring shall be carried out as specified in the Monitoring plan ● Share air quality data with SPBC and relevant agencies and discuss options for mitigate air quality degradation associated with greater traffic volume	As specified in the monitoring plan	As per monitoring plan	PIU, SPCB	PIU

O6	Water Quality	● Silt fencing, oil & grease traps, etc. shall be provided at sensitive water bodies to ensure that the water quality is not impaired due to contaminants from road run-off ● Monitoring shall be carried out as specified in the monitoring plan	As specified in the monitoring plan	As per monitoring plan	PIU, SPCB	PIU
		● Contingency plans to be in place for cleaning up of spills of oil, fuel and toxic chemicals ● Monitoring shall be carried out as specified in the Monitoring Plan	All area and as specified in the monitoring plan	Plan to be developed at state/district level by early operation stage	PIU, SPCB, Local Government Bodies	PIU
O7	Noise and Vibration	● Monitoring shall be carried out as specified in the Monitoring plan ● Install noise barrier (wall etc.) in sensitive areas, if necessary	As specified in the monitoring plan	As per monitoring plan	PIU, SPCB	PIU
O8	Waste and Hazardous Material	● Compliance with the Hazardous Wastes (Management and Handling) Rules, 1989 including: ✓ For delivery of hazardous substances, permit license, driving license and guidance license will be required. ✓ These vehicles will only be harbored at designated parking lots. ✓ In case of spill of hazardous materials, the relevant departments will be notified at once to deal with it with the spill contingency plan.	All area	Manual/guideline to be prepared during early operation stage	PIU	PIU
Social Impact						
O9	Unequal distribution of benefits and damages	● Monitoring of Resettled PAH, implementation of IRP	PAH	Post resettlement	State Gov	State Gov
O10	Religious Facilities	● Monitoring (particularly for noise and vibration)	As per monitoring plan	As per monitoring plan	PIU, SPCB	PIU
O11	Sensitive Facilities	● Monitoring (particularly for noise and vibration)	As per monitoring plan	As per monitoring plan	PIU, SPCB	PIU
O12	Public Health	● Public awareness camplaign for HIV/AIDS and other STDs	All areas	Continue from construction stage	PIU/NGO	PIU
O13	Occupational Health	● Same as construction state measures	All area	From Construction state	PIU	PIU

Other						
O14	Accidents	● Traffic control measures including speed limits to be enforced strictly. ● Local government bodies and development authorities will be encouraged to control building development along the highway.	All area	Throughout operation stage	PIU, Local Government Bodies	PIU
O15	Climate Change	● Trees planted for reforestation shall be maintained for a period of three years. Maintenance works include, watering of the saplings, replacement of the bamboo fence (if applicable) every year for three years and other necessary measures for survival of the sapling. ● Monitoring of flora and fauna along the highway shall be carried out to assess conditions of ecosystem against the baseline. Condition of nearby protected area shall be collected from Environment Department for checking any indirect impacts due to greater traffic volume.	All area and as per the monitoring plan	Immediately from the planting of sapling, and as per monitoring plan	PIU, NGO	PIU

Source: JICA Study Team

Based on the above, the cost for implementation of EMP is provisionally estimated as Rs. 120 lakh.

8.3 Environment Monitoring Plan

To ensure effective implementation of the EMP, it is essential that an effective monitoring plan be designed and carried out. The environmental monitoring plan provides such information on which management decision may be taken during construction and operational phases. It provides basis for evaluating the efficiency of mitigation and enhancement measures and suggest further actions that need to be taken to achieve the desired effect. The monitoring includes: i) Visual observations; ii) Selection of environmental parameters at specific locations; and iii) Sampling and regular testing of these parameters.

Monitoring methodology covers the following key aspects: Components to be monitored; parameters for monitoring of the above components; monitoring frequency; monitoring standards; responsibilities for monitoring; direct responsibility, overall responsibility; and monitoring costs. Environmental monitoring of the parameters involved and the threshold limits specified are discussed below.

