

**Pollution Control Board, Assam**  
**Conservation of River Kolong, Nagaon**  
**Detailed Project Report**  
**December 2013**

**DRAFT**



Joint Venture of THE **Louis Berger Group**, INC  
and **DHI (India) Water & Environment Pvt. Ltd.**





# CONTENTS

contents i

FIGURES vii

TABLES Error! Bookmark not defined.

LIST OF ABBREVIATIONS .....x

EXECUTIVE SUMMARY .....1

Conservation Schemes and Summary of Costs.....2

**1 About the Project Area.....1-1**

1.1 Authority for preparation of project .....1-1

1.2 Description of Project Area.....1-1

1.2.1 Brief History of the town .....1-1

1.2.2 Geographical Location .....1-1

1.3 Population in the Project Area .....1-2

1.4 Status of water supply .....1-2

1.5 Status of existing waste water disposal system .....1-2

1.6 Status of drains .....1-2

1.7 River Water quality .....1-2

1.8 Justification of the project for pollution abatement of the river .....1-2

**2 Collection of Data.....2-1**

2.1 Introduction .....2-1

2.2 Data Required at Different Levels.....2-1

2.2.1 Drainage Basin Map.....2-1

2.2.2 Raster Layers.....2-2

2.2.3 Shape Layers .....2-3

2.3 Town Related Data.....2-4

2.3.1 Maps Related to City .....2-4

2.3.2 Land Use, Contour, Drainage and Other Thematic Maps: .....2-5

2.3.3 Use of State of Art Tools like Remote Sensing and GIS .....2-5

2.3.4 Population of the Town:.....2-5

2.3.5 Land Use, Contour, Drainage and Other Thematic Maps: .....2-7

2.3.6	Use of State of Art Tools like Remote Sensing and GIS .....	2-7
2.3.7	Population of the Town .....	2-8
<b>3</b>	<b>Conservation Measures .....</b>	<b>3-1</b>
3.1	General Conservation Framework .....	3-1
3.2	Road Map for the Conservation of Kolong River .....	3-1
3.3	Root Cause Analysis & Measures Solution Options.....	3-3
<b>4</b>	<b>Sewerage Schemes .....</b>	<b>4-1</b>
4.1	Approach .....	4-1
4.1.1	Design Criteria.....	4-3
4.1.1.1	System configuration .....	4-3
4.1.1.2	Wastewater Generation Rate.....	4-3
4.1.1.3	Groundwater Infiltration .....	4-5
4.1.1.4	Depth of Flow .....	4-5
4.1.1.5	Peak Factor .....	4-5
4.1.1.6	Hydraulic Design Formula.....	4-6
4.1.1.7	Flow Velocity and Gradient .....	4-6
4.1.1.8	Maximum Depth to Invert.....	4-7
4.1.1.9	Minimum Cover and Sewer Protection.....	4-7
4.1.1.10	Minimum Pipe Diameter .....	4-7
4.1.1.11	Sewer Transition.....	4-7
4.1.1.12	Material of Sewer Line .....	4-7
4.1.1.13	Structural Design of Sewer .....	4-12
4.1.1.14	Manhole.....	4-12
4.1.1.15	Sewer Crossing .....	4-14
4.1.1.16	Sewage Pumping Station.....	4-14
4.1.1.17	Sewer Warning Tape .....	4-17
4.1.2	Design Periods .....	4-17
4.1.3	Population Projections .....	4-18
4.1.4	Norms of Rate of Water Supply .....	4-18
4.2	Calculation of Waste Water Discharge.....	4-19
4.2.1	Actual Water Supply from Different Sources .....	4-19
4.2.2	Projected Waste Water Flows.....	4-19
4.3	Decentralized STPs .....	4-21
4.3.1	Projected Waste Water Flows in each District in Design years .....	4-21
4.3.2	Length of Sewer Lines and Capacity of SPS, STPs in each District.....	4-22

4.3.3	Availability of Land for various Components in each District.....	4-22
4.3.4	Cost of STP including O&M.....	4-23
4.3.5	Cost of proposed sewer network including O&M costs .....	4-24
<b>5</b>	<b>Solid Waste Management .....</b>	<b>5-1</b>
5.1	Introduction .....	5-1
5.2	Existing Situation.....	5-1
5.2.1	Baseline information.....	5-1
5.2.2	Deficiencies in SWM System.....	5-6
5.2.3	Justification for Upgrading the Present System or a New System .....	5-7
5.3	Proposed MSW Management System.....	5-7
5.4	Details of Proposed MSW Management System .....	5-8
5.4.1	Calculation of Infrastructure required.....	5-9
5.4.1.1	Secondary Waste Storage System .....	5-9
5.4.1.2	Proposed Infrastructure for Secondary Waste Collection System:.....	5-10
5.4.1.3	Waste Transportation System .....	5-10
5.5	Landfill site .....	5-11
5.5.1	Landfill design .....	5-11
5.5.2	Layout of the MSW landfill.....	5-12
5.5.3	Completed Waste Fill Features .....	5-13
5.5.4	Estimation of landfill Capacity.....	5-14
5.5.4.1	Selection of Liner Systems.....	5-14
5.5.4.2	Selection of Leachate Control Facilities.....	5-15
5.5.4.3	Selection of landfill Gas Control Facilities .....	5-15
5.5.4.4	Aesthetic Considerations.....	5-15
5.5.4.5	Monitoring Facilities.....	5-16
5.5.4.6	Determination of Equipment Requirements .....	5-18
5.5.4.7	Design Life .....	5-18
5.5.4.8	Post Closure Care .....	5-18
5.5.4.9	Technical Specifications .....	5-18
5.6	Proposed Institutional Framework .....	5-19
5.7	Cost Estimate.....	5-20
<b>6</b>	<b>River Environment Improvement .....</b>	<b>6-1</b>
6.1	Introduction .....	6-1
6.2	River Front Development along Kolong River.....	6-1
6.2.1	Parks & jogging tracks.....	6-1

6.2.2	Bathing and washing ghats.....	6-2
6.2.3	Amphitheatre .....	6-3
6.3	Cost Estimate .....	6-4
<b>7</b>	<b>Other Non-Sewerage Schemes.....</b>	<b>7-1</b>
7.1	Community toilets .....	7-1
7.2	Community Kiosks.....	7-4
7.3	Crematoria.....	7-4
7.4	Cost Estimate .....	7-4
<b>8</b>	<b>Water Augmentation and Channel Improvement Schemes.....</b>	<b>8-1</b>
8.1	River System .....	8-1
8.2	Modelling.....	8-2
8.3	Water Augmentation from Brahmaputra River .....	8-3
8.4	Water Augmentation by linking Kolong with Beels .....	8-10
8.5	Desiltation.....	8-11
8.6	Cost Estimate .....	8-2
<b>9</b>	<b>River Monitoring Schemes.....</b>	<b>9-1</b>
9.1	General Technical Concept .....	9-1
9.2	Design Principles.....	9-1
9.3	Functional Requirements.....	9-1
9.4	Technical Specifications .....	9-2
9.5	Telemetry (GSM/GPRS Communication).....	9-4
9.5.1	GSM/GPRS Data Collection Station .....	9-5
9.6	Data Centre .....	9-5
9.7	Equipment Specifications .....	9-6
9.7.1	Data Collection Platform .....	9-6
9.7.2	GSM/GPRS Radio and Antenna.....	9-6
9.7.3	Water Level Sensors .....	9-6
9.7.4	Rainfall Sensors .....	9-7
9.7.5	Solar Power and Battery.....	9-8
9.7.6	Current Meters.....	9-8
9.7.7	Water Quality Sensors.....	9-9
9.7.7.1	Specification for pH.....	9-9
9.7.7.2	Specification for Turbidity.....	9-9
9.7.7.3	Specification for Conductivity.....	9-9
9.7.7.4	Specification for Water Temperature .....	9-10

9.7.7.5	Specification for Dissolved Oxygen .....	9-10
9.7.7.6	Specification for Dissolved Ammonia.....	9-10
9.7.7.7	Specification for COD.....	9-11
9.7.7.8	Specification for Nitrates.....	9-11
9.7.7.9	Specification for Chlorides.....	9-11
9.8	River Monitoring Network .....	9-12
9.9	Cost Estimate.....	9-13
<b>10</b>	<b>Environment Impact Assessment .....</b>	<b>10-1</b>
10.1	Existing conditions of Kolong River, Nagaon town.....	10-1
10.1.1.1	Water Quality .....	10-1
10.1.2	Fish species in the Kolong River .....	10-2
10.1.3	Flora.....	10-3
10.1.4	Fauna.....	10-4
10.1.5	Forest and Biodiversity .....	10-5
10.2	Proposed Actions/structures and Mitigation measures to restore Kolong River .....	10-5
10.2.1	Sewage Collection and Treatment Options.....	10-6
10.2.2	River Environmental Improvement .....	10-6
10.2.3	Water Augmentation schemes.....	10-6
10.2.4	De-silting, De-weeding, and De-sludging.....	10-6
10.2.5	Community toilets/ sanitation.....	10-6
10.2.6	Solid waste management (collection, transport and disposal). .....	10-6
10.3	Environmental Impact Assessment for the proposed schemes.....	10-7
10.3.1	Sewerage and Sanitation .....	10-7
<b>10.3.1.1</b>	<b>Construction Phase Impacts.....</b>	<b>10-7</b>
<b>10.3.1.2</b>	<b>Operational Phase Impacts .....</b>	<b>10-8</b>
10.3.2	Pumping Stations .....	10-9
<b>10.3.2.1</b>	<b>Construction Phase Impacts.....</b>	<b>10-9</b>
<b>10.3.2.2</b>	<b>Operation Phase Impacts .....</b>	<b>10-9</b>
10.3.3	Sewage Treatment Plant.....	10-9
<b>10.3.3.1</b>	<b>Design Phase Impacts .....</b>	<b>10-9</b>
<b>10.3.3.2</b>	<b>Construction Phase Impacts.....</b>	<b>10-10</b>
<b>10.3.3.3</b>	<b>Operation Phase Impacts.....</b>	<b>10-10</b>
10.3.4	River Front Environment Development.....	10-11
10.3.4.1	Construction Phase impacts.....	10-11
10.3.4.2	Operation Phase impacts .....	10-11
10.3.4.3	Water Augmentation - Hydraulic Improvements .....	10-11

10.3.4.4	Construction Phase impacts .....	10-11
10.3.4.5	Operation Phase impacts.....	10-12
10.3.5	De-silting, De-weeding, and De-sludging .....	10-12
<b>10.3.5.1</b>	<b>Construction phase impacts.....</b>	<b>10-12</b>
10.3.5.2	Operation phase impacts .....	10-12
10.3.6	Community toilets/ sanitation .....	10-12
10.3.6.1	Construction phase impacts.....	10-12
10.3.6.2	Operation phase impacts .....	10-12
10.3.7	Solid waste management (collection, transport and disposal).....	10-13
10.3.7.1	Construction phase impacts.....	10-13
10.3.7.2	Operation phase impacts .....	10-13
10.3.8	Cultural and Socio-Economic Impacts of the proposed activities .....	10-13
10.4	Concluding Remarks .....	10-13
<b>11</b>	<b>Stakeholder Consultation .....</b>	<b>11-1</b>
11.1	Initial fact finding meetings.....	11-1
11.2	Community consultations.....	11-2
11.3	Inception Workshop .....	11-4
11.4	Stakeholder Consultation Workshop.....	11-5
11.5	Public Consultation Workshop .....	11-7
11.6	Consultation with other officials and individuals .....	11-8
<b>12</b>	<b>Education and Public Awareness Schemes .....</b>	<b>12-1</b>
12.1	Introduction.....	12-1
12.2	Education and awareness based on issues .....	12-2
12.3	Education and Awareness for solid waste management .....	12-2
12.3.1.1	Introduction.....	12-2
12.3.1.2	Information, Education and Communication (IEC) Plan .....	12-4
12.3.1.3	Identification and Action.....	12-5
12.3.1.4	Training and Capacity Building of ULBs for MSW management .....	12-7
12.3.1.5	Awareness Schedule: .....	12-8
12.4	Partnership for education and awareness programmes .....	12-8
12.5	Monitoring.....	12-9
12.6	Cost Estimate .....	12-9
<b>13</b>	<b>Capacity Building and Training .....</b>	<b>13-1</b>
13.1	Introduction.....	13-1
13.2	Institutional Arrangement.....	13-2

13.2.1	Project management Unit .....	13-3
13.3	Capacity Building Framework .....	13-3
13.4	Training needs Assessment .....	13-4
13.5	Training Programmes .....	13-6
13.6	Cost Estimate .....	13-7
<b>14</b>	<b>Project Implementation Plan .....</b>	<b>14-8</b>
14.1	Project Management Unit .....	14-8
14.2	Project Management Consultancy .....	14-8
14.3	Review and approvals .....	14-9
14.4	Monitoring and Evaluation .....	14-9
14.5	Completion Reports.....	14-9
14.6	Schemes Implementation Plan .....	14-9
<b>15</b>	<b>Cost Estimate .....</b>	<b>15-1</b>
<b>16</b>	<b>Financial and Economic Analysis .....</b>	<b>16-1</b>
<b>17</b>	<b>References.....</b>	<b>17-1</b>
<b>Annex -1: Water Quality Test Reports.....</b>		<b>2</b>
<b>Annex- 2: Maps.....</b>		<b>3</b>
<b>Annex- 3: Drawings .....</b>		<b>4</b>
<b>Annex- 4: Detailed Calculation of Dredging .....</b>		<b>5</b>
<b>Annex- 5: International and National Best Practices .....</b>		<b>6</b>

## FIGURES

Figure 1.1-1: Location Map.....	1-1
Figure 3-1 Framework of River Conservation .....	3-1
Figure 4-1 Sources of water supply in Nagaon Town(Census 2011) .....	4-19
Figure 4-2 Ward Map of Nagaon with waste water zones.....	4-20
Figure 4-3 Sewerage network with decentralized STPS .....	4-23
Figure 5-1 Indiscriminate solid waste disposal to Kolong River .....	5-2
Figure 5-2 Swatch Plasma system Installed by Nagaon Municipal Board for Waste Disposal .....	5-2

Figure 5-3 Composition of Solid Waste .....	5-3
Figure 5-4 Dumped waste from Hospital .....	5-5
Figure 5-5 Waste dumping along Kolong River .....	5-5
Figure 5-6 Solid waste transported by NMB .....	5-6
Figure 5-7 Ward Map of Naogaon with SW dumping sites .....	5-8
Figure 5-8 Proposed waste dumping sites in Google map .....	5-9
Figure 6-1 River front environmental development work Kolong river .....	6-2
Figure 6-2 Other ghats will be improved in similar ways.....	6-2
Figure 6-3 River Front development in Kolong - location of Amphitheater.....	6-3
Figure 6-4 Section B-B of the Amphitheatre at Nehru ground .....	6-4
Figure 7-1 Community Toilet.....	7-1
Figure 7-2 community toilets with hygiene messages .....	7-2
Figure 7-3 Location of low cost community sanitation .....	7-3
Figure 7-4 Location of low cost sanitation and Cematoria in Morigaon.....	7-3
Figure 8-1 Kolong River Network .....	8-1
Figure 8-2 Simulated discharge at upstream of Naogaon Town.....	8-2
Figure 8-3 Historical discharge of kolong upstream of Nagaon .....	8-3
Figure 8-4 Kolong River Links with the Brahmaputra River (source: WRD, Assam) .....	8-4
Figure 8-5 Upper Reaches of River Kolong Chocked by Water Hyacinth (photo: LBG-DHI November 2013).....	8-5
Figure 8-6 Barge mounted pumps at the Brahmaputra River (photo: LBG-DHI Nov 2013).....	8-6
Figure 8-7 Pumps discharging into the Irrigation Canal (Photo: LBG-DHI Nov 2013) .....	8-6
Figure 8-8 Irrigation Canal Regulator at the old course of Kolong (Photo: LBG-DHI Nov 2013) ...	8-7
Figure 8-9 Brahmaputra River at the Kolong River offtake .....	8-7
Figure 8-10 Satellite Image at Kolong River Offtake .....	8-9
Figure 8-11 Water bodies (beels) around Nagaon and Morigaon.....	8-10
Figure 8-12 Linking of Kolong to beels in Nagaon.....	8-11
Figure 8-13 Linking of Kolong to Samaguri Beel in Morigaon.....	8-11
Figure 8-14 Longitudinal profile of Kolong river before dredging .....	8-1
Figure 8-15 Longitudinal profile of Kolong after dredging .....	8-2
Figure 8-16 L-Profile of Kolong close to Nagaon town (before dredging) .....	8-1
Figure 8-17 L-profile of Kolong near Nagaon town after dredging .....	8-1
Figure 8-18 Sample Cross sections of Kolong before & after Dredging.....	8-2
Figure 9-1: Automatic Rainfall Station.....	9-2
Figure 9-2: Typical arrangement of radar sensor for bridge sites .....	9-3
Figure 9-3: Typical arrangement of Stilling Well/Shaft Encoder.....	9-3
Figure 9-4: Typical Current meter .....	9-4

Figure 9-5: Monitoring System Overview .....	9-5
Figure 9-6: Typical data collection platform and online battery charger.....	9-6
Figure 9-7: Map showing Monitoring Stations for Kolong River Basin .....	9-12
Figure 10-1 Water Quality Sampling Locations around Nagaon and Morigaon .....	10-1
Figure 10-2 Fish Species observed in Kolong River .....	10-3
Figure 10-3 Showing avifauna species observed in Kolong River.....	10-5
Figure 11-1 Common Interest sectors for river restoration .....	11-1
Figure 11-2 : Interaction with local people during field trips in the town.....	11-2
Figure 11-3 Consultation with people .....	11-3
Figure 11-4 Interaction with local people during field trips in the Morigaon town .....	11-4
Figure 11-5 Stakeholders Meeting at Nagaon.....	11-7
Figure 11-6 Public notice issued by PCBA .....	11-8
Figure 12-1 Strategy of awareness programme against solid waste dumping.....	12-3
Figure 13-1 Levels of Capacity Building.....	13-1
Figure 13-2 Capacity building framework.....	13-4
Figure 14-1 Project Implementation Plan.....	14-1

## LIST OF ABBREVIATIONS

AUWSSB	: Assam Urban Water Supply and Sewerage Board
BOD	: Biological Oxygen Demand
CDM	: Clean Development Mechanism
COD	: Chemical Oxygen Demand
CPCB	: Central Pollution Control Board
CPHEEO	: Central Public Health Environmental Engineering Organisation
CSP	: City Sanitation Plan
CWC	: Central Water Commission
DA	: Drainage Area
DBO	: Design, Build & Operate
DO	: Dissolved Oxygen
DPR	: Detailed Project Report
GIS	: Geographical Information System
GL	: Ground Level
GoI	: Government of India
ICT	: Information and communications technology
IEC	: Information, Education & Communication
JNNURM	: Jawahar Lal Nehru National Urban Renewable Mission
LPD	: Litres Per Day
MLD	: Million Litres per Day
MoEF	: Ministry of Environment and Forests, Govt. of India
MSW	: Municipal Solid Waste
NGRBA	: National Ganga River Basin Authority
NMB	: Nagaon Municipal Board
NRCD	: National River Conservation Directorate
NRCP	: National River Conservation Plan
O&M	: Operation and Maintenance
PCBA	: Pollution Control Board, Assam
PFR	: Project Feasibility Report
PHE	: Public Health Engineering
PMU	: Project Management Unit
PS	: Pumping Station

RFD	:	River Front Development
SPS	:	Sewage Pumping Station
SS	:	Suspended Solids
STP	:	Sewerage Treatment Plant
SWM	:	Solid Waste Management
TSS	:	Total Suspended Solids
ULB	:	Urban Local Bodies



## EXECUTIVE SUMMARY

The Kolong River stretch which runs through the city of Nagaon suffers from environmental degradation and continues to impact the health/hygiene of the inhabitants in the surrounding area. The sources of pollution that have been identified are discharge of untreated waste water to the river at various places, flow of street pollution, solid waste dumped into the river and its banks. Key water quality parameters measured during the preparation of the DPR (December 2013) also show that the river water is not suitable for human use. For example, the average BOD<sub>5</sub> ranged from 24 mg/l to 68 mg/l measured at five key locations of the river. These values are much higher than NRCD's prescribed standards of 3 mg/l for bathing water quality in a river. Lack of civil amenities along the river is also a reason for the river being slowly abandoned by the public.

Therefore, the Pollution Control Board, Assam (PCBA) has given a high priority in restoring the river by adopting a series of conservation measures. The conservation measures being studied include wastewater management, solid waste management, water augmentation improvement of channel conveyance, provision of civil amenities along the river and around the area of influence and creation of awareness among communities and stakeholders not to abuse the river. The conservation measures are analysed and documented in the Detailed Project Report (DPR) following the Guidelines of National River Conservation Directorate (NRCD), Ministry of Environment and Forest (MOEF), New Delhi. The DPR will serve the main purpose for funding of conservation measures by NRCD. NRCD may consider funding of conservation schemes which are related to treatment of waste water, removal and management of solid waste directly dumped in the river and banks, desilting of river channel, river front development, community sanitation, capacity building and public education and awareness programmes. NRCD does not provide funds for overall municipal solid waste management because this may be funded by the Ministry of Urban Development. NRCD does not provide fund industrial pollution control schemes, hospital waste management etc, because they are required to comply with effluent regulation set by the Government.

The overall aim of the project is to revitalize the Kolong within the context of the continued urbanization of Nagaon by restoring it to its natural state, while allowing the river system to continue to support flood management, landscape development and recreational activities. The water quality of the river will be restored per NRCD guidelines by: restricting inflows of raw sewerage from residential/commercial establishments; limiting direct discharge from storm water drains along roads adjacent to the river; and preventing unabated dumping of solid waste by communities residing along the river. Measures will be adopted to improve the carrying capacity of the river channel by desilting at selected locations. Linking of the Kolong Rivers to fresh water bearing wetlands in Naogaon and Morigaon districts are also considered for augmenting flow to the Kolong river during the dry winter months.

The revitalization efforts will incorporate riverfront development to encourage public participation and ownership of the river. It is noted that this DPR is one of the several

initiatives currently underway by the Government of Assam to improve the living conditions in Nagaon.

The river restoration project will enable and promote social and cultural activities along the river to the delight of the habitants living in Nagaon in addition to the full lives of flora and fauna in the river. The present project is one component of the overall road map and one of the several initiatives being taken by the Government of Assam to improve the living conditions of the habitants in Nagaon.

The DPR also addresses diverse yet related issues like environmental sustainability and dependency of local communities, including downstream impacts along Morigaon. The DPR is prepared following an extensive consultation with stakeholders which include Government agencies, local municipal bodies, NGOs and civil societies, academic institutions and individuals, communities affected and to be benefitted, and the public at large. The Draft DPR was made available at the PCBA Website ([www.pcbassam.org](http://www.pcbassam.org)) for public study and comments. Comments and suggestions received are considered in finalizing the e DPR. However, PCBA will also welcome suggestions from stakeholders any time before and during implementation so that the conservation measures being adopted serve the greater interest of the stakeholders.

Prior to the preparation of the DPR a City Sanitation Plan (CSP) has been prepared for the City of Nagaon followed by a project Feasibility Report (PFR) for sewerage schemes.

## Conservation Schemes and Summary of Costs

Package No.	Scheme Name	Scheme Description	Approx. cost (Rs. Crore)
P-1	Water Augmentation	Water augmentation to increase dry season flow by linking the Kolang river to wetlands (beels) in Naogaon and Morigaon	24.000
P-2	Desilting of Klong River	Desilting of Klong River at selected locations	43.859
P-3	Sewer Network	Collection and transport of waste water from the affecting wards	89.416
P-4	Sewage Treatment	Decentralized Sewage treatment plants along Kolang River	47.967

EXECUTIVE SUMMARY

P-5	Solid Waste Management	Management of solid waste directly dumped to the river and its banks	8.499
P-6	River Environment Improvement	Development of greenways and Parks	47.100
P-7	Development of Sanitation facilities	Bathing and washing ghats, community toilets, crematoria	4.836
P-8	Education, public awareness, capacity building	Capacity building of institutions, staff development, education and public awareness campaigns	4.235
P-9	River monitoring & warning system	Establishment & operation of river monitoring (flood and water quality), and warning system	3.534
P-10	Project Management	Establishment of Project Management Unit and Operation; support of Project management Consultancy in the implementation of the project including consultancy for modelling & river monitoring	24.952
	TOTAL Project Cost		298.396



## 1 About the Project Area

### 1.1 Authority for preparation of project

The authority for preparation of the project is:

Pollution Control Board:: Assam

Bamunimaidam; Guwahati-21

Ph.No.: 2652774 & (M) 9435343530

Fax: 0361-2550259

Website: [www.pcbassam.org](http://www.pcbassam.org)

### 1.2 Description of Project Area

#### 1.2.1 Brief History of the town

#### 1.2.2 Geographical Location

Figure 1.1-1: Location Map

- 1.3 Population in the Project Area
- 1.4 Status of water supply
- 1.5 Status of existing waste water disposal system
- 1.6 Status of drains
- 1.7 River Water quality
- 1.8 Justification of the project for pollution abatement of the river

## 2 Collection of Data

### 2.1 Introduction

As per the NRCD guidelines data requirement of stated Project has been captured at different levels with the required levels of information. The collected data has been used for preparation of Detailed Project Report for pollution abatement is a three step process namely: City Sanitation Plan (CSP), Project Feasibility Report (PFR) for Sewerage works, followed by the Detailed Project Report (DPR). The Gaps of the Data at the required stretches of the polluted river has been filled by field surveys. The CSP, PFR & DPR have been prepared on the basis of available / surveyed data (Primary / Secondary Data) that have been generated by the concerned agencies.

Detailed data and maps collected and prepared during the course of this study are presented in Annex 2.

### 2.2 Data Required at Different Levels

- i. Required data Drainage basin of the Kolong River has been prepared. In the basin map the polluted stretches have been identified and in respect of which the pollution abatement project has been prepared. This will help in identifying at priority basis for taking up pollution abatement works to improve the river water quality.
- ii. The town which is causing pollution of the river and for which an integrated project has been prepared for the abatement of pollution from waste water and solid waste.
- iii. Data of the rivers are required for detailed analysis, planning and design of the conservation measures.

#### 2.2.1 Drainage Basin Map

A map of the basin on 1:50,000 scale SOI topographical sheet showing the following features has been prepared.

### Drainage map

S. No	Item	Complied (Y/N)
i.	Tributaries,	Y
ii.	Main stem and	Y
iii.	Existing water bodies	Y

### Cities / Towns in the basin with

S. No	Item	Complied (Y/N)
i.	River water quality being below the desired level	Y
ii.	Cities with cultural, social and tourism importance	Y

### Recent Land Use, if available, from State Remote Sensing Centre

S. No	Item	Complied (Y/N)
i.	Agriculture	Y
ii.	Forests	Y
iii.	Mining.	
iv.	Industrial Areas	

## 2.2.2 Raster Layers

This report uses different sets of satellite and Elevation data to produce different sets of Maps. The satellite data has been used from ISRO, Bhuwan, DEM from CGIAR-CSI – SRTM & CartoSat.

The Satellite data used from Bhuwan is AWiFS, which is Multispectral Data with 56 m Resolution. It has a coverage size of 370 km x 370 km and gives data in 3 or 4 Bands. The data from Google has also been used to analyses different layers of the Maps. Google provides the data of high resolution of Approx 2 Meter to 5 Meter in the Project Area.

### 2.2.3 Shape Layers

Shape file are the base database for preparing different maps of the Region. There is a set of different Shape Layers / Shape Files used for creating different maps for the Kolong region having different purpose. The lists of Shape Files Created for the Report are as below:

S. No	Shape File Name	Type	Remarks
1.	Country	Polygon	The Indian Country.
2.	Assam State	Polygon	The State of Assam.
3.	Naogaon District	Polygon	The District of Naogaon.
4.	Zone Map	Polygon	The Zones of Naogaon. Metropolitan / Naogaon Town.
5.	Ward Map	Polygon	The Ward Map of Naogaon Town.
6.	Wetland	Polygon	Wetland area showing the location of Mari-Kolong and other small wetland Locations including water Bodies.
7.	River Front Development	Polygon	The Development location along the River.
8.	Water Body	Polygon	Water Body Locations of the Naogaon Town Area.
9.	Road	Line	Road Network of the Naogaon Town.
10.	River / Drainage	Line	Kolong River Network of the Town and In the entire Basin.
11.	Contour Map - Zone 1	Line	This Map shows the contour Maps of Naogaon Town Area.
12.	Outfall Locations	Point	Outfall Location of the Kolong River Network
13.	Solid Waste	Point	Solid Waste Dumping Location
14.	Structures	Point	Showing location of Sluice, Bridges etc. over Kolong River N/W
15.	STP Location	Point	STP Location for Naogaon Town
16.	Crematoria	Point	Cremation Location for Project Area
17.	Water Sampling Location	Point	Location of the Places where Water samples were collected.

The coordinate system specification followed for the Shape Files are:

Property	Specification
PROJECTION:	WGS 1984 UTM Zone 46N.
GEOGCS:	GCS WGS 1984.
DATUM:	D WGS 1984.
SPHEROID:	WGS 1984, 6378137.0, 298.257223563.
PRIMEM:	Greenwich, 0.0.
UNIT:	Degree, 0.0174532925199433.
PROJECTION:	Transverse Mercator.
PARAMETER:	false easting, 500000.0.
PARAMETER:	false northing, 0.0.
PARAMETER:	Central meridian, 93.0.
PARAMETER:	Scale factor, 0.9996.
PARAMETER:	Latitude of origin, 0.0.
UNIT:	Meter, 1.0

### Source of Different Data:

Category	Data	Concerned Department	Available
River and Hydrology Related data	Cross Section	Water Resource Department	Kolong
	Water Levels	Water Resource Department	Kolong
	Water Quality Data	Water Resource Department	Yes , EREC lab
	Soil Map Land Use (If Available)	State remote sensing center	Yes
Sewerage	Map of Existing Sewerage System, if any	N/A	Yes
	Area Name	Municipal Corporation	Yes
	Building and Temple Locations	Municipal Corporation	yes
	Road Network	Municipal Corporation/PHED	Yes
	Location of Outfalls	Municipal Corporation	Yes
	Structures on the River	Municipal Corporation/ Field Survey	Yes
Demography	Population of wards as per Census	Municipal Corporation	Yes
	Slums Location	Municipal Corporation	yes
	Other data	Municipal Corporation	NA
Crematoria	Location of Crematorium	Municipal Corporation	yes
River front development	Location of River Front Development	Survey	Yes

## 2.3 Town Related Data

### 2.3.1 Maps Related to City

The Town has been covered in the report as different maps in Digital Format. These digital Formats are the combination of Raster and Vector Data.

To prepare Maps different data and sources in the form of Vector and Raster Layer has been used. The maps contain the layers as listed below:

- i. Important land marks of the city.
- ii. Rivers and their flood plains.
- iii. Other water bodies.
- iv. River banks where solid waste is dumped.
- v. Drains, and their respective outfalls and catchments (drainage areas).
- vi. Municipal wards.
- vii. Open spaces.
- viii. Residential areas.
- ix. Points of discharge of industrial effluents.
- x. Slums.
- xi. STPs and sewage pumping stations.
- xii. Crematoria.
- xiii. River front (Ghats) developed in the past.
- xiv. Sites on river banks for cattle wallowing, dhobi Ghats, washing of motor vehicles and carcasses are dumped.

### 2.3.2 Land Use, Contour, Drainage and Other Thematic Maps:

The thematic maps related to Landuse have been created using suitable SOI Maps and Satellite data. These maps are used to categorise the Landuse patterns and find the suitable locations required for the project in creating STP and other related locations. The Data has been prepared using the latest Satellite data to the actual satiation present on the ground to have the optimized solution of the situation. The land used has been created using LISS-III and AWiFCS Data along with the usage of Google Earth Imageries. SOI Topo sheet has been used as the Base Point of starting of GIS Database to the authentic source of base map data.

### 2.3.3 Use of State of Art Tools like Remote Sensing and GIS

For creating maps and other data Latest tools and technology has been used. Tools like MIKEbyDHI, ArcGIS & AutoCAD has been used to create, Process, edit and finalize the Maps & Database and reports. These tools have been used to generate different themes and layouts in GIS and AutoCAD Formats. The different layout depicts the water-bodies, River Network, Drainage Network, Structures and Outfall Location etc.

### 2.3.4 Population of the Town:

Rivers are flowing through many important town areas and to have a river restoration plan to be successful we need to consider the basic fundamental issue, i.e. The Population. The consideration of Population is one of the important factors to be considered. The ward-wise Population load using the suitable trend analysis has been calculated to get the pollution load on different river stretch along the river Shape file are the base database for preparing different maps of the Region. There is a set of different Shape Layers / Shape Files used for creating different maps for the Kolong basin having different purpose. The lists of Shape Files Created for the Report are as below:

S. No	Shape File Name	Type	Remarks
18.	Country	Polygon	The Indian Country.
19.	Assam State	Polygon	The State of Assam.
20.	Naogaon District	Polygon	The District of Nagaon.
21.	Zone Map	Polygon	The Zones of Nagaon. Metropolitan / Nagaon Town.
22.	Ward Map	Polygon	The Ward Map of Nagaon Town.
23.	Wetland	Polygon	Wetland area showing the location of Mari-Kolong and other small wetland Locations including water Bodies.
24.	River Front Development	Polygon	The Development location along the River.
25.	Water Body	Polygon	Water Body Locations of the Nagaon Town Area.
26.	Road	Line	Road Network of the Nagaon Town.
27.	River / Drainage	Line	Kolong River Network of the Town and In the entire Basin.

28.	Contour Map - Zone 1	Line	This Map shows the contour Maps of Nagaon Town Area.
29.	Outfall Locations	Point	Outfall Location of the Kolong River Network
30.	Solid Waste	Point	Solid Waste Dumping Location
31.	Structures	Point	Showing location of Sluice, Bridges etc. over Kolong River N/W
32.	STP Location	Point	STP Location for Naogaon Town
33.	Crematoria	Point	Cremation Location for Project Area
34.	Water Sampling Location	Point	Location of the Places where Water samples were collected.

The coordinate system specification followed for the Shape Files are:

Property	Specification
PROJECTION:	WGS 1984 UTM Zone 46N.
GEOGCS:	GCS WGS 1984.
DATUM:	D WGS 1984.
SPHEROID:	WGS 1984, 6378137.0, 298.257223563.
PRIMEM:	Greenwich, 0.0.
UNIT:	Degree, 0.0174532925199433.
PROJECTION:	Transverse Mercator.
PARAMETER:	false easting, 500000.0.
PARAMETER:	false northing, 0.0.
PARAMETER:	Central meridian, 93.0.
PARAMETER:	Scale factor, 0.9996.
PARAMETER:	Latitude of origin, 0.0.
UNIT:	Meter, 1.0

Source of Different Data:

Category	Data	Concerned Department	Available
River and Hydrology Related data	Cross Section	Water Resource Department	Yes
	Water Levels	Water Resource Department	Yes
	Water Quality Data	PCBA, New sampling by project	Yes , EREC lab
	Soil Map Land Use (If Available)	State remote sensing center	Yes
Sewerage	Map of Existing Sewarge System, if any	N/A	
	Area Name	various	Yes
	Drainage System and Related Data if	various	Yes

	any		
	Building and Temple Locations	maps	yes
	Road Network	NMB	Yes
	Location of Outfalls	Field surveys	Yes
	Diameter of the Pipes	N/A	
	Manholes	N/A	
	Structures on the River and Sewage System	Survey & Project survey	Yes
	Slope	Survey	Yes
	Spot Levels	Survey	yes
<b>Water Supply</b>	Existing Water Supply	NMB	Yes
	Demand and sources	NMB	Yes
<b>Demography</b>	Population of wards as per Census	NMB	Yes
	Slums Detail	NMB	yes
	Other data	NMB / others	yes
<b>Crematoria</b>	Location of Crematorium	NMB	yes
<b>River front development</b>	Location of River Front Development	Survey	Yes
<b>Low cost Sanitation</b>	Location of Public Toilets	NMB	yes
<b>Solid Waste</b>	Location of Waste Disposal, if any	NMB	yes

### 2.3.5 Land Use, Contour, Drainage and Other Thematic Maps:

The thematic maps related to Landuse have been created using suitable SOI Maps and Satellite data. These maps are used to categorise the Landuse patterns and find the suitable locations required for the project in creating STP and other related locations. The Data has been prepared using the latest Satellite data to the actual satiation present on the ground to have the optimized solution of the situation. The land used has been created using LISS-III and AWiFCS Data along with the usage of Google Earth Imageries. SOI Toposheet has been used as the Base Point of starting of GIS Database to the authentic source of base map data.

### 2.3.6 Use of State of Art Tools like Remote Sensing and GIS

For creating maps and other data Latest tools and technology has been used. Tools like MIKEbyDHI, ArcGIS & AutoCAD has been used to create, Process, edit and finalize the Maps & Database and reports. These tools have been used to generate different themes and layouts in GIS and AutoCAD Formats. The different layout depicts

the water-bodies, River Network, Drainage Network, Structures and Outfall Location etc.

### 2.3.7 Population of the Town

The ward-wise Population load using the suitable trend analysis has been calculated to get the pollution load on different river stretch along the river. Data for Population has been referred from Census of India database. The ward wise population has been referred from Municipal Reports and their database to prepared maps and reports. The population trend analysis has been done using arithmetic, incremental increase, geometric, and exponential methods.

### 3 Conservation Measures

#### 3.1 General Conservation Framework

Figure 3-1 shows the general framework of conservation of the Kolong river.



Figure 3-1 Framework of River Conservation

#### 3.2 Road Map for the Conservation of Kolong River

Table 3.1 presents a road map for the conservation of Kolong River. The road map addresses the related issues such as institutional, waste water management, solid waste management and river front development distinctly and is therefore presented in four sub-tables.

The road map briefly describes the existing situation, and states the desired goal. Then a phase wise implementation plan is proposed consisting of immediate, mid- and long-term activities. The present investment project for which this DPR is prepared deals with the immediate action plan required to improve the present situation of unacceptable water quality in the river. It is expected that Government of Assam will implement other complementary projects to achieve the long term goal shown in the road map.

Table 3.1 Road Map for the conservation of Kolong River

1. Institutional aspects

Existing Situation		Immediate term (2014-2017)	Goal
River & Lake Conservation Cell under Pollution Control Board, Assam. Several Institutions active, inadequate coordination mechanism	Mandate & functions not clearly defined.  Funding of river conservation measures & related development works not ensured	Use the proposed Conservation project to establish the Assam River Conservation Authority, build capacity (supported by PMU)	A fully functional Assam River & Lake Conservation Authority, with clear mandates, ensured funding and capacity to restore & conserve key water bodies to desired level.

2. Solid Waste Management

Existing Situation	Immediate action (2014-2017)	Mid-term long term (by 2020)	Goal
Kolong river is abused with solid waste dumped into the channel and banks, also a major source of water pollution.	<ol style="list-style-type: none"> <li>1. Remove solid waste from the river and banks</li> <li>2. Establish garbage collection along the banks and transport to dumping sites.</li> <li>3. Public awareness campaign to stop dumping waste into the river</li> </ol>	Solid Waste management system in Nagaon city fully functional as in a modern city	A clean & livable Nagaon city (including all water bodies) free of unwanted solid wastes

3. Waste Water Management

Existing Situation	Immediate term (2014-2017)	Mid- & Long Term Actions (by 2025)	Goal
River is polluted due to discharge of untreated sewage and septic tank effluent.	Intercept waste water coming from the city urban catchment area (wards), and discharge treated effluent from decentralized STPs. (to be integrated into the city’s sewerage master plan)	Nagaon city Sewerage and drainage project implemented, city fully covered with piped water supply.	A clean Kolong river sustaining desired national environmental conditions.

4. River Front Development

Existing Situation	Immediate term (2014-2017)	Long term (by 2025)	Goal
Inadequate public facilities in river/ lack of recreation areas	<p>River front development along the city areas, walkways, greenways.</p> <p>Improved bathing and washing ghats.</p> <p>Development of Parks and jogging tracks.</p>	<p>Further development of the whole reach.</p> <p>Encourage public, private and cultural groups to use river front.</p>	Kolong river is the center of recreation & public life in Nagaon City

3.3 Root Cause Analysis & Measures Solution Options

The conservation measures proposed are part of the roadmap presented above and also are based on the root cause analysis of pollution and other river degradation

factors. Table 3.2 Presents the details of the root cause analysis and the proposed measured.