Ambient air quality

Ambient air quality parameters recommended for monitoring road transportation developments are PM10, PM 2.5, Carbon Monoxide (CO), Oxides of Nitrogen (NO_X), Sulphur Dioxide (SO_2) and Lead (Pb). These will be monitored at designated locations starting from the commencement of construction activity. Data should be generated at all identified locations in accordance to the National Ambient Air Quality Standards, 2009. The location, duration and the pollution parameters will be monitored and the responsible institutional arrangements are detailed out in the Monitoring Plan.

Water quality

The physical and chemical parameters recommended for analysis of water quality relevant to road development projects are pH, total solids, total dissolved solids, total suspended solids, oil and grease, COD, chloride, lead, zinc and cadmium. The location, duration and the pollution parameters to be monitored and the responsible institutional arrangements are detailed in the Environmental Monitoring Plan. The monitoring of the water quality is to be carried out at all identified locations in accordance to the Indian Standard Drinking Water Specification – IS 10500: 1991.

Noise and Vibration

The measurements for monitoring noise levels would be carried out at all designated locations in accordance to the Ambient Noise Standards formulated by Central Pollution Control Board (CPCB) in 1989. Noise should be recorded at an "A" weighted frequency using a "slow time response mode" of the measuring instrument. The location, duration and the noise pollution parameters to be monitored and the responsible institutional arrangements are detailed in the Environmental Monitoring Plan

The monitoring plan for the various performance indicators of the project in the construction and operation stages is summarized in the Table 8.4.

Table 8.4 Environmental Monitoring Plan

Sl. No	Item	Project Stage	Parameters	Guidance	Standards	Location	Frequency	Duration	Responsibility	
									Implementation	Supervision
M1	Air	Construction	SPM, RSMP, SO_2, NOx, CO, HC	• Dust sampler to be located 50m from the plan in the downwind direction. • Use method specified by CPCB for analysis	Air (P&CP) Rules, CPCB, 1994	Hot mix plant/ batching plant	Twice a year for three years	Continuous 24 hours	Contractor through approved monitoring agency	PIU
M2		Construction	SPM, RSPM	• Dust sampler to be located 50m from the earthworks site downwind direction. Follow CPCD method for analysis	Air (P&CP) Rules, CPCB, 1994	Stretch of road where construction is underway	Twice a year for three years	Continuous 24 hours	Contractor through approved monitoring agency	PIU
M3		Operation	SPM, RSMP, SO_2, NOx, CO, HC	• Use method specified by CPCB for analysis	Air (P&CP) Rules, CPCB, 1994	Sampling location specified in EIA report	Twice a year for one year	Continuous 24 hours	PIU	PIU
M4	Water	Construction	pH, BOD, COD, TDS, TSS, DO, Oil & Grease and Pb	• Sample collected from source and analyze as per Standard Methods for Examination of Water and Wastewater	Water quality standards by CPCB	Sampling locations specified in EIA report	Twice a year for three years		Contractor through approved monitoring agency	PIU
M5		Operation	pH, BOD, COD, TDS, TSS, DO, Oil & Grease and Pb	• Grab sample collected • from source and analyze as per Standard Methods for Examination of Water • and Wastewater	Water quality standards by CPCB	Sampling locations specified in EIA report	Twice a year for one year		PIU	PIU
M6		Operation	Cleaning of drains and water bodies	• Choked drains, water bodies undergoing siltation and subject to debris disposal should be monitored under cleaning operations	To the satisfaction of the engineer (PWD)	All area	Post-monsoon		PIU	PIU

M7	Noise and vibration	Construction	Noise levels on dB (A) scale	• Free field at 1m from the equipment whose noise levels are being determined	Noise standards by CPCB	At equipment yard	Once every 3 Month (max) for three years, as required by the engineer	Reading to be taken at 15 seconds interval for 15 minutes every hour and then averaged	Contractor through approved monitoring agency	PIU
M8		Operation	Noise levels on dB (A) scale	• Equivalent Noise levels using an integrated noise level meter kept at a distance of 15 m from edge of Pavement	Noise standards by CPCB	At maximum 15 sites inc. those listed in EIA report for noise monitoring locations	Twice a year for 1 years	Readings to be taken at 15 seconds interval for 15 minutes every hour and then averaged.	PIU	PIU
M9	Soil erosion	Construction	Turbidity in Storm water; Silt load in ponds, water courses	• Visual observations during site visits	As specified by the engineer / Water quality standards	At locations of stream crossings and at locations of retaining wall and breast wall	Pre-monsoon and post-monsoon for three years		Contractor	PIU
M10		Operation	Turbidity in Storm water; Silt load in ponds, water courses	• Visual observations during site visits	As specified by the engineer / Water quality standards	As directed by the engineer	Pre-monsoon and post-monsoon for one year		PIU	PIU
M11	Construction camp	Construction	Monitoring of: 1.Storage Area; 2. Drainage Arrangement 3. Sanitation in Camps	• Visual Observations and as directed by the engineer	To the satisfaction of the engineer and Water quality standards	At storage area and construction workers' camp	Quarterly during construction stage		PIU	PIU