Table 3.2 Root Cause Analysis and Proposed Solution Options

Causes / Pollution sources	Solution Options	Conservation Packages
Reduced dry season flow from upstream	Flow augmentation by exploring linking Kolong river to wetlands in Nagoan and Morigaon	<b>P-1:</b> Linking Kolong River to wetlands in Nagoan and Morigaon
Reduced carrying capacity of river channel due to siltation & solid waste disposal	Improve conveyance by dredging & solid waste removal	<b>P-2:</b> Solid waste removal, Desiltation
Pollution due to solid waste disposal into the channel and in river banks	Solid waste management, Awareness programmes	<b>P-7:</b> Solid waste management plan <b>P-8:</b> Public awareness & education programs

Cause / Pollution sources	Solution Options	Conservation Packages
Sewage and septic tank effluent discharged directly into the river (including street pollution)	<ol style="list-style-type: none"> <li>1. Collection of waste water from the wards affecting the Kolong river at present, separation of domestic sewage, transported to a centralized Treatment Plant</li> <li>2. Collection of waste water from the wards affecting the Kolong river at present, separation of domestic sewage, transported to Decentralized STPs along the river.</li> </ol>	<b>P-3:</b> Sewerage network in the wards, transportation to decentralized treatment plants along the river. <b>P-4:</b> Decentralized STPs along Kolong River

Cause / Pollution sources	Solution Options	Conservation Packages
Inadequate public facilities / lack of recreation areas	Water Front development programmes, community sanitation access	<b>P-5:</b> Water Front development along the Kolong River <b>P-6:</b> Community Sanitation facilities
Inadequate information & data for decision making	River monitoring & warning systems	<b>P-10:</b> Establishment and operation of a river monitoring & warning system (water quality and flood)
Lack of ownership, capacity, sustainability issues	Education & Awareness programmes, capacity building & training	<b>P-8:</b> Education awareness & capacity building programmes <b>P-9:</b> Establishment of Project Management Unit (PMU), provision of O&M budget



## 4 Sewerage Schemes

### 4.1 Approach

This section describes the basic input used for providing an effective sewage collection, conveyance, treatment, and disposal system for Nagaon town to safeguard the River and also normal ecological system of the river Kolong. The proposed scheme has been formulated based on the latest version of National Ganga River Basin Authority (NGRBA) Guidelines issued by National River Conservation Directorate, Ministry of Environment and Forests, December 2010. Also, the criteria furnished in the 'Manual on Sewerage & Sewage Treatment' published by CPHEEO, Ministry of Urban Development, Government of India, has been used as necessary.

Adoption of a comprehensive system strategy is important in developing an effective sewerage system. The following system strategy has been formulated to provide the best engineering solution to the prevailing sanitation problem for the town.

- The current arrangement of wastewater collection will have to be modified after sewer lines are installed in the project area. Only the households need to be connected to proposed sewer lines either directly to manholes or through catch pits depending on the site conditions and space availability. This will ensure discharge of domestic wastewater flow (DWF) only into the sewer lines. Existing road side drains will be used exclusively to collect and convey storm water runoff (SWF). Connection of open drains to sewage collection network will be restricted and given only in cases where individual house connection is not possible due to space constraints. A suitable arrangement of such connection will be developed and proposed in the future.
- Wards directly overlooking the river Kolong would be taken up for providing sewage interception, collection, and diversion first. Subsequent areas would be covered and integrated with this centralized sewage collection system in the future.
- The proposed sewage collection system will include construction of house connections with an aim to intercept sewage at the very location of its generation. This would also avoid intermixing of sewage and storm water runoff. Though initially some intermixing of storm water is expected in view of any organized storm water management scheme for the town, it is expected that over time a storm water collection network would be installed rendering the now proposed system more efficient in collecting only the wastewater from households and other sources.
- The project area has narrow lanes (even < 2.5 m) with surface drains on either side. From the standpoint of feasibility of installation of sewer lines in these narrow lanes, the minimum road width where sewer line is proposed has been restricted to 2.5-3 m, i.e. the distance between the existing surface drains on either side. Also, to reduce the number of manholes in the streets, rider sewers may have to be laid along the length of main sewers. However, such a decision may be taken at the time of detail design depending on site conditions and feasibility of construction.
- In order to avoid duplication of pipeline, it has been proposed to pump wastewater from pumping station to the nearest gravity sewer as opposed to

conveying the entire flow in a pressure conduit all the way to the next pumping station or treatment facility. This way, maximum efforts have been made to avoid installation of gravity sewer and pressure main along the same alignment, unless it was absolutely necessary over limited stretches.

- The options for decentralized wastewater treatment were explored keeping in view the isolated nature of wards on either side of the town. The space might be available at selected locations for construction of a sewage pumping station and treatment facility on a segregated basis. However, availability of land and location of nearest discharge location within town boundary (for treated effluent) might be two deterrent factors. Even if a treatment plant had been proposed here, the treated effluent would have to be conveyed by pressure conduit to a suitable discharge location. It also seems preferable to avoid multiple operating points for management of its wastewater treatment system for a small town like this one. However, considering land availability a series of decentralised STPs are recommended along the river, where free land is available. These STPs will discharge treated effluent to the river which will also help in maintaining the ecological balance.
- The maximum depth of invert of proposed sewer line will be restricted to 4 m, and at certain places this can be up to 5 m, if absolutely necessary. The sewer invert will never be proposed at a depth more than 5 m as the water table is very high in Nagaon city. This is suggested in view of town setting, advanced technique employing deep sewer construction does not seem to be either feasible or preferable. Narrow street/lanes in wards, to negotiate acute space constraints, avoid damage to the foundation of existing building due to sewer installation, and ensure feasibility of excavation of trenches for sewer construction, also support this concept.
- Generally, roads having  $\leq 5$  m width (distance between the property lines on either side) will be provided with sewer line in the centre. House connections will be given to these lines from either side of existing road. For any existing road  $> 5$  m wide, sewer line will be laid along one particular flank of the road preferably outside the black top road surface, provided space is available.
- The manholes will be constructed in brick masonry having rectangular in shape with access shaft to reduce cost and facilitate relatively easy and quick construction. Size of manhole will vary according to their depth of invert, which will be decided at the time of detail design.
- There might be a few critical manholes that will receive discharge from pressure mains. These manholes will serve as collection manholes and velocity/energy dissipation locations for incoming flow. Such manholes will be built in reinforced concrete of suitable grade to avoid any erosion/abrasion effect inflicted by the continuous inflow of wastewater discharged under pressure. Apart from being manholes, these structures will also serve as energy dissipation locations to ensure smooth gravity flow on the downstream sewer.
- Maintenance of sewer against possible silt accumulation and other repair works are mandatory. For sewer cleaning works, suitable equipment (both for trunk sewer and branch sewer) will have to be procured under this project and such provision has been kept in the estimates.

A few critical elements in framing the proposed scheme have been identified that would involve permissions and approval from other agencies. These are acquisition of land for construction of proposed sewage pumping station and treatment plant, alignment of

pressure main along existing roads, laying of sewers, thrust boring for underpass crossing, etc. These will be addressed individually on approval of the scheme.

### 4.1.1 Design Criteria

Formulation of the sewerage collection, treatment and disposal scheme will be framed by following the guidelines given in the Manual of Sewerage and Sewage Treatment (Second Edition), Ministry of Urban Development, 1993. It is a normal engineering practice followed by all engineering consultants and government authorities across India to comply with the recommendations of this Sewerage Manual in designing and detailing of sewerage systems. Apart from this, a number of design criteria, were taken from the recently revised "Guidelines for Preparation of Project Reports under National River Conservation Plan and National Ganga River Basin Authority" (December 2010), issued by Ministry of Environment & Forest, Government of India. After completion of field surveys, remaining data collection and a study of existing field conditions, certain design parameters and considerations may require revision in order to suit specific project requirements.

#### 4.1.1.1 System configuration

Separate sanitary and storm sewers are expected for any underground drainage system. The main advantages of separate system are protection of water-courses from pollution and exclusion of storm runoff from treatment system with a significant saving in construction and operation cost. At times, however, for older communities where the existing road widths are very narrow, combined sewers are frequently encountered and providing separate systems is found to be extremely difficult and costly. Under the present study, the proposed system is provided and designed exclusively to convey the wastewater generated and accordingly the design norms have been formulated.

There is considerable stretches of existing surface drains in Project Area. These drains will be used for disposal of storm runoff with suitable expansion and augmentation to be planned at a later date. It is conceived that sewers from individual premises will discharge to a master pit/collection pit within its property boundary. This master/collection pit will be connected with manholes to be built under this project.

Configuration of proposed system will comprise of house connection, wastewater collection system, sewage pumping station(s) at strategic locations for conveyance of wastewater to treatment facility, wastewater treatment, and final disposal to natural water body. Efforts will be made to plan and design the collection network in a cost-effective way with an aim to reduce the number of pumping stations. Whenever the depth of manhole exceeds a stipulated depth, sewage pumping stations will be provided.

The collected sewage will be treated in proposed sewage treatment facility and disposed off to inland surface water. Reuse of treated sewage will be decided as suitable.

#### 4.1.1.2 Wastewater Generation Rate

Design of sewerage system is based on flow or the volume of the waste water generated. With respect to flow, peak flow rates must be known in order to decide the hydraulic capacities of sewers, dimensioning of pumping station(s), sizing of sewage treatment plant(s), and effluent disposal facilities. Three important components, namely domestic sewage, industrial wastewater (if applicable), and ground water infiltration

have been considered for estimation of expected flow of wastewater. This is referred to as Dry Weather Flow (DWF) and will determine the normal loading on the above components impacting the hydraulic capacity required for sewers, pumping stations and force mains.

Per capita sewage generation as per the CPHEEO Sewerage manual is given as 80% of the per capita water supply. Per capita sewage flows are conventionally determined from a study of existing per capita rate of water supply and population served in case no wastewater flow monitoring data from the contribution area is available. In absence of any such flow monitoring data, future wastewater flow will be estimated by per capita rate of sewage generation.

The existing water supply scenario in Nagaon town is expected to improve after implementation of any future piped water supply scheme for the area. Since the concerned authority does not have any immediate plan for any major augmentation of water supply in the area, current supply rate has been considered for estimation of wastewater flow over the design years. However, suitable provision for future augmentation in water supply has been considered. Based on these considerations on the perspective of present and future water demand, the following assumptions have been made.

- Water demand for population covered with piped water supply system is @ 135 lpcd considering fully developed water supply system in the area.
- Water demand for remaining population not covered by piped supply at present will be covered in future by the above rate,
- The above supply rate includes other demand, i.e. possible Institutional Commercial & Industrial (ICI) demand for Nagaon city.

When a water supply system is implemented the sewerage generation per capita will be:

Table 4-1: Calculation of per Capita Sewage Generation.

S. No.	Description	Demand (lpcd)
1	Net per capita water demand for Nagaon	135.00
2	Add 10% for ICI demand <sup>1</sup> @ 10%	13.50
2	Add ground water infiltration @ 5%	6.75
<b>Sub Total</b>		<b>155.25</b>
3	Considering 80% for sewage generation	124.20
<b>USE</b>		<b>125.00</b>

As the town grows and develops, including the water supply system, the total waste water generation will increase.

#### 4.1.1.3 Groundwater Infiltration

As the project area is situated in close proximity of the banks of river Kolong, the water table in the city is as high as 10-15ft. In view of possibility of infiltration of ground water in sewers, it will be proposed to adopt strict quality control measures for selecting material and workmanship during execution. The amount of groundwater infiltration in sewers will largely depend on the following factors,

- Depth of sewer line and position of existing groundwater table,
- Material and type of joints for sewer pipes used, and
- Workmanship of sewer installation work.

CPHEEO Manual suggests a range of 500 to 5,000 litres per km of sewer line per day (l/km/d) as possible infiltration depending on situation. Considering high groundwater table in the project area, 5% of ultimate peak sewage flow will be considered as contribution from groundwater infiltration. For the ultimate design year, it amounts to about 2200 l/km/d. This looks reasonable and in line with the provisions in the Manual.

#### 4.1.1.4 Depth of Flow

The maximum depth of flow in sewer will be taken as 0.8 or 80% of the conduit diameter for all sizes of sewers. In other words, maximum value of “d/D” ratio will be taken as 0.8 (where “d” is depth of flow in sewer and “D” is inside diameter of sewer) at peak design flow. Sewer design will be done with this maximum depth of flow and corresponding value of “q/Q” ratio (where “q” is peak design flow and “Q” is discharge at full depth).

This maximum depth of flow in sewers is restricted to keep some extra provision in design and provide adequate ventilation inside sewers to avoid crown corrosion. But, if the same criterion of 80% maximum depth is used for the smaller diameter sewers, this might not be fulfilling the basic objective for keeping this extra provision. In other words, the space left over 150 mm, 200 mm, 250 mm, and 300 mm diameter conduits, considering 80% depth of flow are 30 mm, 40 mm, 50 mm, and 60 mm respectively. It seems that such minimal space over the maximum water surface in sewers is not sufficient to provide proper ventilation. Hence, restricting the maximum depth of flow in conduits  $\leq 300$  mm to 50% depth might have been useful and ensured ample space for ventilation with conservative design practice. However, in line with the provisions kept in the Manual, the 80% maximum depth criterion has been used.

#### 4.1.1.5 Peak Factor

Flow of wastewater would vary depending on the size of contributing population and over a day. Hydraulic design of sewer needs to take care of such variation in wastewater flow for adequate hydraulic design of sewers. The ratio of peak to average daily flow (peak factor, PF) is as given by the Giffit Equation (for population more than 500) is as below,

$$PF = \frac{5}{P^{0.167}} \quad \text{Eqn. 1}$$

Where P is population in 1,000 people

An approximation of this formula in calculating peak factors for various population figures is given in CPHEEO Manual. The design flow in a sewer is the average dry weather flow multiplied by this peak factor plus infiltration. Peak factor for any sewer will be calculated by the number of contributing population adopting the peak factors as given below.

Table 4-2: Peak factors for various population figures.

Population	Peak factor
For population ≤ 20,000	3.00
For population > 20,000 and ≤ 50,000	2.50
For population > 50,000 and ≤ 7,50,000	2.25
For population > 7,50,000	2.00

Source: CPHEEO Manual

#### 4.1.1.6 Hydraulic Design Formula

Manning's formulae for open channel flow inside circular conduits is used for hydraulic design of sewers, as given below:

$$V = \frac{1}{n} (3.968 \times 10^{-3}) D^{2/3} S^{1/2} \quad \text{Eqn. 2}$$

and

$$Q = \frac{1}{n} (3.118 \times 10^{-6}) D^{2/3} S^{1/2} \quad \text{Eqn. 3}$$

Where, V is velocity in m/s, n is Manning's coefficient of roughness, D is inside diameter of pipe in mm, S is slope or hydraulic gradient, and Q is discharge in l/s. The value of Manning's roughness coefficient to be adopted in the design is 0.011 for spun RCC pipes with socket and spigot joints (and 0.011 for uPVC sewers, if used).

#### 4.1.1.7 Flow Velocity and Gradient

Domestic wastewater contains significant amount of organic and inorganic solids in floating or suspended forms. If velocity of flow in the sewer is low, these solids might be deposited at the invert of the conduit and cause obstruction to free flow of sewage. Hence, it is necessary to maintain the self-cleansing velocity at least once in a day during peak flow conditions at all sections of the sewerage system.

Sewers will be designed for a self-cleansing velocity of 0.6 m/s at peak design flow in immediate phase. Considering the limited gradient available in the project area and to restrict the invert of sewers to a certain depth for practical reasons, it might not be possible to maintain self-cleansing velocity in initial stretches (mostly laterals) of sewers during the early years. To overcome this problem, these stretches need to be flushed

intermittently. However, trunk sewers will be designed to maintain self-cleansing velocity even for peak design flow in immediate phase.

### 4.1.1.8 Maximum Depth to Invert

Maximum depth of invert of a sewer line will be dictated by practical and economic considerations. The choice will normally be between having a deep sewer and providing a sewerage pumping station. The suggested criterion is that sewerage pumping station should only be proposed when absolutely necessary to restrict the depth of invert of sewers to a specified value. Maximum depth of sewer invert is restricted to 4.5 m for the Nagaon city sewerage system also because of high water table in the city.

### 4.1.1.9 Minimum Cover and Sewer Protection

Sewers should always be laid at depths which will serve not only all existing properties but also any future properties within its service area. Normal current practice is to have at least 0.9 m cover above the top of the sewer, however at times this might be reduced by providing extra protection to the sewer. It should be noted that the depth of a sewer is the distance between the top of the barrel and ground level.

However, applying this criterion to initial lengths of sewer will lead to unnecessarily deep sewers, and the cost of providing protection to initial lengths of shallow sewer can be saved by reduction in depth of all subsequent sewers. A shallow sewer at a depth of 0.6 m, with adequate protection by proper concrete encasement, is considered acceptable, economically justified and is not technically detrimental. Minimum cover to sewers will be 0.90 m without protection and 0.60 m with a concrete encasement .

### 4.1.1.10 Minimum Pipe Diameter

Regular and periodic blockage of smaller sewers is common due to mishandling by the public and insufficient sewer cleaning. In view of this, it is advisable to stipulate a minimum diameter of 200 mm for public sewers. However, The Design Manual recommends that the minimum diameter of conduit should be 150 mm except for hilly areas where it can be reduced to 100 mm where there are high slopes. In line with this, minimum size of sewer is adopted as 150 mm. It needs to be pointed out that this size does not apply to house/property connections. The suggested minimum size for such connection is 100 mm diameter, which can be increased appropriately depending on its size.

### 4.1.1.11 Sewer Transition

Hydraulic design of sewers will adopt a criterion of matching the soffit levels of incoming and outgoing pipes wherever there will be a transition of sewer from smaller diameter to larger diameter. The soffit level is the crown in the inside of circular sewer. This will ensure better hydraulics for the sewer as opposed to matching the full flow depth (i.e. 80%) of upstream and downstream sewers.

### 4.1.1.12 Material of Sewer Line

There are various pipe materials available for application in wastewater collection systems and each of these materials has a unique characteristic used under different conditions. Pipe material selection considerations include trench conditions (soil conditions), corrosion potential of ground, temperature variations, safety requirements,

and cost. Key pipe characteristics are corrosion resistance (both interior and exterior), the scouring factor, leak tightness, jointing method and hydraulic characteristics. Pipe manufacturers follow requirements set by the Indian Standards or applicable International Standards for specific pipe materials. Specification standards cover the manufacture of pipes and specify parameters such as internal diameter, loadings classes, and wall thickness. The methods of pipe construction vary greatly with the pipe materials.

Some new pipe materials and construction methods use the basic materials of concrete pipes with modifications (e.g. linings). Other pipe manufacturing methods use newly developed resins which offer improvements in strength, flexibility, ease of laying and jointing, and resistance to certain chemicals. Construction methods may also allow for field modifications to adapt to unique conditions (i.e., river crossings, rocky trenches, etc.) or may allow for special, custom ordered diameters and lengths.

The applicability of different pipe materials might vary with each site and system requirements. The selected pipe material must be compatible with the chemistry between soil and groundwater. The pipe material also should be compatible with the soil structure and topography of the site, which affects the pipe location and depth, supports for the pipe fill material, and required strength of pipe material. A summary of various factors to be considered for determining the type of best pipe material is given below (not necessarily in order of priority),

- Expected overburden, dynamic, and static loading on pipe,
- Lengths of pipe available, joining materials and installation equipment required,
- Time taken and ease of laying,
- Soil properties and chemistry, location of water table, stability,
- Chemical and physical properties of the wastewater and its corrosion potential,
- Joint tightness and level of craftsmanship required,
- Size range requirements, availability,
- Compatibility with existing system,
- Manholes, pits, sumps, and other required structures to be connected,
- Maintenance requirements, durability, and space required for installation.

However, the prioritization of criteria for selection of pipe material varies from one project to another and ultimately dictates the selection. Under the present scenario, the following criteria have been classified as the most critical ones,

- Time of construction of sewer network should be as less as possible since the areas are extremely congested and at places just have enough space for laying of sewers. But these areas cannot be closed down during sewer laying for a very long period as this will interfere with the regular use of these roads/streets causing difficulty to the stakeholders. So, it would be better if pipes to be used here are laid easily without requiring high craftsmanship and as quickly as possible.
- Pipes should be strong enough to take on the overburden pressure as it is expected that the depth of excavation can be as high as 5 to 6 m. Depths of pipe installation are optimized to balance between the quantity of earth cutting

and segregation of sewerage zones (also called sewerage districts) to provide pumping stations.

- The water table in the site is very near to surface and this should be taken into consideration while selecting the material to ensure stability of pipes and the joints. Differential settlements at pipe joints can result in leakage causing groundwater contamination and are very difficult to pinpoint, even if repair is undertaken.
- Lastly, cost of pipe used in sewage collection network forms a significant portion of the cost of total sewerage scheme and this has to be kept in view. Even a small difference in per unit length of pipe cost can ultimately prove to be a significant percentage of total project cost.

The most common material being used for sewer network all over India is Reinforced Cement Concrete (RCC) pipe of classes NP3 and NP4. Apart from RCC, other pipe materials considered for application under this project are ductile iron (DI), unplasticized poly-vinyl chloride (uPVC), vitrified clay or stoneware (SW), and high density poly-ethylene (HDPE). Glass reinforced plastic (GRP) pipes are yet to enter the Indian market for application in new sewerage line and have not been considered here.

A comparative statement of advantages and disadvantages of various pipe materials is given in Table 4-3.

Table 4-3: Advantages and Disadvantages of Various Pipe Materials.

SN	Material/Ref. IS Codes	Advantages	Disadvantages
1	Ductile Iron/ IS 8329:2000.	Good corrosion resistance when cement mortar lining is used. High impact resistance. Ease in laying.	Costly.
2	Reinforced Cement Concrete/ IS 458:2003.	Widespread availability. High strength. Corrosion resistance when coated or lined or better quality cement is used.	Heavy. Requires careful installation to avoid cracking. Susceptible to attack by H <sub>2</sub> S and acids when pipes are not coated.
3	Vitrified Clay/Stoneware/ IS 651: 2007.	Very resistant to acids and most chemicals. Easy in handling and installation.	Short length and more joints make it prone to infiltration and costly to install. Joints are susceptible to chemical attack. Brittle (may crack) and requires careful installation. Available only up to a certain size.
4	Un-Plasticized poly-Vinyl	Very lightweight, easy to	Susceptible to chemical attack,

	<p><b>Chloride/ IS 4985:2000.</b></p> <p><b>High Density Poly-Ethylene/ IS 4985:2000.</b></p>	<p><b>install and flexible.</b></p> <p><b>Economical and good corrosion resistance.</b></p> <p><b>Smooth surface reduces friction losses.</b></p> <p><b>Long pipe sections reduce infiltration potential.</b></p>	<p><b>particularly by solvents.</b></p> <p><b>Pipe must be restrained from floating in the presence of groundwater.</b></p> <p><b>Strength affected by sunlight unless UV protected.</b></p> <p><b>Requires special bedding which can very well offset the cost difference.</b></p> <p><b>Available only over a particular range of diameters.</b></p>
--	---	---	--

On careful review of the qualitative and quantitative comparison of various materials, it is recommended that RCC pipes will be primarily used for sewage collection system. However, keeping in mind that the project area has less space at some places and the streets where sewer lines and house connections are to be laid are very narrow, in some case narrower than even 3.5 m. It is suggested to use uPVC pipe of 110 to 315 mm outer diameter to hasten the process of providing individual house connections and relative flexibility of laying in difficult field conditions.

RCC pipe has been used for sewers for a long time primarily due to its inherent strength and relatively low cost when compared to other products. The pipe can now be made in several joint configurations and can also be lined with PVC and other materials for protection against crown corrosion. The pipe can be designed on the basis of allowable stresses resulting from overburden pressure and laying conditions. It is important that the design of pipeline is done with the best approach to suit the anticipated design conditions.

Concrete pipe designed and manufactured properly can deliver excellent service for the conveyance of domestic wastewater. However, the converse is also true, i.e. pipe manufactured poorly or based on improper design criteria can lead to poor service life. Today, concrete pipe is expected to function properly in the field if strict adherence to specifications and plant quality control/quality assurance are maintained. The referenced specification dictates minimum reinforcement steel requirements that can be expected to deliver the stated design conditions of superimposed load or allowable stresses resulting from earth cover or internal pressure.

RCC is a high-density, wet-cast pipe meeting the requirements of IS 458 specifications. This pipe is designed as a rigid pipe, meaning that it is designed to carry construction, earth, and traffic loads without significant cracking, or deflection of the barrel. RCC pipe is designed to deliver an agreed upon level of performance at a specified design. The measure of performance is the formation of a 0.01-inch crack for a length of 12 inches pursuant to IS standards. Over the years, the pipe manufacturing technology has been improved in terms of producing more durable RCC pipes. This has been done both in terms using better material of construction and also protective linings for pipes. These are discussed categorically to select and recommend the best quality of RCC pipe for the project.

There are generally three types of lining that are used to prevent sulfuric acid attack on the interior of the concrete pipe (known as crown corrosion). This attack is due to sulfides escaping the sewage as hydrogen sulfide gas and then reforming as sulfuric

acid through bacterial action at the crown of the pipe. The degree of this problem is dependent on the amount of hydrogen sulfide forming in the sewage flows, amount of hydrogen sulfide released, and temperatures necessary to support sulfuric acid formation. In a tropical country like India, formation and release of hydrogen sulfide may very well be correlated to the high reaction kinetics inflicted by conducive sewage temperature and crown corrosion remains a persistent problem in sewers. With the availability of linings today and their reasonable cost, it is prudent to recommend linings to protect the pipe material from crown corrosion and extend its service life.

**Plastic Lining** – PVC lining is physically bonded into the concrete pipe interior with “T” shaped PVC corrugations to prevent crown erosion. This lining is placed into the interior of the form during the manufacture of the pipe and cast into the interior wall of the pipe. Sometimes, the amount of T-Lock placed into the pipe is limited to the top 90 degrees of the crown of the pipe. However, due to noted sulphide attack in large, low-flowing sewers, the degree of coverage has gradually increased to where it is now standard practice to provide the lining over the entire inside surface of the sewer pipe. The lining in each section of the pipe is welded to the lining in the next joint in the field. This process requires the use of high-quality equipment by well-trained plastic welders to ensure that good seals are obtained. Full-time inspection and PVC weld testing are required with most contractors to obtain high quality PVC lining and are an important part of the construction quality control program. Such pipes are now available in India.

Such plastic lining provides protection of the interior of the pipe from acid attack and crown corrosion throughout the pipe barrel. The cost for the lining system is reasonable and this is easily field repairable. However, such lining requires field PVC welding of the lapped joints at each joint of pipe and low quality PVC welding has resulted in acid attack under the liner in warm sluggish sewer systems. Also, high level of inspection of the welds is required to ensure sound installation.

**Cured-in-Place Fiberglass Liner** - The lining can also be provided by placing a glass-resin-impregnated flexible felt tube inside the pipeline. Availability of this lining is limited in India and is not considered for further consideration.

**Sprayed on Protective Coatings** - This method includes spraying high build epoxy, two part epoxy, or cementitious epoxy coatings onto the interior surface of the RCC pipe. Due to the costs, application issues, and historical performance these systems are not recommended for lining the pipe barrel and are not further considered.

**Bitumen Lining** – To protect the inside surface of the pipe from the reaction of a variety of sulphates which can attack the concrete directly, bituminous coating, whether asphaltic or coal tar, is applied to protect the structure against such attack. This can be field applied, yet careful supervision is required to ensure quality of application.

**RCC Pipe with Sulphate Resistant Cement** - Use of pipes manufactured with high density sulphur resistant cement is only recommended. These pipes are made of slag cement that contains fewer calcareous ( $\text{CaOH}_2$ ) particles than pipes made of ordinary portland cement. These particles react with the sulphuric acid (produced by oxidation of hydrogen sulphide) generated inside the sewer environment and cause crown corrosion. If this particular cement is used, lifetime of concrete sewers can be enhanced beyond the anticipated design life of 30 years. RCC pipes are also manufactured with sulphate resistant cement when the soil contains sulphur and other corrosive substances.

**Jointing** – The types of concrete pipe joints are evaluated for this project, single gasket concrete joint with projected socket, double gasket concrete joint with projected socket, and embedded steel joint rings with smooth or projected socket. However, considering the ease of laying and other factors, only single gasket joint is recommended. To test the joint two inflatable bladders, or temporary bulkheads, one located on each side of the joint are installed and the area between the bladders pressurized. For smaller sewers, the entire installed length may be subjected to an overall leakage-performance installation test. The advantages of this type of joint are, these are easy to install, standard joint used in concrete pipe industry, long-term history of success, competitive cost. Disadvantages associated with single gasket joints include, manufacturing joint sockets within standard roundness tolerances has been a problem for some manufacturers and difficulty in testing each joint.

**Inspection of Manufacture and Installation** - To help ensure proper manufacture of concrete pipe, inspection services should be provided at the manufacturing plant for a project of this magnitude. To ensure proper placement of the rigid pipe, proper placement of bedding at trench bottom and compaction of backfill are very important. To ensure proper support, the bottom of the trench should be provided with stipulated granular or PCC bedding of adequate dimensions in the trench following pipe placement. The remainder of the bedding should be placed and compacted in lifts to provide additional support and to prevent trench settlement. It follows that the class bedding achieved at the jobsite must be at least equal to or exceeds the class bedding used in design.

#### 4.1.1.13 Structural Design of Sewer

Structural design of sewers is important to ensure that these buried pipelines can structurally withstand the overburden pressure and superimposed load to which they are likely to be subjected. For gravity sewer lines, internal pressure is not significant. At greater depths, these pipes will be provided with proper bedding which will also be feasible to install under difficult site conditions. Properly compacted backfill plays a critical role in dispersion of superimposed loading.

The computation of loads on buried pipelines and calculation of safe load for a particular diameter of pipeline installed at certain depth underground has been established by Marston and others, and such methods are summarised in the Sewerage Manual. A safety factor of 1.5 has been applied and the loading conditions are adopted on the basis of these lines being laid below roads with heavy traffic as per recommendations in the Manual. Keeping in view the practicability of providing bedding for sewer lines in limited space, only granular and PCC beddings are proposed, as applicable and to be decided by the supervising engineer during actual laying of pipelines. In order to avoid differential/ordinary settlement and soil movement around sewers, strict adherence to suggested bedding has to be ensured during construction. The RCC pipes used will be of socket and spigot type with push-on rubber ring joints.

#### 4.1.1.14 Manhole

Manholes have been proposed based on the following criteria and other salient features. These will be constructed in brick masonry to reduce cost of the project. No use of precast or fabricated manholes have been considered.

##### **Location**

Manholes are located based on the criteria as given below,

- At changes of slopes in sewer pipeline.
- At change in direction.
- At sewer junctions and probable house connections.
- At change in sewer diameter.
- At termination of sewer.
- At any designated special location as envisaged by planning.

### Spacing

The spacing of sewers is dependent on the type of maintenance envisaged. Such spacing varies depending on whether sewers can be physically entered for inspection or maintenance or not. The sewers that would be installed in the project area are expected to be less than 1,100 mm hence these can be categorized as “non-man entry” sewers. A spacing of 30 m has been stipulated by the Manual for non-man entry sewers which is mainly based of the type of cleaning apparatus or procedure intended to be used. Manholes will primarily be located following the criteria given above. On continuous stretch, the spacing provided will be 30 m.

### Size of Manhole

The size of manholes is related to its invert level (i.e. depth of manhole) and size of outgoing sewer. Manholes will be rectangular to facilitate ease of construction, time of installation, and future maintenance. Based on structural requirements to ensure appropriate design of manhole, the criteria given in Table 3 will be used. Deeper manholes will be provided with suitable access shafts. Manholes will be provided with RCPC covers and frame and polypropylene steps for accessing the sewers.

### Manhole Levels

In paved areas, cover level of manholes will match with the final paved level, and in open and unpaved areas cover level will be 50 mm above the ground level. Also, the invert of manhole will be finished with a difference of 0.025 m or 25 mm below the proposed invert of the outgoing pipe.

### Sewer Ventilation

Vent shafts are normally provided for venting off the gas generated inside sewer lines and as per requirement, practicability of construction, etc. Ventilation pipe is recommended for every house connections. In case of trunk sewers, such provision may be kept as suitable without causing any obstruction to other services.

Table 4-4: Manhole types and size.

SN	Manhole		Size, L x B (m x m)	Max. diameter of Outgoing Sewer (mm)
	Type	Depth of Invert, m		

1	M1	1.5 ≤	0.9 x 0.9	400
2	M2	> 1.5, 2.5 ≤	1.2 x 0.9	500
3	M3		1.2 x 1.2	800
4	M4		1.2 x 1.5	1000
5	M5	> 2.5, 4.0 ≤	1.4 x 1.2	800
6	M6		1.4 x 1.5	1200
7	M7	> 4.0, 6.5 ≤	1.4 x 0.9	600
8	M8		1.4 x 1.2	800
9	M9		1.4 x 1.5	1200

#### 4.1.1.15 Sewer Crossing

Gravity trunk sewers and pressure mains are expected to cross beneath roads and railway tracks. At major road, railway, drainage crossings, pipes will have to be protected by concrete encasement or sleeve pipes. Sewers are not to be laid above water supply pipelines. When laid under water supply lines, there should be at least 0.5 m clear distance between the two pipes. If required, pipelines may have to be installed by trenchless technology (i.e. thrust boring) to cross important utility lines. The cost of utility shifting (e.g. water, drains, electric, telephone, optical fibre cable, etc.) needs to be added to cost of sewer pipe laying at specific locations.

#### 4.1.1.16 Sewage Pumping Station

Sewage pumping station will be provided only when the depth of excavation for laying sewers exceeds a certain limit. In the present case, this depth has been stipulated at 4.5 m. pumping station will also be required to pump sewage from a lower level to a higher elevation, where gravity conveyance of sewage to a terminal location (i.e. treatment plant) is not feasible. A few relevant features of the proposed sewage pumping station are given here.

Sewage pumping stations normally forms a weak point in the entire sewerage system due to lack of adequate maintenance. Hence, the effort will be made to reduce their number as much as practicable. On a different aspect, other environmental impacts are expected due to possible odour/noise problem, silt/sludge removal, etc.

##### **Inlet Structure**

Sewage pumping station will be provided with exclusive inlet arrangement. The inlet will comprise two parallel and separate channels, one with a manual bar screen and the other with mechanical bar screen. The size of opening of screen will be 25 mm to safeguard the pumps against possible abrasion and clogging caused by larger particles. Sluice gates will be provided at upstream and downstream ends of each channel for isolation and maintenance. Such an arrangement is proposed to ensure system flexibility in case any of the bar screen requires cleaning/maintenance, the other can cater the entire estimated flow to the pumping station.

## Wet Well

The wet well will be suitably sized to cater for any combination of wastewater inflow and pumping. The capacity of wet well is related to the maximum level of water in the sump and minimum pump suction level. The wet well will be suitably dimensioned to ensure running of minimum capacity pump for at least 5 minutes and maximum retention of sewage for a period of 30 minutes.

## Pumping Arrangement

To ensure simple operational procedure and keeping in view the capacity of each pumping station, non-clog and wear-resistant submersible sewage pumps are proposed. These pumps will be installed in the wet well of the sewage sump and capable to handle solids of 100 mm spherical size and operate near to their duty points as given by the manufacturer. The design criteria for selecting the size of sewage pumps as recommended is given below,

Table 4-5: Recommended Capacity of Sewage Pumps.

SN	Criteria	Capacity	No.	Total No.
<b>A</b>	<b>As per Recommendation of Sewerage Manual</b>			
1	Smaller capacity pumping station	1 DWF	1	3
		2 DWF	1	
		3 DWF	1	
2	Larger capacity pumping station	0.5 DWF	2	5
		1 DWF	2	
		3 DWF	1	
<b>B</b>	<b>As per Recommendation of NRCD Guidelines</b>			
1	When rising main is long	0.5 Peak flow	2	4
		Non-peak flow pumps	2	
2	When rising main is short	0.25 Peak flow	5	6 (1 stand by)
		0.25 Peak flow	1	

Duty conditions and capacity of individual sewage pump will be selected depending on projected sewage flow in two phases. Diesel generator sets will be provided at each pumping station location, if sufficient space is available, to insulate its operation from power failure. These stations will be well-ventilated to ensure there is accumulation of gases inside the stations which can seriously compromise the working condition and prove to be extremely detrimental to operators' health.

## Pumping Main

Pumping main from sewage pumping station will be of ductile iron (DI). The hydraulic design of pipelines is given by the Hazen-Williams formula as below:

$$Q = 1.292(10^{-5})Cd^{2.63}S^{0.54} \quad \text{Eqn. 4}$$

$$V = 4.567(10^{-3})Cd^{0.63}S^{0.54} \quad \text{Eqn. 5}$$

Where, Q is discharge in m<sup>3</sup>/hr, V is velocity of flow in m/s, d is the diameter of pipe in mm, C is the Hazen-Williams Co-efficient, S is the slope of hydraulic gradient in m/m. Hazen-Williams Coefficient ('C' value) of 140 is adopted for design purpose for cement mortar lined DI pipes. The minimum diameter of pumping main has been restricted to 150 mm so that there is no clogging problem. Minimum velocity of flow in pipe will be 0.6 m/s to avoid settlement of solids inside the conduit and maximum velocity will be 3 m/s.

The pumping main will be laid with a clear cover of 1 m, with necessary sluice, washout, and air valves for maintenance (suitable to use for sewage). The pumping can discharge sewage to treatment plant, receiving sewage pumping station, or manhole. The discharge head of pumping main will be suitably dampened to reduce turbulence and corrosion of civil structure. These discharge locations will be well-ventilated to avoid accumulation of undesirable gases.

### **Pump Operation Philosophy**

The control philosophy of pumping operation will be dictated by the prevailing water level in wet well. The detention volume refers to the storage volume between the High Water Level (HWL) and Low Water Level (LWL) of wet well used for formulation of this operational strategy of pumps. Accordingly, sizing of the well will be finalized based on (a) plan area of the well as per the space requirements for installation of pumps and (b) proposal for level controlled operation of the pumps.

For monitoring the levels ultrasonic level sensors and level controllers will be provided with a display unit inside the pump house. Operation of the pumps will be controlled by signals from the level controllers. Sensitivity of ultrasonic level sensors available in the market is generally within the range of 0.1 to 0.2 percent of the measuring range. Considering average depth of wet well as 6 m, the sensitivity comes to about 1 cm. Based on the above, the cut in/cut off levels of the pumps will be devised. The proposed logic for determining progressive intermediate cut in/cut off levels of pumps, depending on inflow to the well, is described below:

- Each pump will start at a pre-determined level L1 and stop at a pre-determined low cut-off level (LCL).
- Different levels will be decided on the basis of incoming flow, wet well size and respective pump capacities so that each pump runs for at least 5 minutes.
- In case any pump fails to start as per the above sequence, the next pump shall be automatically introduced.
- No pump shall be in operation below low cut-off level (LCL) to prevent dry running of pumps.
- There shall be manual override to auto-operation of the pumps.

- Automatic pump selector for periodically changing selection of equal capacity pumps with manual override will be provided for uniform distribution of running time between various pumps.

#### 4.1.1.17 Sewer Warning Tape

Sewer line is suggested to be laid with warning/caution tape. Such tape will be installed precisely following the alignment of sewer line at about 0.3 m above it. This tape will be required to identify the underlying sewer in case of any emergency or unplanned excavation undertaken at a later stage. This caution tape will be of green colour with “sewer” written on it and a metallic strip. The metallic strip is necessary to identify the alignment and depth of sewer in case GIS mapping of this utility is intended in future. Such provision will help future identification of sewers and help in management of assets created under the project.

#### 4.1.2 Design Periods

Designing a suitable and adequate sewage collection system for collecting domestic wastewater generated by population and likely ground water infiltration are the main component of an organized sewerage system. Sewerage system are designed keeping in mind the financial viability of the project and can be achieved by considering the future population of 30 years, which is the general practice in India. In case of Kolong city also the design period will be for 30 years, starting from year 2014. A design period of 30 years is also recommended by the “Manual for Sewerage and Sewerage Treatment” for all types of sewers and its components. The design life of mechanical components like pumping machinery, equipment, etc. are generally taken as 15 years after which these are expected to be suitably replaced in phased manner depending on the condition of the equipment.