M12	Afforestation	Construction and operation	Plant survival	• The success of tree planting. Monitor the rate of survival after six months, one year and 18 months in relation to total numbers of trees planted		All area	Minimum three years after planting		NGO, PIU	PIU
M13	Flora and Fauna	Construction and Operation	Condition of ecosystem	• Comparison to pre-project flora and fauna	As specified in TOR	As specified in TOR	Twice a year for three years		PIU	PIU

Source: JICA Study Team

CHAPTER 9 PUBLIC CONSULTATION AND INFORMATION DISCLOSURE

Stakeholder consultation is an important method of involving various stakeholders particularly, local community with reference to the proposed development initiatives. Consultations provide a platform to participants to express their views, concerns and apprehensions that might affect them positively or negatively. This process is of particular importance for this project given the high ST share among the affected population. The World Bank OP 4.10 on Indigenous Peoples emphasizes "a process of free, prior, and informed consultation with the affected Indigenous People's communities at each stage of the project, and particularly during project preparation, to fully identify their views and ascertain their broad community support for the project. Stakeholder Through participation and consultation stakeholders influence development initiatives, and decision-making process. The effectiveness of participation and consultation is directly related to the degree of involvement by the likely project affected persons and the local community and integration of outcome of consultations wherever feasible in the proposed development initiatives.

The purpose of consultations was to inform people about the project, take note of their issues, concerns and preferences, and allow them to make meaningful choices. It ensured participation of potential project affected persons (PAPs), local community and other stakeholders. People in general were informed in advance, and allowed to participate in free and fair manner. Consultations provided meaningful contributions with regard to reducing adverse impacts, address safety issues, etc. Concerns, views and suggestions expressed by the participants during these consultations were integrated into the design aspects wherever feasible. The following sections present details of the consultations.

9.1 Schedule and Attendance of Consultation Meetings

The schedule and attendance of 1st round of consultation meetings are shown below.

Table 9.1 Schedule and Attendance of 1st Round of Consultation

Bypass	Date	No. of Attendees		
		M	F	Total
BP1	26 February 2016	30	10	40
BP2	24 February 2016	14	1	15
BP3	23 February 2016	68	14	82
BP4	22 February 2016	39	6	45
	Total	151	31	182

The 2nd round of consultation meetings were organize meetings per Village Council in response to the request from the community so that participants can discuss issues thoroughly. Hence, a total of nice consultation meetings were held. In addition, additional briefing session targeting two Village Council in BP2 area was held in July 23rd and 25th for those who have missed the official consultation meetings. The two meetings were attended by 12 and 17 people respectively.

Table 9.2 Schedule and Attendance of 2nd Round of Consultation

Bypass	Date	Target VC	No. of Attendees		
			M	F	Total
BP1	12 July 2016	Chhiathlang VC,	45	16	61
BP2	11 July 2016	New Serchhip 'North' and 'South'	51	15	66
	11 July 2016	New Serchhip, 'P& E'	21	5	26
	12 July 2016	New Serchhip, ' Thianga' VC VII, VC II, 'Court '	13	13	26
		BP2 Total	85	33	118
BP3	8 July 2016	Peniel VC	42	7	49
	9 July 2016	Hnathiel N 1	28	7	35
	13 July 2016	Hnathiel N 2, 'Court'	13	3	16
		BP3 Total	83	17	100
BP4	6 July 2016	Lawngtlai VC, College Veng	8	2	10
	7 July 2016	Lawngtlai VC, Chanmary	13	2	15
		BP4 Total	21	4	25
Overall Total			**234**	**70**	**304**