As per the NRCD Guidelines, “base year” should be taken as year of expected commissioning of the project and for design of its various components. Consideration the size of the town; the design and tendering of the scheme should be completed by year 2014, and “base year” for the system implementation should be taken as 2015. Accordingly, the ultimate design horizon for the sewerage system is taken as 2044. The design life of electro-mechanical components to be installed in sewage pumping station(s) and treatment plant(s) is considered as 15 years, i.e., these will be replaced around year 2030 depending on the condition of these assets. Correspondingly, year 2030 has henceforth been referred to as “intermediate stage” and 2044 as “ultimate/final stage”. Design periods for various components are summarized in Table 4-6 below.

Table 4-6: Design Year for Components.

SN	Component	Design Year (from base year)	Remarks
1	Sewerage System	30	As per NRCD guidelines and CPHEEO Sewerage Manual
2	Sewage pumping station (Civil)	30	Economical to invest in civil works for full design period of 30 yrs.
3	Sewage pumping station	15	Economical to invest in a phase-

	<b>(Electro-Mechanical)</b>		<b>wise manner</b>
<b>4</b>	<b>Pumping main</b>	<b>30</b>	<b>As per NRCD guidelines and CPHEEO Sewerage Manual</b>
<b>5</b>	<b>Sewage treatment plant</b>	<b>15</b>	<b>Design period of 30 years phased out in two phases of 15 yr. each</b>
<b>6</b>	<b>Land for Sewerage Treatment Plant</b>	<b>30</b>	<b>For additional treatment plant(s) if phased out or done on modular basis</b>

Source: *Analysis*

### 4.1.3 Population Projections

The ward wise population projections is done based on considering the overall growth of 60% in the whole town of Nagaon and equitable distribution of the growth of Nagaon city.

### 4.1.4 Norms of Rate of Water Supply

According to the guidelines of Government of India, and as per the Manual on Water Supply and Treatment by CPHEEO, which are applicable all over the country, following water supply rates are to be adopted:

Table 4-7: Recommended per capita Water Supply levels for designing Schemes.

<b>SN</b>	<b>Classification of cities</b>	<b>Recommended Max Water Supply Levels (LPCD)</b>
<b>1</b>	<b>Cities provided with piped water supply but without sewerage system</b>	<b>70</b>
<b>2</b>	<b>Cities provided with piped water supply where sewerage system is existing/ contemplated</b>	<b>135</b>
<b>3</b>	<b>Metropolitan and Mega cities provided with piped water supply where sewerage system is existing/ contemplated</b>	<b>150</b>

As the city of Nagaon gets water from different sources like piped water supply, hand pumps, bore wells etc. it is assumed that the existing water supply to the city is not more than 70 lpcd, although there is no official records available with Nagaon municipal board regarding the average water supply to the households as 77% households use hand pumps for their daily need of water supply. For the consideration of this project it is assumed that piped water supply scheme will be implemented with average water supply of 135 lpcd as recommended by CPHEEO manual.

## 4.2 Calculation of Waste Water Discharge

### 4.2.1 Actual Water Supply from Different Sources

Nagaon town gets its potable water almost exclusively from the ground. Untreated discharge of waste water from septic tank into the ground, and also into the river, is contaminating the ground water and creating health hazards for the people of Nagaon. Details of the various sources are listed in Table 4-8 and **Error! Reference source not found..** About 77% of the household in Nagaon town use hand pumps, tube and bore wells as the ground water table is high (3 to 4 m below the surface).

Table 4-8: Water Supply by Source.

S. No.	Source	No. of Households	Population	Percentage
1	Tap water	6,394	27,273	22.40
2	Wells (open + closed)	108	461	0.38
3	Hand pumps	19,153	81,695	67.20
4	Tube wells / Bore wells	2,778	11,849	9.70
5	Other (springs, etc.)	82	488	0.29
	<b>Total</b>	<b>28,515</b>	<b>1,21,766</b>	<b>100.00</b>

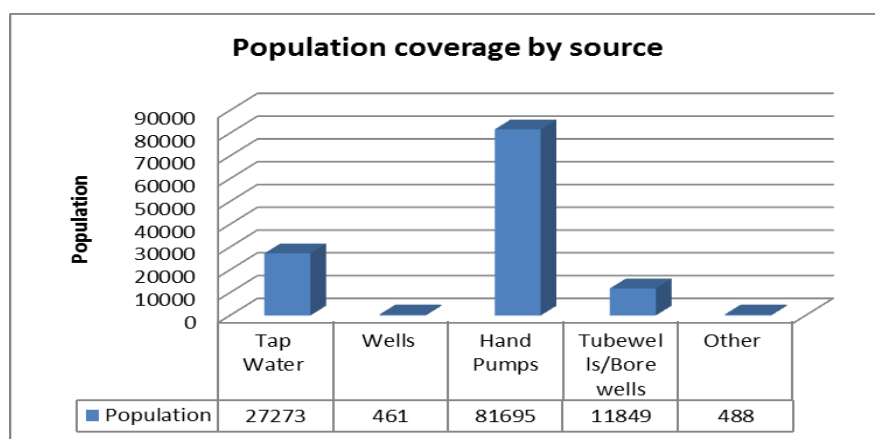


Figure 4-1 Sources of water supply in Nagaon Town(Census 2011)

### 4.2.2 Projected Waste Water Flows

Nagaon city has been divided into four sewerage district zones as West, East, Central and Putta Kolong sewerage zones. The division of these zones was done based on the topography and geographic features, ridge lines, alignment of drains, major roads, national highway and the ward boundaries. Number of wards considered in west zone is

ward number 1,3,5,6 and 19, for East zone ward number is 7, 8,10,14,15 and 23, for central zone ward number is 9 and 11 whereas for Putta Kolong ward number is 16 (Figure 4-2).

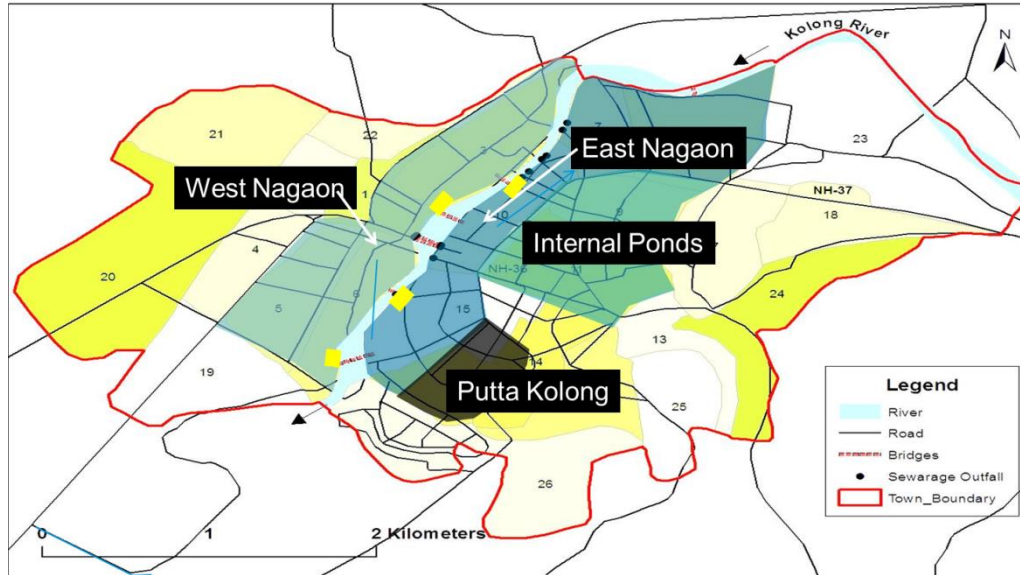


Figure 4-2 Ward Map of Nagaon with waste water zones

Projection of waste water flows is done by multiplying the projected population by per capita sewage generation. Calculation of per capita sewage generation is as shown in the following table.

Table 4-9: Calculation of per Capita Sewage Generation.

S. No.	Description	Demand (lpcd)
1	Net per capita water demand for Nagaon	135.00
2	Add 10% for ICI demand <sup>1</sup> @ 10%	13.50
2	Add ground water infiltration @ 5%	6.75
<b>Sub Total</b>		<b>155.25</b>
3	Considering 80% for sewage generation	124.20
<b>Say</b>		<b>125.00</b>

Source: Analysis

Following table shows the total waste water generation within the catchment area and also by the sewerage district zones. Details regarding the number of wards in each sewerage zone are assumed, whereas number of household in each ward, population in each ward is collected from census 2011 data. Population projection is done and is then multiplied with per capita sewage generation to get the total expected waste water generation from each zone and for the complete catchment area.

Table 4-10: Projected waste water generation.

Sewerage Districts	Ward no	No. of House hold	Population	Projected Population (1.6X) 2044	Total Expected Sewage 2044 (lpcd)	Expected Sewage Discharge (lpcd)
West	1	350	1,705	2728	341000	4112400
	3	1,035	4,151	6642	830200	
	5	1,038	4,456	7130	891200	
	6	1,565	6,873	10997	1374600	
	19	813	3,377	5403	675400	
Central	9	583	2,429	3886	485800	1483600
	11	1,108	4,989	7982	997800	
Putta Kolong	16	861	3,563	5701	712600	712600
East	7	748	3,022	4835	604400	4355400
	8	970	3,858	6173	771600	
	10	449	1,831	2930	366200	
	14	706	3,117	4987	623400	
	15	567	2,641	4226	528200	
	23	1753	7,308	11693	1461600	
<b>Total</b>						<b>10664000</b>
<b>Say Total (MLD)</b>						<b>11</b>

Source: Analysis

From the above table it can be seen that total waste water generated from all the catchment area is approximately 11mld, where west zone is contributing approximately 4.2MLD, East zone contributing approximately 4.4 MLD and remaining contribution is from central and Putta Kolong sewerage zones.

### 4.3 Decentralized STPs

#### 4.3.1 Projected Waste Water Flows in each District in Design years

Total waste water generated in west, east, central and Putta Kolong is 4.11mld, 4.35mld, 1.48mld and 0.72mld respectively. Total waste water generated in the catchment area would be approximately 11mld, which will be for the year 2044. For the decentralised option, four STPs of 4.5mld,4.5mld,1.5mld and 1mld needs to be installed in each West, East, central and Putta Kolong area of Nagaon city respectively. However,

since the modular STPs proposed for this project are available only either of 1 MLD, 2 MLD or 5 MLD capacity, the combination proposed is two 5 MLD and two 1 MLD capacity modular STPs.

A detailed analysis of centralized and decentralized STP system is given in the Project Feasibility Report (December 2013)

#### 4.3.2 Length of Sewer Lines and Capacity of SPS, STPs in each District

Total length of the sewer in the entire four sewerage districts will be 84km, which will include the length of sewer required to tap the individual connection and connecting it to the sewer network and also the small lanes which are required to be connected. The sewerage district wise length of the sewer network and capacity of STP in each district is as shown in the following table:

Table 4-8: Length of sewers

SN	Name of the District	Length of sewer network	Capacity of STP
1	West	43.00 km	4.5 MLD
2	Central	6.50 km	1.5 MLD
3	Putta Kolong	2.00 km	1.0 MLD
4	East	32.50 km	4.5 MLD
<b>Total</b>	<b>All</b>	<b>84.00 km</b>	<b>10.50 MLD say 11 MLD</b>

Source: Analysis

The length of sewer network includes the individual connections to sewer line, trunk and sub trunk sewer, branch and lateral sewer lines in all the four sewerage districts. Length of trunk/sub trunk, branch and lateral and individual sewer connection line will be worked out in Detail Project Report.

#### 4.3.3 Availability of Land for various Components in each District

Sewerage network is laid on the road side on publicly owned land; hence no land is required to be acquired for sewer. However, land is required for intermediate pumping stations and decentralised sewerage treatment plants in each district. Generally an area of about 20 sq. meters is required for a sewerage pumping station and an area of about 200 sq. meters per MLD is required to put the decentralized treatment plants. Figure 4-3 shows the proposed sewerage network with the decentralized STPs option.

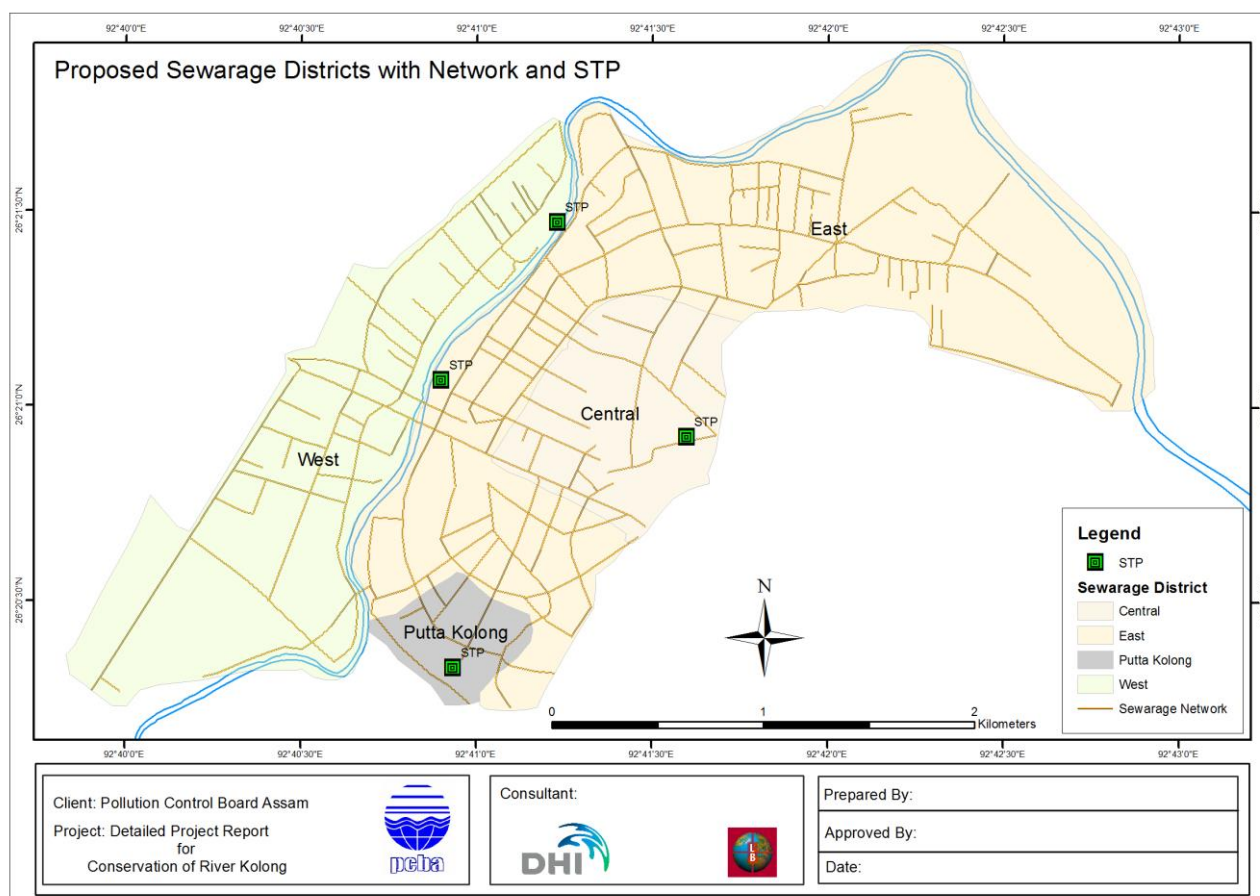


Figure 4-3 Sewerage network with decentralized STPS

#### 4.3.4 Cost of STP including O&M

Table 4-9 Cost of the Proposed STPs

S.No.	Item	Qty	Unit	Rate	Amount
1	Decentralised STPs including supply of compact bioreactor units, installation, contractors' fees all complete				
	2 Nos., 5 MLD Modular STP	10	MLD	2,37,30,000	23,73,00,000
	1 MLD Modular STP	1	MLD	2,37,30,000	237,30,000
	1 MLD Modular STP	1	MLD	2,37,30,000	237,30,000
	Total				28,47,60,000
	Contingencies			5%	

					1,42,38,000
2	O&M costs @Rs. 4000/MLD/Day for 5 years adjusted to escalation	1	LS	18,06,75,000	18,06,75,000
	Grand TOTAL				<b>47,96,73,000</b>

#### 4.3.5 Cost of proposed sewer network including O&M costs

Table 4-10 Cost of the proposed sewer network including O&M.

S.No.	Item	Qty	Unit	Rate	Amount
1	Trunk Mains	32000	m	1550	4,96,00,000
2	Laterals	54600	m	9300	50,77,80,000
3	Pumping Mains	8400	m	6200	5,20,80,000
4	Pumping Stations	20	No	20,00,000	4,00,00,000
5	Utility Relocations	11940	m	7625	9,10,42,500
6	Subtotal				74,05,02,500
7	Contingencies			5%	3,70,25,125
8	Total				77,75,27,625
9	O&M for 5 years @ 5 % (per year) of the total capital cost , adjusted to escalation				11,66,29,144
10	Grand TOTAL				89,41,50,765

## 5 Solid Waste Management

### 5.1 Introduction

Solid Waste Management (SWM) is a process of storage, collection and disposal of the waste generated from various sources like households, commercial, markets, etc. Improper disposal of Municipal Solid Waste (MSW) has a negative impact in terms of contamination of soil, surface water, ground water and generation of toxic and greenhouse gases. However, use of adequate information, resources, and efficient management practices could turn some of the solid waste into a useful resource.

The Ministry of Environment and Forests (MoEF), Government of India, published the “Municipal Solid Waste (Management and Handling) Rules” of 2000 (MSW Rules 2000). These rules were developed in compliance with Sections 3, 6, and 25 of the Environment Protection Act, 1986, and aim at standardization and enforcement of SWM practices in the urban sector. These rules dictate the following:

*“Every municipal authority shall, within the territorial area of the municipality, be responsible for the implementation of the provisions of these rules, and for any infrastructure development for collection, storage segregation, transportation, processing and disposal of municipal solid wastes”.*

In addition, the rules state:

*“The CPCB shall coordinate with the State Pollution Control Boards (SPCB) and the Pollution Control Committees in the matters of MSW disposal and its management and handling”.*

### 5.2 Existing Situation

#### 5.2.1 Baseline information

According to the Municipal Solid Waste (Management and Handling) Rules, 2000, municipalities are responsible for municipal solid waste management and in Nagaon town; the NMB is doing the municipal solid waste management. The total waste generated per day in Nagaon town is approximately 30-32 metric tonnes (MT) from various sources like households, commercial establishments, hotels, market places, drain cleaning and street sweeping, construction waste etc. Out of the total generated waste about 22-23 MT are collected on the daily basis, which is about 70% only. As per the information provided by NMB staff, there are around 90-100 bins placed all over the town. The material of these bins is either fibre or cast iron. The condition of these bins is bad as can be seen from Figure 5-1.



Figure 5-1 Indiscriminate solid waste disposal to Kolong River

Solid waste collection is done on the daily basis from the collection points/ bins. Ten vehicles transport the waste to the landfill site, which is located 8 km away from the town in the Sialmari area. The landfill site is used on a rental basis as the NMB does not have any government land available for disposal of solid waste. Rent of Rs. 2000/- per month is paid to the owner of the land. Apart from the landfill site, the NMB has a solid waste incineration machine called “Swatch-Plasma system” with a capacity 500 kg per day. The system is the first initiative by the Pollution Control Board for scientific disposal of municipal solid waste.



Figure 5-2 Swatch Plasma system Installed by Nagaon Municipal Board for Waste Disposal

The total NMB staffs available are about 100 people, of which 51 are sweepers and remaining are labourers, drivers, tricycle pullers, etc. During the filed visit, it was observed that people threw garbage along the river side where there are no garbage bins, which is a cause of pollution for the river.

#### Category Wise Quantity of Solid Waste and its Characteristics

As stated above, the estimated waste generated across the town is 32 MT, which implies that the total waste generated per capita is approximately 0.2 kg/capita/day, considering an average family size of 5 persons. Official data on the category wise solid waste generated are not available. However, the general composition of the solid waste is as shown in Table 5-1 and Figure 5-3.

Table 5-1 : Composition of Solid Waste.

S. No.	Composition of waste	Percentage
1	Food and garden waste	40
2	Glass and ceramics	5
3	Paper	27
4	Metal	15
5	Inert	4
6	Plastic rubber	6
7	Textile	3
	<b>Total</b>	<b>100</b>

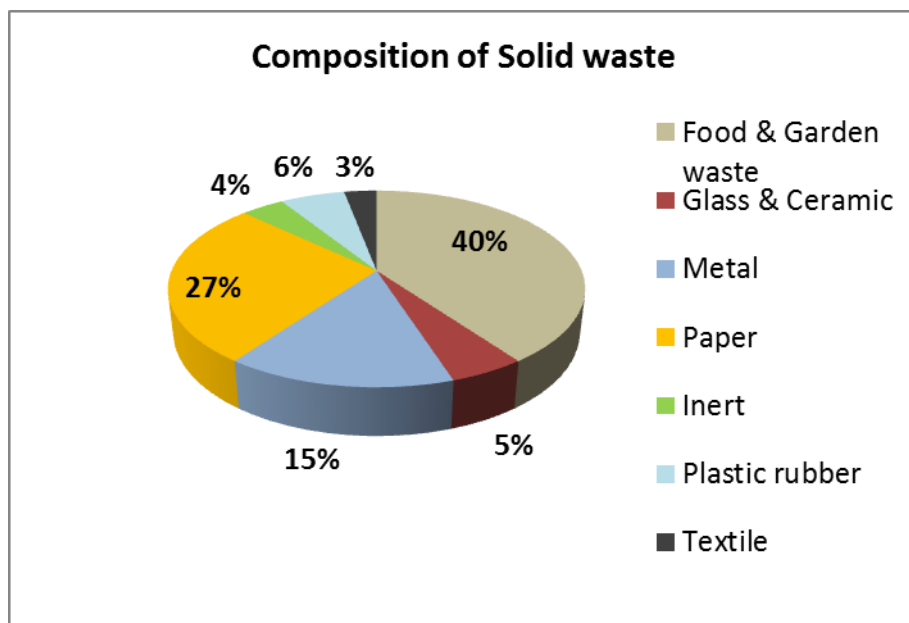


Figure 5-3 Composition of Solid Waste

#### Biodegradable and Non-Biodegradables Waste

Solid waste contains both biodegradable and non-biodegradable components. Based on the primary survey, it is estimated that 70% of the total waste is biodegradable and 30% is non-biodegradable. A major part of the waste is from households that generate a considerable part of biodegradable waste such as food, fruit, paper, etc. Increasingly, the use of plastic and packaged products contributes to non-biodegradable municipal waste.

## Industrial Waste

There are no major industries in the Nagaon town, however there are some small rope-making enterprises which contribute to the solid waste. In addition, there are motor garages, wood furniture shops, etc. that contribute to the waste generation.

## Bio-medical Waste

Bio-medical waste is generated by hospitals and other health services providers and consists of discharged drugs, waste shapes, microbiological and biotechnological waste, human anatomical waste, animal waste, etc. There is no exclusive bio-medical waste management system for the Nagaon area. According to the bio-medical waste (Management and Handling) Rules 1998, authorization by the State Pollution Control Board is mandatory for each medical service provider including research laboratories handling bio-medical waste. According to the Rules, the generator of the bio-medical waste is responsible for safe handling & management of the waste.

The Nagaon district has the following healthcare facilities:

- One (1) district hospital
- Eleven (11) child health clinics
- Seventy-one (71) public health clinics
- Thirty-three (33) nursing homes/private hospitals and diagnostic centres/laboratories.

All of the above are handling and producing bio-medical waste.

According to the District Authority and the Joint Director, Health Services (Jt. DHS), Nagaon does not have any information regarding authorization or a system for handling bio-medical waste. However, information furnished by the Jt. DHS revealed that no organisation has an incinerator for disposing bio-medical waste as per specified norms of the Board. Thus, in absence of any mechanism for disposing bio-medical waste, its dumping in open spaces creates air pollution and health hazards. The survey team found that the private hospitals/nursing homes in the town are not segregating their waste and the bio-medical waste generated from these institutions is dumped along with the MSW. Dumped waste from a hospital was found on the river bank during the field visits (Figure 5-4).

## Segregation of the Solid Waste

In Nagaon town, there is no official process of the segregation of solid waste. Rag pickers collect some of the waste produced for their livelihood and as such that can be considered an unofficial segregation of the waste. But it is far from sufficient.

## Collection and Storage System

The NMB is responsible for the collection, transport and disposal of municipal solid waste. For the collection of solid waste in Nagaon town there are 90 to 100; six) mechanical dumper placers. To carry out the collection work, the town employs 51 sweepers, 47 drivers, labourers, tricycle pullers, etc. About 22-23 MT of the solid waste is collected through fibre and cast iron bins. The system is not sufficient and for that reason waste is also dumped at Unauthorised/random sites in the town, along open drains and Kolong river and its banks. According to the field investigations conducted by team, there are more than 20 open dump sites which were identified along the Kolong River in Nagaon town. Rag pickers collect the recyclable fraction of the waste produced and sell those for their livelihood.



Figure 5-4 Dumped waste from Hospital



Figure 5-5 Waste dumping along Kolong River

Transfer System

In some areas solid waste transportation vehicles come and collect the waste, but not in all areas. Solid waste is carried in open carts and trucks and dumped at the landfill

site in the Sialmari area. There is no proper schedule or an integrated solid waste collection system present in Nagaon town.

For the collection and transportation of the solid waste the town has 10 vehicles (5 tipper, 4 tractors, 6 trolleys, and one TATA truck). For the collection of solid waste dumped on the ground the town has one excavator/loader and one loader skid.

In certain parts of the town the roads are narrow (the average road width is 3m). This restricts the movement of heavy vehicles. An example of the collection of waste is shown in (Figure 5-6).



Figure 5-6 Solid waste transported by NMB

#### Garbage Dumping and Disposal Sites

The town has one location to dump garbage and one machine to burn garbage, as stated previously. The dumping location is located 8 km from the town at the Sialmari area. The rent for the area is 2000 INR/month. The location can only be sustained for about one more year. One swatch machine behind Marar Park. It has a garbage burning capacity of 500 MT/day. The Pollution Control Board has installed it as an experiment for the disposal of solid waste.

#### Solid Waste converted to Compost - Composting Site and its Capacity

There are no composting sites and no official information on conversion of waste into compost in Nagaon town; although the options for the same can be worked out in the future for better management of solid waste. It is important to look at segregation of solid waste at the source so that it can be used for the compost.

#### Solid Waste Recycled

As there is no separation of waste at any level (neither at the household level or at the dumping ground level) it is difficult to recycle the waste. No organised official recycling process is done in Nagaon town. Rag pickers do collect recyclable waste from the waste dumping sites for their livelihood and hence some of the waste is recycled.

### 5.2.2 Deficiencies in SWM System

From the information available and primary survey done in Nagaon town it can be observed that there are deficiencies in solid waste management, including the storage,

collection, transportation and disposal of waste. In terms of storage facilities, the number of dust bins is small, and existing bins are not in good conditions especially along the Kolong River. Furthermore, the collection of the waste is a problem because the waste is not properly stored in the collection bins.

Although the NMB has some solid waste collection trucks and carts for the collection and transferring the solid waste, it is not sufficient for handling the waste generated from the entire town. On top of that, there is no proper disposal site since the existing site is not sustainable over long term.

### 5.2.3 Justification for Upgrading the Present System or a New System

In view of the existing waste generation and handling scenario and future growth potential of the Nagaon town, it is necessary to upgrade the existing solid waste management system (SWM) into an integrated management system to ensure proper management of disposal of solid waste.

The following key issues have been identified in Nagaon town:

- It is mandatory for all urban local bodies in India to comply the MSW (Management & Handling) Rules, 2000 of the Government of India. However, Nagaon town is well behind in regards to the compliance of this mandate primarily with regards to the MSW operational management aspect.
- Part of the uncollected solid waste is disposed into the water bodies of the town including the Kolong River. This results in the accumulation of solid waste and deposition of silt along certain stretches of the river. This in turn reduces the water-carrying capacity of the river besides polluting it and acting as a breeding ground of mosquitoes and other disease causing elements.
- Dumping of solid wastes in the open and leaving it for a longer period causes generation of leachate from such waste. There is a probability of contamination of ground water resource of the town basin and also deterioration of the river water quality due to seepage of such leachate.
- Stretches of the Kolong River flowing through the densely populated and developed areas of Nagaon town is susceptible for easy dumping due to lack of fencing or barricades by the residents and other establishments located adjoining the river. But only some limited stretches should be considered for fencing.
- Some storage containers and vats exist along the Kolong River but these are not properly designed to handle the volume of waste generated, are too few (i.e., widely spaced) and are usually uncovered. Wastes from many of these containers/vats spill over and provide easy access to stray animals. Part of such exposed waste thereafter finds its way to the Kolong River.

## 5.3 Proposed MSW Management System

To address the above mentioned issues and to safeguard the Kolong River from pollution, a set of measures are required in addition to the initiatives already taken up by the NMC for improvement of the existing SWM of the town. These measures are

proposed to be implemented during the project related to the restoration of Kolong River.

- Provide additional secondary storage containers and litter bins along the Kolong River, specifically in the densely populated area of Nagaon town. The provision for these additional storage facilities should be synchronized with the overall secondary storage facilities of Nagaon town.
- Procurement of additional collection and transport vehicles for removal of the waste stored in the proposed secondary storage facilities.
- Develop and operate a scientific landfill site
- Public awareness program including banners/hoardings along the river stretch. It was found that the inhabitants do not place waste into designated bins. However, the inhabitants defended themselves and claimed that since the waste management is not organised by the government and scheduled they do also not need to act responsibly.

## 5.4 Details of Proposed MSW Management System

This section provides the details of additional Infrastructure required for SWM along the Kolong River and integrated SWM plan for secondary waste collection systems and transportation system for Kolong River. The proposed plan also includes the infrastructure requirements, quantities, and corresponding cost estimates for the collection and transportation systems. This section also describes the quantification and justification of additional infrastructure.

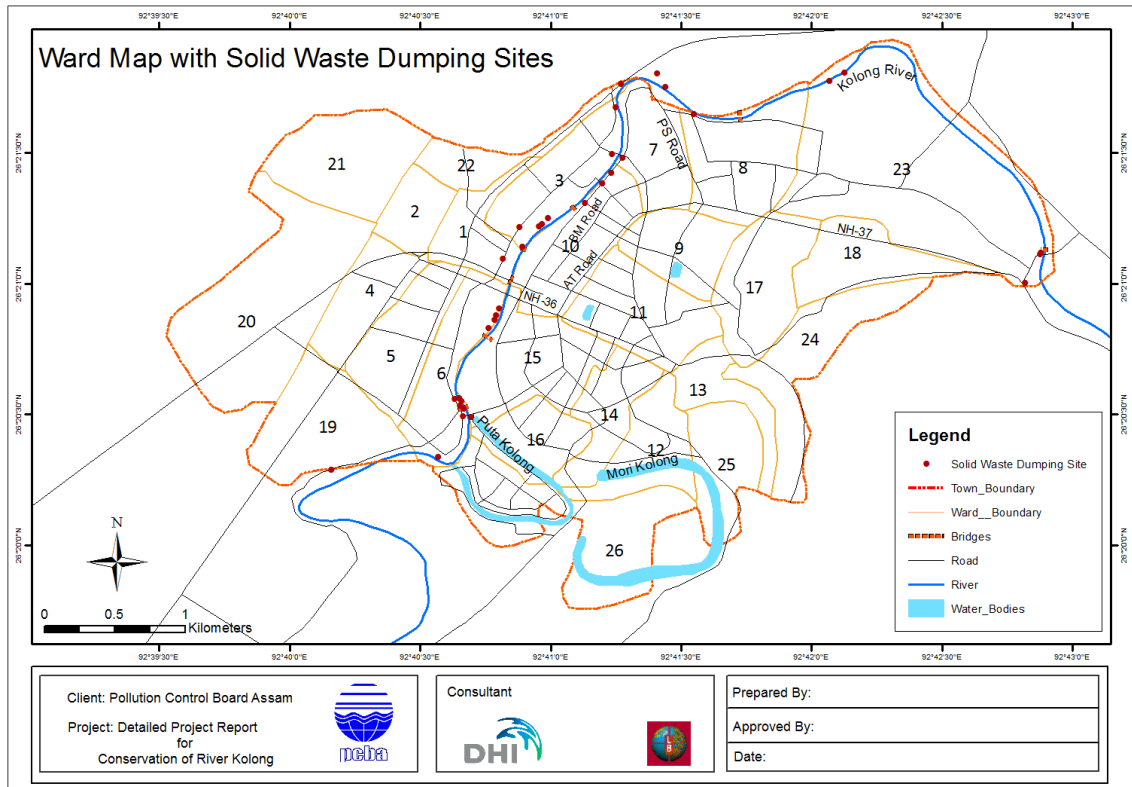


Figure 5-7 Ward Map of Nagaon with SW dumping sites

As describe in the previous sections along the Kolong River 9 point were identified as the major waste dumping points (Figure 5-8).

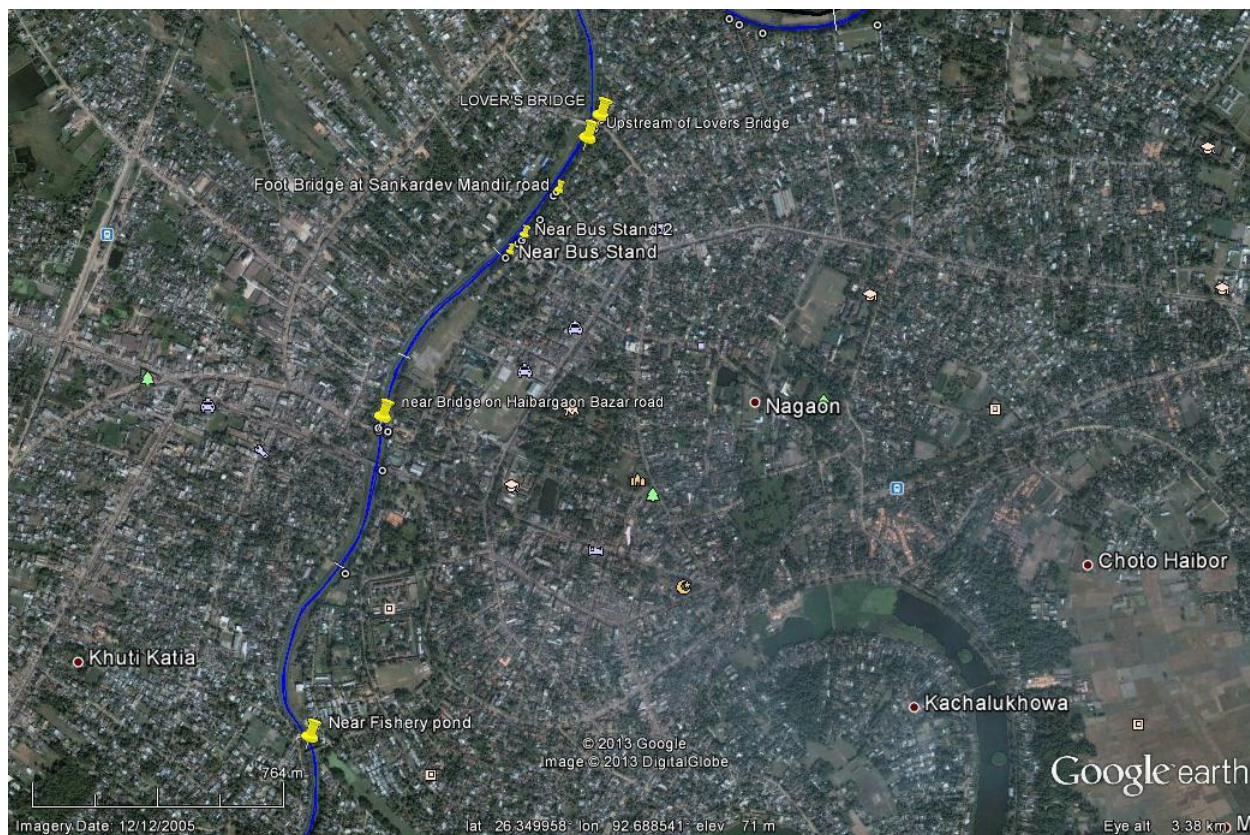


Figure 5-8 Proposed waste dumping sites in Google map

#### 5.4.1 Calculation of Infrastructure required

To collect the waste from these 9 major points additional secondary storage containers and litter bins along the Kolong River, specifically in the densely populated area of Nagaon town.

##### 5.4.1.1 Secondary Waste Storage System

As mentioned earlier there is no existing secondary waste storage system for MSW management along the River. Open waste dumps have come up at various locations over a period of time depending on the convenience of the local residents. Hence, these open dump sites were taken as a basis to develop a secondary waste collection system for Kolong.

There are three types of waste streams from the primary collection of waste – ‘bio-degradable’, ‘recyclables’ and ‘non-biodegradable’ (drain silt, street silt and other mixed waste). It is proposed to provide secondary collection facility for biodegradable and non-biodegradable waste. The recyclables will be sold directly in the market by waste collectors. MSW at every secondary collection point shall be stored in two separate covered containers – green for bio-degradable and black for non-biodegradable. The sweeper shall not travel more than 250m to dispose off primary collection waste. Therefore distance between two secondary waste collection locations shall not be more than 500m.

The bin design and strength shall be able to facilitate its hydraulic lifting by transportation vehicles. The secondary waste collectors shall be well equipped to avoid direct contact with waste.

#### 5.4.1.2 Proposed Infrastructure for Secondary Waste Collection System:

The study area under of Kolong River is approximately 12 km. Population density near the River is quite high in many places therefore it is proposed to have one secondary collection point for every 400m area. Therefore, total number of secondary collection locations =  $12/0.4 = 30$ . Total waste generation in Nagoan = 32 MT/day. Non-collected waste 10 MT, which includes biodegradable and non-biodegradable waste. Therefore, it is proposed to have a set of 1100 litre bin (one for biodegradable waste and one for non-biodegradable waste) at each secondary collection location. The study area of Nagoan has 63 km of road network. The proposed 1100 litre bins are to be placed at regular intervals on the road. The waste from narrow roads is to be collected through rikshaw/handcarts and brought to the nearest secondary collection point. Total number of 1100 litre bins required =  $30 \times 2 = 60$  bins. Additional 5% back-up is provided for all equipment for replacement in case of any such requirement. Therefore total number of bins =  $60 \times 1.05 = 63$ .

The infrastructure at secondary waste location points will function as per the following schedule:

- Bio-degradable wastes shall be cleared every day to avoid foul smell and degradation of waste.
- Non-biodegradable waste shall be cleared once in two days.

#### 5.4.1.3 Waste Transportation System

The MSW transportation system along River Kolong is proposed in conjunction with the waste collection system described in the preceding section. The requirement of transportation vehicles has been estimated based on the following plan:

- The NMB workers shall transport the bio-degradable waste (green containers) from secondary collection points to a designated composting site (need to identify in near future) on a day-to-day basis.
- The NMB workers shall transport the non-biodegradable waste (black containers) from secondary collection points to a designated integrated waste processing facility at least once in two days.
- The transportation shall be done in two shifts – 7:00 AM and 11:00 AM and between 7:00 PM and 11:00 PM.
- Hydraulically operated equipment shall be used for transportation of waste. The waste, under any circumstances, shall not be handled manually.

It is proposed to use 8 m<sup>3</sup> refuse collector for waste collection from secondary storage locations along the River Kolong. The transportation vehicle requirement is based on following assumptions:

A refuse collector will make one trip of loading waste from 8-15 bins (depending upon capacity of refuse collector and waste quantities in bins) and unloading waste at the designated site in 1 hr 30 min – 2 hr. The transportation of waste is done in two shifts with effective transportation time of 7.30 hrs in each shift, therefore total number of trips is 8 trips in a day. Therefore, requirement of 8 m<sup>3</sup> refuse collectors = 4 (2 for lifting biodegradable waste, 1 for lifting non-biodegradable waste and 1 as back up). The number of drivers required per shift to transport the waste will be 4. One helper is required with every driver. Other equipment required are gloves, boots, masks and uniform for the staff.