Source: JICA Study Team

9.2 Key Concerns and Opinions Raised During Consultation Meetings

During the consultation meetings, the preliminary alignment was presented with participants and it was explained that the proposed bypass is in response to the request from the community who would like to have a new bypass rather than widening of the existing road during consultation meetings held in 2015. Participants were also informed of the results of environmental impact assessment and proposed measures for mitigation and management plan for each stage of project implementation. Also, they were informed of the activities related to land acquisition and resettlement, including social impact assessment to be carried out by the Government of Mizoram and proposed Grievance Redress Mechanism. Major concerns and comments raised during the meetings and responses from NHIDCL and relevant government officers such as Revenue and Environment and Forest Department are summarized below. In the table, issues/comments specific to a particular bypass is marked in bracket.

At the end of the meeting, PAHs (for all four bypasses) expressed their support to the project and demanded that the project be implemented as soon as possible. Some reminded that fair and timely payment of compensation will be crucial for smooth and successful implementation of the project.

Table 9.3 Summary of Consultation Meetings

Bypass	Key Concerns/Comments	Responses
BP1: Chhiahtlang	*General issues* • While appreciating the new bypass project, participants requested that the alignment be finalized as soon as possible because they may need to adjust their plan for renovating their current house or constructing a new agricultural hut.	• A satellite imagery with proposed alignment was presented at the meeting, and participants were assured that the final alignment will be shared with them as soon as they are ready. Also, social impact assessment will be carried out by the Government of Mizoram so that their views and concerns can be incorporated in the final design, if necessary.

	• Village Council members suggested that vegetation be cleared so that villagers can clearly see the proposed alignment in hilly area.	• Clearance of vegetation and forest will be done after forest clearance permit is obtained. Also, reforestation will be carried out to offset the loss of forest.
	Environment and Social Impacts • PAHs raised concerns about the treatment of surplus soil. Proper dumping areas should be allocated for debris created because of the project. Based on their past experience, they do not trust what is written in paper (such as EMP) and want to have a mechanism that actually works.	• In addition to the provisions in EMP for properly managing surplus soil, monitoring will be undertaken both internally and externally so that any deviation or negligence of environmental safeguards will be identified and rectified. • Also, PAHs and village council members were encouraged to use surplus soil for local construction (for playground etc.) if appropriate.
	• Further, natural stream and springs should not be affected by the soil debris created by the project or cutting of hills etc.	• The bypass is designed in a way to minimize impacts to jhum land, for example by not disturbing natural waterways.
	• Participants while recognizing that some deforestation will essentially be done because of the project, suggested that to offset the damage, afforestation will also need to be considered. Endangered species, if any, should be protected during project execution. • Forests need to preserved and protected as much as possible with least or minimal clearing of the vegetation.	• Afforestation will be carried out to offset the impact in consultation with the Forest Department. • While no endangered species has been confirmed in the project area during the field surey, appropriate protection measures will be implemented if/when they are spotted. Construction workers will be informed of key characteristics of such species so that they can identify the species.
	•	
	• Improper sanitation of workers in camp or local inhabitants may also pollute water, particularly drinking water sources. Participants suggested that the construction camp, if needed, should be provided with appropriate waste disposal and sanitation facilities in order to avoid such pollution.	• As per the provisions in EMP, proper sanitation and waste disposal facilities will be provided at workers camp. Also, the location of workers camp will be decided so as not to cause nuisance to built-up area.
	• Some raised concerns if construction of bypass will increase the risk of landslide. Also, they were worried about the potential impacts on their jhum land that will be bifurcated by bypass	• Slope protection measures will be installed to reduce the risk of land slide and other hazard. The risk will actually decrease compared with no-project scenario.
	• PAHs asked if local graveyard is affected by the project (BP1).	• It was confirmed that local graveyard will not be affected by the project.
	Other Issues • Recognizing the benefits of the project, participants highlighted the need for	• Iterative consultations will be carried out

	awareness campaign as part of community mobilization and preparedness for the project, to make them aware about the project and its benefits.	in the course of project implementation as well as preparation and implementation of rehabilitation plan.