## 5.5 Landfill site

### 5.5.1 Landfill design

Preliminary design engineering has been done for the construction of municipal solid waste (MSW) landfill facility for Nagoan city. This facility comprises Secured landfill (SLF), Compost Plant, Effluent Treatment Plant (ETP), Office building, Laboratory, Parking area, MCC Room and other associated facilities. The construction of landfill shall be taken up into five phases. Each phase will serve for approximately 5 years. After filling of each phase it will be covered with top cover and filling of MSW in the next phase area will be started. The landfill facility shall require around 24 acres of area to accommodate the landfillable waste for 25 years in Nagoan city. In this chapter a summary of the conceptual design considerations are discussed. A detailed inventory survey indicated that presently approximately 32 tonnes of municipal solid waste is generated daily in various wards located in Nagoan municipal area. Presently the quantity to be disposed of in MSW landfill is around 7 tonnes per day.

#### ***Access Road***

The proposed landfill shall receive MSW by road from various wards/localities located within Nagoan municipal area, as such the site shall be suitably connected with a good road network. A 5 m wide road including 3 m wide bitumen road and 1 m shoulder on either side, connecting the landfill area is planned to reach the landfill site and within the facility for proper circulation and movement of vehicles.

#### ***Land Area***

The design of MSW landfill facility has been planned by considering 24 acres (approx.) of total land including compost plant. About 21 acres of the land has been utilized for MSW landfill so that the landfill holds large amount of waste covering for a disposal period of about 25 years. Around 20% of the area has been earmarked for green belts, associated facilities and buffer zones in as much as the surrounding environment is not disturbed/effected by noise, odors and defacement (from aesthetic considerations). All services are accommodated within this area.

#### ***Operational Plan***

The facility shall be developed as a MSW disposal facility conforming to the statutory guidelines of MoEF/CPCB/SPCB and CPHEEO Manual with elaborate operation and management (O&M) plans matching to the size and environmental protection requirements. The O&M plan shall ensure operational efficiency and also timely feedback well before onset of any eventuality/emergency. For this the following areas have been given emphasis:

a) **Inventorization and Characterization of MSW**

A mechanism shall be established whereby continuous update on MSW inventory in Nagoan is available. Special attention shall be placed in case of entry of any development of new colonies, institutions, mandis, markets etc. A separate cell has been planned to track quantity and characteristics of such MSW. The cell shall comprise of one environmental engineer assisted by a laboratory support. The team shall develop liaison with ULBs, RWAs etc. Conforming to changing scenarios and rulings of the governmental agencies due modifications/improvements shall be implemented. A liaison engineer shall be appointed for monitoring and updating these activities.

b) **Operation Manual**

An operation manual conforming to the procedures for effective running shall be developed wherein the landfill facility operator, local residents and the government agencies are appraised of their roles and responsibilities.

c) **Emergency Management Program**

In case of any emergencies like vandalism, fire, floods, earthquake, groundwater and soil contamination, etc. the emergency cell on site shall keep liaison with the concerned agencies such as fire fighting squad, hospitals, police, district administration, local PCB office, etc. for a coordinated timely action.

d) **Monitoring Program**

Adequate instrumental monitoring systems for knowing the condition of the landfill and the surrounding areas (soil, groundwater, air) covering range of 2 km has been planned. These instruments shall be maintained and operated as per the operation manual. A well-equipped laboratory for exercising quality controls is also planned. A monitoring cell shall be responsible for upkeep of the monitoring program. Logbooks and records relating to waste quantities received, disposed in the landfill, etc. shall be maintained in soft and hard copies by this cell.

e) **Human Resource Plan**

A team shall be created for addressing issues related to environmental concerns, public unrest, grievances, on-site and off-site health hazards, compensations, etc. This team shall make timely and coordinated efforts to sorting out differences, if any.

5.5.2 **Layout of the MSW landfill**

The landfill facility shall have 1.8 m high permanent fencing all along the boundary with one lockable secured gate 3 m wide. A complete list of the utilities, services and buildings that are planned in this MSW landfill are given in Table 5.2. The locations of the facilities are marked in these drawings.

**Table 5.2 List of facilities provided at Nagoan landfill**

SI No	Description	Size / Nos
1	Main Entrance Gate	3m wide
2	Security office	3MX3M

3	Weigh Bridge and Scale Room	2.7MX4.17M
4	Office Building	5MX4M
5	Laboratory	5MX3M
6	Parking (Paved Area)	20MX15M
7	MCC Room	5MX4M
8	Temporary Storage/ Segregation Area (Covered)	22MX32M
9	Workshop Area	5MX20M
10	Wheel Wash Pit	10MX4M
11	Leachate Collection sump	3.5MX3.5Mx2M (WD)
12	Area for Daily Cover Material	AS/SITE
13	Monitoring Well	4 Nos
14	Earthen Embankment	1V:2H Slope
15	Green Belt	3 M wide
16	Ground Water Monitoring Well	4 Nos.
17	High Mast (HM) lighting	4 Nos.
18	Storm Water Drain	1485 M
19	ETP for Leachate	1 Acre (Approx.)
20	Compost Plant	2.5 Acres (Approx.)

### 5.5.3 Completed Waste Fill Features

The design of MSW landfill has been done by considering 24 acres of land out of which 2.5 acres has been earmarked for the compost plant and rest of the area would be used for MSW landfill and its associated facilities. The ground water table has been assumed around 10 below ground level. Hence base of landfill i.e. top of liner has been kept at 3 m below ground level and 5 m high (above G.L) earthen embankment has been provided to achieve the required storage capacity within the area available. Top width of the embankment has been kept at 5.0 m, which will accommodate 3.0 m wide bituminous road for vehicular movement and 1 m shoulders on each side. Inner & outer slopes of the embankment have been kept at 1V: 2H for stability of slopes. All around the landfill site 1.8 m high fencing shall be provided to prevent any unauthorized entry & stray animals. A 3.0 m wide green belt has been provided all along the facility boundary.

The geocomposite liner has been provided on the inner side of the landfill as per the requirement of Central and State Pollution Control board norms. Leachate collection system has been provided at the base of the landfill with 355 mm dia HDPE header and 110 mm dia perforated HDPE lateral pipes. Leachate shall be collected in the Leachate collection sump from where it will be pumped to Effluent Treatment Plant. Leachate transfer pumps shall be provided of adequate capacity.

MSW shall be dumped in the landfill by trucks, which shall be further levelled and compacted. Periodic waste audits will ensure that non-conforming waste shall not be dumped at the landfill site. The waste shall be compacted in thin layers using compacters and covered with a daily cover of soil layer or inert waste. After the landfill is filled it will be covered with top cover system with single liner arrangement and on the top 450 mm thick surface layer (Top Soil) shall be provided with vegetation. The slope of top cover shall be kept as 5% to provide quick drainage of rainfall. For ground water monitoring 4 Nos. of wells shall be provided. A suitable ramp to reach the embankment top shall be provided so that truck/ dumper can reach the top of embankment and can directly dump the municipal solid waste in the landfill.

#### 5.5.4 Estimation of landfill Capacity

The estimation of capacity of landfill is 23.30 acres, including area of landfill (16.50), area of compost plant (2.50), area of ETP (1.0), and other facilities (3.30).

The leachate treatment units, leachate collection sumps, equalization tanks, treatment control room etc. shall be provided outside the embankment. These shall be located 0.5 m above the lowest ground level. Waste conveying facilities are provided for mechanically depositing the residue into the MSW landfill after segregation.

No specific intermediate cover is provided other than the daily cover. However if the problem of odor persists intermediate cover may also be considered. In that case one intermediate cover of soil of thickness 450 mm may be provided at the mid-level. The top cover shall have the highest point at the center and slopes towards the edges radially with around 5 % slope (after pre-grade settlement) towards the embankment. A network of intercepting drains and peripheral drains are provided for quick draining of the rainwater. The facility shall have green belts, trees and turfing on the embankment/ formation slopes as slope protection and to present pleasing appearance.

##### 5.5.4.1 Selection of Liner Systems

The objective in the design of liners is to minimize the infiltration of leachate and gases into subsurface soils below the landfill eliminating the potential for ground water contamination. Composite liner designs employing a geomembrane and clay layer provide more protection and are hydraulically more effective than other types of linings. Liners provide an effective hydraulic barrier beneath the waste to contain the waste and to allow for effective removal of leachate generated during containment. In the present MSW landfill, single composite liner system shall be provided meet stringent performance criteria that provide a high margin of safety. Each of the liner system is discussed in more detail in the following sections.

##### a) **Bottom Liners**

The bottom portion of the landfill directly rests on stable compacted specially prepared soil bed. The various layers of liners from bottom to top are:

- 600 mm thick compacted clay/ amended soil ( $k \leq 10^{-7}$  cm/sec.)
- 1.5 mm thick High Density Polyethylene (HDPE) Geomembrane
- 200 mm thick silty sand protective layer
- 300 mm thick granular soil drainage layer (Leachate Collection Layer)

**b) Side Liners**

The side slopes in the soil formation are similarly made on firm compacted specially prepared stable slopes of 2H: 1V. The various layers of side liners from bottom to top are:

- 450 mm thick compacted clay/ amended soil ( $k \leq 10^{-7}$  cm/sec.)
- 1.5 mm thick High Density Polyethylene (HDPE) Geomembrane
- 100 mm thick protective layer (selected soil)

**c) Top Cover Liners**

The top cover the landfill directly rests on compacted specially shaped waste surface. The bed shall be laid to 3 to 5 % slope (after allowing for pre-grade settlements of the waste) for providing good natural drainage. The various layers of liners from bottom to top are:

- 450 mm thick granular soil (Gas Collection layer)
- 600 mm thick compacted clay/ amended soil ( $k \leq 10^{-7}$  cm/sec.)
- 300 mm thick topsoil /Sweet earth laid to 5 % slope

#### 5.5.4.2 Selection of Leachate Control Facilities

The leachate collection layer is provided in the granular soil (drainage) layer of the bottom liner system. The collection layer shall comprise of a network of perforated HDPE lateral pipes laid at a slope of 2% and 20 m c/c spacing. These laterals collect leachate and transfer it to the HDPE header pipe, which is laid at a slope of 1%. The header pipe ultimately transfers the leachate into the Leachate collection sump.

#### 5.5.4.3 Selection of landfill Gas Control Facilities

The landfill is a secured landfill with single composite liners well in place at bottom, sides and top. The liner system consists of one-layers of geomembrane and one-layers of 2ft. (600mm) thick amended clay as liners whereby the chances of gases escaping from the ground and contaminating the groundwater and soil are remote. The gases developed due to continued confinement of degradable wastes, if any, are released through the gas extraction facilities provided in the landfill. For this purpose GI Vents are planned at 20 mx20 m grids.

#### 5.5.4.4 Aesthetic Considerations

Adequate measures are planned to give a facelift by utilizing the abundantly available on site natural soil for raising buffer zones /embankments. Two rows of vegetative plantation shall be developed along the circumference of the outer embankment along with turfing on the slopes. In addition the top cover shall also be developed as a green belt.

#### 5.5.4.5 Monitoring Facilities

The soil, air and water in the area shall be continuously monitored for no contamination. Both sampling methods and non-sampling methods are adopted and monitored as per the monitoring plan for timely action to be taken before water contamination and leakage of gases into the soil. The facility is provided with a minimum four monitoring wells for soil water and gas measurements. The details of the monitoring plan are given in Table 5.3, wherein instruments /monitoring areas proposed are listed.

Table 5.3 Monitoring Plan

Monitoring Method	Type of Monitoring	Equipment Used	Information/data to be recorded
<b>Sampling Monitoring Method</b> (Methods involving collection of samples for laboratory analysis)	Air Monitoring (Collection of Air samples)	Gas Syringes  Air Bags	Air quality/analysis of gas
	Ground Water Monitoring	Monitoring wells	Water quality
	Collection of Leachate samples	In landfill piezometers	Leachate quality
	Vadose Zone Monitoring	Collection Lysimeters, Soil gas probes & Suction Cup Lysimeters	Analysis of Leachate between, VOC in soil, Gas monitoring, liquid monitoring in Vadose zone
<b>Non-sampling Monitoring Method</b> (Methods involving Physical and Electrical measurements)	Ground water Conductivity	Conductivity cells	Monitor changes in Groundwater Conductivity
	Leachate Monitoring	Inland fill Piezometers	Measure depth of Leachate in landfill
	Temperature	Temperature probes	Measure temperature In land fill

	Vadose zone	Electric probes	Salinity of vadose zone
		Electric Resistance Block	Changes in the water content
		Gamma ray attenuation probes	For monitoring of moisture content
		Neutron Moisture meter	Moisture content in the soil
		Tensiometer	Used to measure negative pressure that exists in soil/landfill
		TDR meter & Thermocouple psychometers	For recording Thermo Dielectric Properties of water and soil - any change in temperature and moisture will be recorded
		Waves Sensing Devices (seismic type)	To identify leak detection

Apart from the above, regular inspection and monitoring of important components of the landfill shall be done as per the schedule given below:

- Final Top Cover:** Once in a year and after each substantial rainfall it should be checked for any erosion, landslides, movement of soil, slope, etc.
- Vegetation:** Four times in a year a check should be made for existence of dead plants/trees. Any plant/tree found dead shall be removed immediately.
- Final Grade:** Twice a year should be checked for ponding/logging of water. If any abnormalities found, slope should be corrected by putting soil.
- Surface drains:** Four times a year and after each substantial rain should be checked for any blockages. Leaves, debris or any other accumulation found in the drain shall be removed immediately.
- Gas Monitoring:** As required in the Management Plan it should be checked for strong presence of odor. The gas monitoring equipment (compressor, pipes, flaring stand, etc) should be checked to ensure their workability as they might become inoperable due to high gas generation.
- Groundwater & other**
- Monitoring:** As per the Action Plan. A regular inspection shall be done to check for any failures in the monitoring system.

#### 5.5.4.6 Determination of Equipment Requirements

The landfill facility shall have minimum operating equipment for the construction stages and no earth moving machinery is planned as the work shall be done by engaging suitable contracting agency. For the operations of daily cover the following nominal equipment shall be provided: One Front-end loader/JCB , one Tipping trucks, One set Safety equipment, Fire Fighting Equipment and one Diesel Generator. For ETP unit suitable supporting plant and equipment are planned. For power supply to equipment, lighting, services etc a substation with transformer yard has been planned. All electrical systems shall have proper earthing and control systems. One number diesel-run electrical generator of 50 KVA is proposed for running the essential services and the ETP.

#### 5.5.4.7 Design Life

The landfill design life relates to active period, closure period and post closure period. The active period is the period in which actual filling takes place. In this case, this will be 25 years. The closure and post-closure period for which a landfill will be monitored and maintained shall be 30 years after the active period.

#### 5.5.4.8 Post Closure Care

Post closure care involves the routine inspection of the completed landfill site, maintenance of infrastructure and environmental monitoring. A well defined closure plan shall be formulated for effective implementation.

#### 5.5.4.9 Technical Specifications

The detail technical specifications of the following items have been given in Annexure 6.1.

1. Preparation of work area/ clearing site/ jungle
2. Striping
3. Excavation & filling work
4. Excavation of trenches
5. Borrow areas
6. Cast-in-situ cement concrete
7. Formwork and staging
8. Reinforcement
9. Structural steel work
10. Stone work-random rubble masonry
11. Filling for clay liner and foundation
12. Foundation for embankment
13. Earthen embankment
14. Turfing
15. HDPE liner
16. Clay liner
17. Geo-textile
18. Geonet
19. Leachate collection system
20. HDPE Pipes
21. Sand layer
22. Gravel layer
23. Vertical centrifugal pump

- 24. Valves
- 25. Leachate treatment plant
- 26. Weighbridge
- 27. Piezometers
- 28. Electrical works
- 29. Schedule of Makes
- 30. Quantity assurance check list
- 31. List of mandatory spares

## 5.6 Proposed Institutional Framework

The success and sustenance of the proposed SWM services depends on robustness and capacity of institutional framework. It is proposed to take steps for institutional strengthening and internal capacity building to ensure that endeavor to improve the existing scenario is successful. Institutional strengthening can be done by adequately decentralizing the administration, delegating adequate powers at the decentralized level, by inducting qualified and competent professionals into the administration and providing adequate training to the existing staff.

The recommendations for the institutional framework are based on the specific tasks to be carried out under the proposed MSW Project. The activities which need to be focused as per the proposed plan include:

- Segregation of waste at source
- Mechanism of waste collection
- Primary collection
- Secondary collection
- Transportation of waste from secondary collection locations
- Development of integrated SWM processing facility
- Operation and maintenance of installed SWM system
- Landfill
- Composting
- Transportation
- Waste collection infrastructure

In the above listed components, several activities/infrastructure developments are proposed to be taken up for implementation for the first time. The NMB requires capacity building to execute the proposed plan. In many cities in India, in view of the limitations of ULBs, private sector participation has been introduced for establishing and operating SWM services. Such public private partnerships have put a check on growth in the establishment costs, brought economy in expenditure and introduced an element of healthy competition between the private sector and the public sector. It is therefore proposed to consider the private sector participation for developing and operating new services. Based on analysis of the merits and demerits of the existing system, it is proposed to have responsibility delegation for undertaking each activity under proposed SWM plan as follows:

Table 5.4: Specific Roles and Responsibilities of Institution Involved in Implementation and O&M

Activities	Organisation /	Scope of work/ Responsibilities
------------	-------------------	---------------------------------

	Institution	
Segregation and collection	NMB	Deploy of sanitary workers Sensitization of residents/public about segregation. Provide facilities/bins for segregation Collection from house holds Transportation of waste to bins. Orientation/sensitization of sanitary workers. Involve NGO's / CBO's in awareness.
Transportation	NMB/ Private agency	Selection of party/ agencies for procurement and execution Work out finance model with agency. Funding Monitoring and supervision of agency work. Readdressing of issues. Monitoring management and coordination. Procurement of equipment/ facilities. Installation of facility. Safety of equipment. Collection/ lifting of waste from secondary collection points. Operation and maintenance of vehicles. Transportation of waste to site
Integrated SWM facility	NMB	Selection of agency for execution Funding Monitoring of construction and management Supervision of commissioning.
	NMB/PPP	Design and construction Commissioning O&M

At several levels of SWM it is proposed to involve private operators, who will deploy and manage staff, but ultimate responsibility of monitoring and ensuring that the people of Nagaor are receiving desired quality of life lies with the NMB. The existing staff of NMB shall be adequate for doing monitoring of SWM services by different private operators but require capacity building to undertake this activity efficiently. Therefore in addition to private operator participation, institutional strengthening is required within NMB to ensure sustainability. For institutional strengthening, it is proposed to decentralize the administration, delegate adequate powers at decentralized levels of the city and bring accountability at all levels.

## 5.7 Cost Estimate

The total cost estimate for solid waste management related to Kolong River restoration is given in Table 5.5. The cost includes O& M for 3 years during the project duration only. After that MNB will take full responsibility of management including the option of engaging a private operator.

Table 5.5 Cost estimate for Solid Waste Management

S.No.	Item	Qty	Unit	Rate	Amount
1	Secondary storage bins (1.1 cu.m. capacity)	63	No	28500	17,95,500
2	Transportation equipment 8( cu.m collector)	4	No	1335000	53,40,000
3	Other equipment for workers	63	set	10000	6,30,000
4	Landfill site development	1	Set	40664636	4,06,64,636
5	Subtotal				4,84,30,136
6	Contingencies			10%	48,43,014
7	Contractor's fees			10%	48,43,014
8	Contractor's tax			10%	48,43,014
9	Total				6,29,59,177
10	O&M costs for 3 years (during project duration only)				1,18,49,040
11	Grand TOTAL				7,48,08,217
	<b>O&amp;M Costs per year</b>				
1	Collection & Transport system	Qty	Unit	Rate	Amount
	Cost of drivers	48	mon	10000	480000
	loaders	48	tue	8500	408000
	fuel etc	48	mon	10000	480000
	maintenance	1	LS	200000	200000
	Sub total				1568000
2	Landfill site O&M				
	Professions staff (chemist, manager) 2 nos	24	mon	12000	288000
	Assiatnts, helpers (3 nos	36	mon	5000	180000
	Drivers 2 nos	24	mon	6000	144000
	Chemicals	12	mon	3000	36000
	Elcetricity	12	mon	3500	42000
	fuel etc	12	mon	12000	144000
	Daily Cover (@214 cu.m./mon)	2568	co.m.	90	231120
	Sub total				1065120
	Total O&M for 1 years				26,33,120
	For 3 years (incl. escalation)				1,18,49,040
	MNB will take up full ownership aftre 3 years				



## 6 River Environment Improvement

### 6.1 Introduction

Kolong River once used for bathing purpose has been deteriorated to such an extent that today it is unfit for human use. One of the major reasons for the contamination of the river is direct discharge of untreated sewer into the river. In the previous sections of this report a detailed measures to curb the pollution of the river are elaborated with detail designs. The success of the river front restoration scheme is dependent upon the acceptance and ownership of the project by authorities and the public.

Currently the Kolong River is considered a resource to the citizens of Nagaon and has an economic value to the community, as many inhabitants are using the river for fisheries purpose. Some of the citizens are also using the river front for recreational activities although the river has the potential for a considerable aesthetic value. The Kolong river extends through the heart of the town and by improving the water quality of the river, removing the solid waste, providing adequate resources and collection point for waste deposit, removing the legacy contamination within the river, and restoring flow, the Kolong River has the potential to attract both commercial and residential development opportunities.

### 6.2 River Front Development along Kolong River

Various projects have been identified as part of river restoration schemes such as defining the proper course of the river within the city limits, development of parks along the river, development of ghats for bathing, and development of amphitheatre along the bank of Kolong River. As part of the river restoration scheme, the first step will be to define the extent of the river along its complete stretch within the city limits and secure it against possible future encroachment, and prevent landslides along the river banks. The next step is to provide proper embankment/stone pitching, which the Nagaon Municipal Board has already started along the RKB bridge stretch of the Kolong River and can be extended till the entire stretch of river within the city limits. This will help define the width of river, channelize the flow of river and is also important to improve the aesthetics of the river.

#### 6.2.1 Parks & jogging tracks

Along the bank of the Kolong River is the existing Pranab Baruah Children Park, which will also be a part of river front development. Further proposed is a jogging track inside the park and proper tree plantation in the park and at other places along the Kolong River. The tree plantation will act as a buffer and will stop the erosion of soil. A conceptual sketch is shown in Figure 6-1 for the park and river front development. The

park will be used by senior citizens for taking a walk and by children who can use the park and various play toys installed within it.



Figure 6-1 River front environmental development work Kolong river

Footpaths are also proposed along the stretch of the river on either side, which can be used for walking purpose.

### 6.2.2 Bathing and washing ghats

Existing Ghats along the Kolong River are used for bathing and washing purpose. Ghats on the temples are used for bathing and other Ghats are used for washing. Ghats along the temple areas should be properly fenced off.



Figure 6-2 Other ghats will be improved in similar ways

6.2.3 Amphitheatre

At Nehru ground an amphitheatre is proposed where social functions can be organised like music concerts, plays, etc. an open area of about 250m X 50m is available, which can be used to develop amphitheatre. The proposed plan for the development of amphitheatre is as shown in Figure 6-3 and 6-4.



Figure 6-3 River Front development in Kolong - location of Amphitheater

**Error! Reference source not found.** Cross section lines A-A and B-B in detail in Figures 6-5 and 6-6

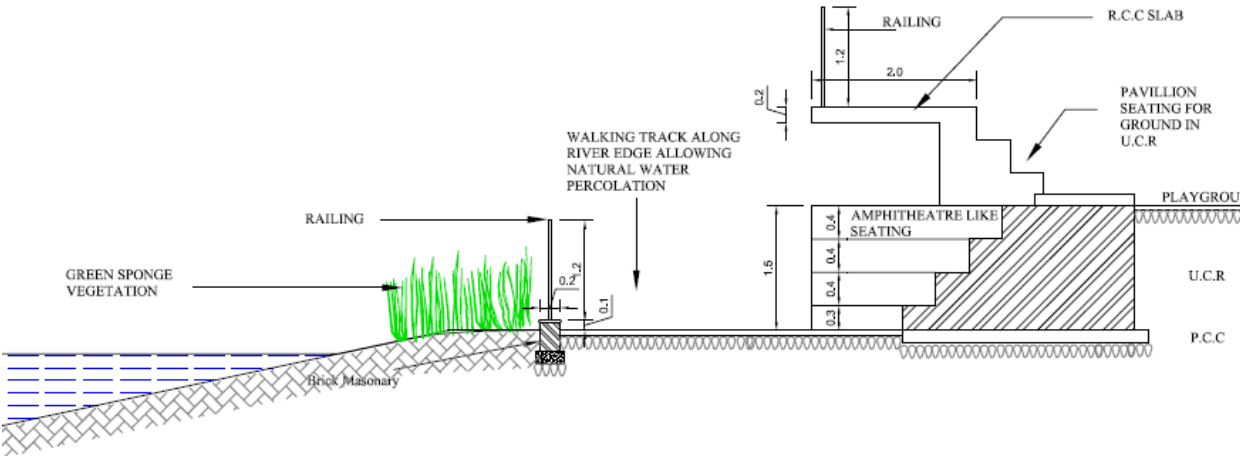


Figure 6-5 Section A-A of the Amphitheatre complex at Nehru ground

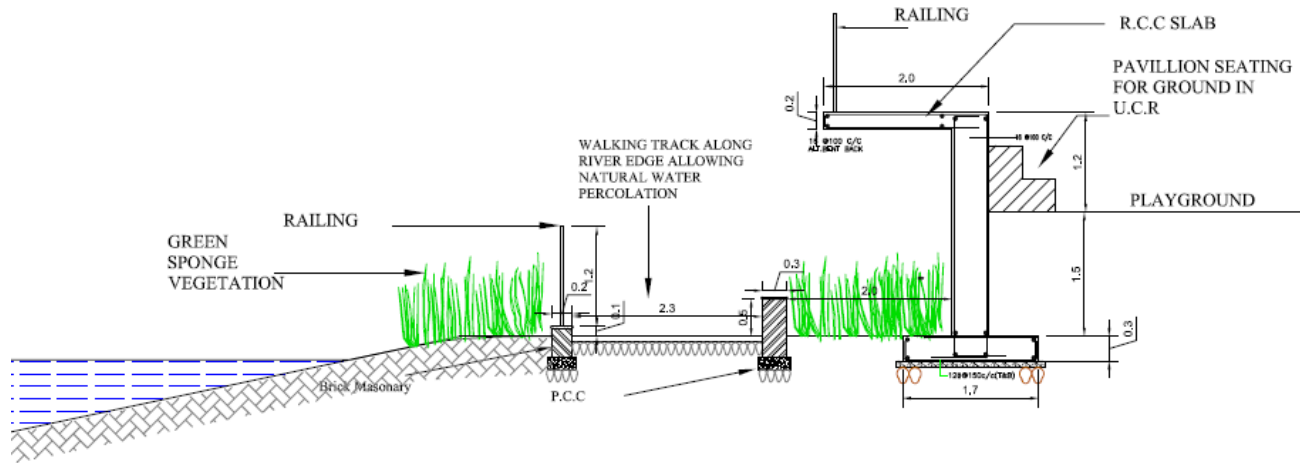


Figure 6-4 Section B-B of the Amphitheatre at Nehru ground

### 6.3 Cost Estimate

S.No.	Item	Qty	Unit	Rate	Amount
1	12 km walkway on both sides (green way), including retaining walls and bank protection	24	km	1000000	24,00,00,000
2	Lighting (Solar)	1	Lot	2500000	25,00,000
3	Green park	1	No	50000000	5,00,00,000
4	Amitheater	1	No	100000000	10,00,00,000
5	Subtotal				39,25,00,000
6	Contingencies			5%	1,96,25,000
7	O&M cost for 5 years @ 2% of capital cost per year adjusted to exalation factor				5,88,75,000
	<b>Grand TOTAL</b>				<b>47,10,00,000</b>

## 7 Other Non-Sewerage Schemes

### 7.1 Community toilets

Community toilets will be constructed along with river front development schemes, bus stands, markets, near river ghats, etc. A total of eight community toilets are proposed in Nagaon area and three in Morigaon area. The toilets will have separate facilities for male, female and the physically challenged people. Example of a community toilet from Bangladesh is seen in Figure 7-1.



Figure 7-1 Community Toilet

The toilets will be built with rain water harvesting on the roof, and solar lighting. The toilets walls will be painted various hygiene information for awareness creation among communities (example of various messages is shown in Figure 7-2).

The operation and maintenance of the community toilets will be outsourced after construction to ensure sustainability and to provide a high quality hygiene services to the people using them along the river front.



Figure 7-2 community toilets with hygiene messages

Location of community toilets also called as low cost sanitation for Nagaon area is shown in Figure 7-3. For the Morigaon area Figure 7-4 shows the location of low cost sanitation and crematoria.

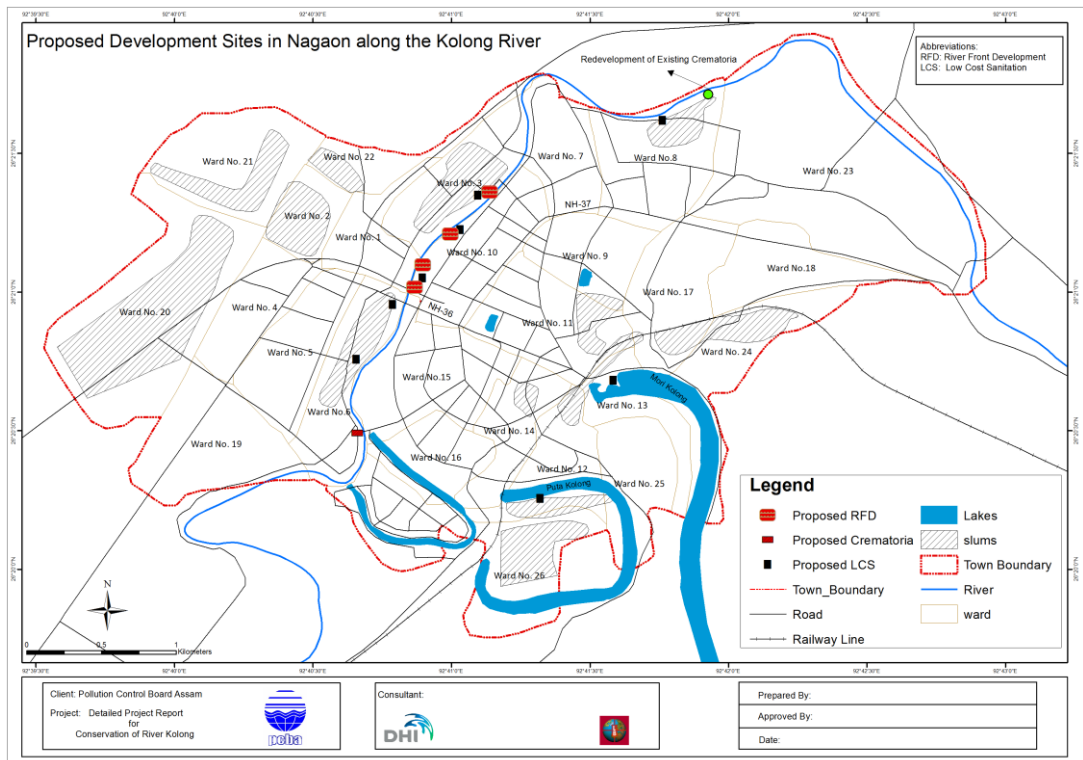


Figure 7-3 Location of low cost community sanitation

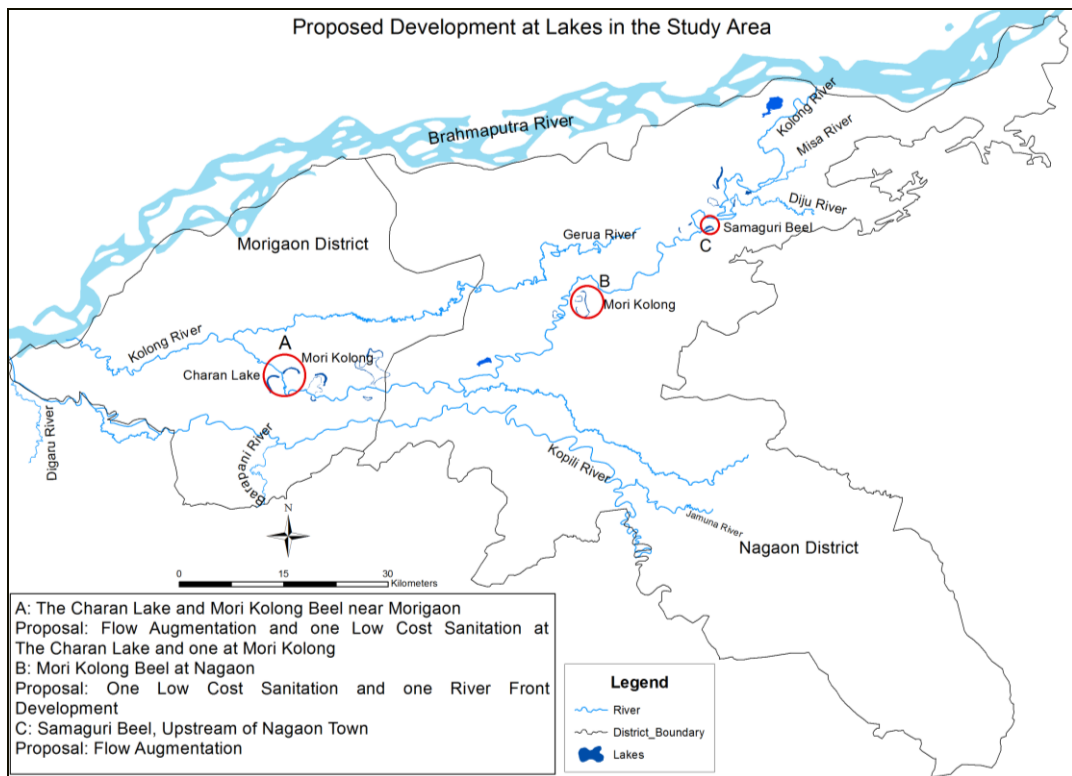


Figure 7-4 Location of low cost sanitation and Cematoria in Morigaon

## 7.2 Community Kiosks

Community kiosks will consist of small houses along the river front. Their purpose is to let individual carry small business activities, such as saloon, water, tea/cold drink, snacks, vending, selling pan, providing first aid treatment and emergency medicines. The individual may also have basic health checking facilities, such as blood sugar and blood pressure. This will enhance the use of river fronts.

The kiosks will have rainwater harvesting and solar lighting. Materials related to community awareness and education will also be available in the kiosks. A small reading library The rental fees charged on these kiosks will be utilised in hiring community security personnel for the benefit of the people.

## 7.3 Crematoria

As shown in Figure 7-3 the old crematorium located on the banks of Kolong in ward no 8 and a new one will be constructed downstream at ward no 6.

## 7.4 Cost Estimate

S.No.	Item	Qty	Unit	Rate	Amount
1	Community toilets	11	No	200000	22,00,000
2	Community Kiosks	6	No	100000	6,00,000
3	Repair of Crematoria (in Nagaon)	1	No	500000	5,00,000
4	New Crematoria (1 in Nagaon and 1 in Morigaon)	2	NO	1000000	20,00,000
5	repair of exiting bathing ghats	3	No	5000000	1,50,00,000
6	New washing & bathing ghats	2	No	10000000	2,00,00,000
7	Subtotal				4,03,00,000
8	Contingencies			5%	20,15,000
9	O&M @2% of capital cost per year, for 5 yaers escalation factor adjusted				60,45,000
10	Grand TOTAL				<b>4,83,60,000</b>

## 8 Water Augmentation and Channel Improvement Schemes

### 8.1 River System

Figure 8-1 shows the Kolang River and its tributaries. The Klong River is a spill channel of the Brahmaputra, which takes off about 13km north-east of Silghat town and its mouth has been closed since 1962, by State Flood Control Department to avoid flood. Therefore the flow in the river is mainly due catchment runoff and assimilation of discharge of its tributaries; though there is some base flow due to ground water seepage and wastewater discharge from various towns. The entire course of the river flows through Nagaon, Morigaon and Kamrup Districts before discharging into Brahmaputra in Kolangpar. Erection of dyke during the 1960s gradually led to the stagnation and degradation of Kolang. Kopilli a major tributary merges with Kolang near Dharamtul. Between the point near Hatimura (now sealed) which is the point of origin of Kolang river and to the point of its confluence with Kopilli, the stretch is nearly 197 km.

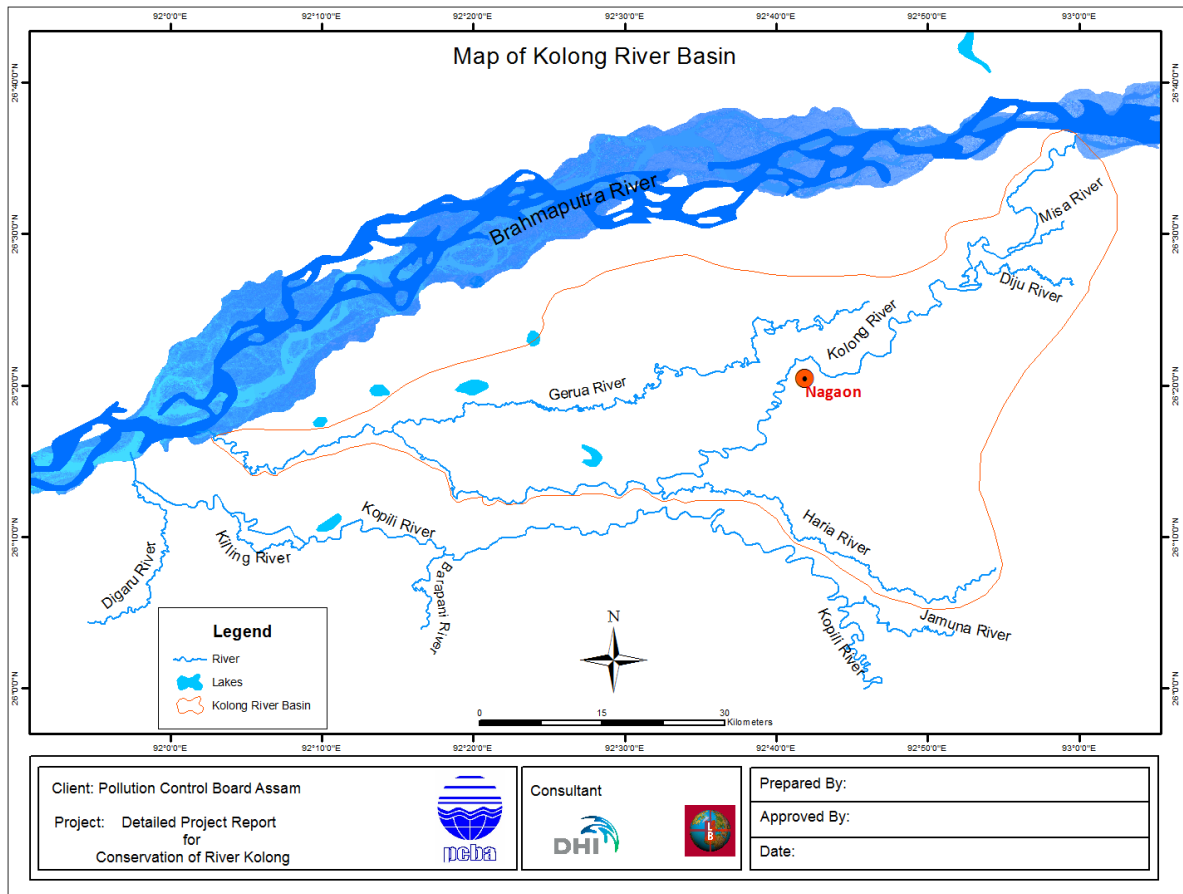


Figure 8-1 Kolang River Network

## 8.2 Modelling

Hydrological and hydrodynamic simulation models were used using available historical data to generate flows along the Kolong river. The rainfall-runoff model is used to generate flows based on catchment rainfall. The simulated discharges are used as inflows to the hydrodynamic model. The hydrodynamic model of the Kolong river system is developed to simulate flow and water level along its length both during the rainy and dry season. River cross section and other data were obtained from WRD Nagaon. Figure 8-2 shows simulated discharge hydrograph of Kolong river upstream of Nagaon for the recent years 2011-2013. Hydrographs for historical years are shown in Figure 8-3.

The model is used to assess dredging requirements for improvement of the channel conveyance.

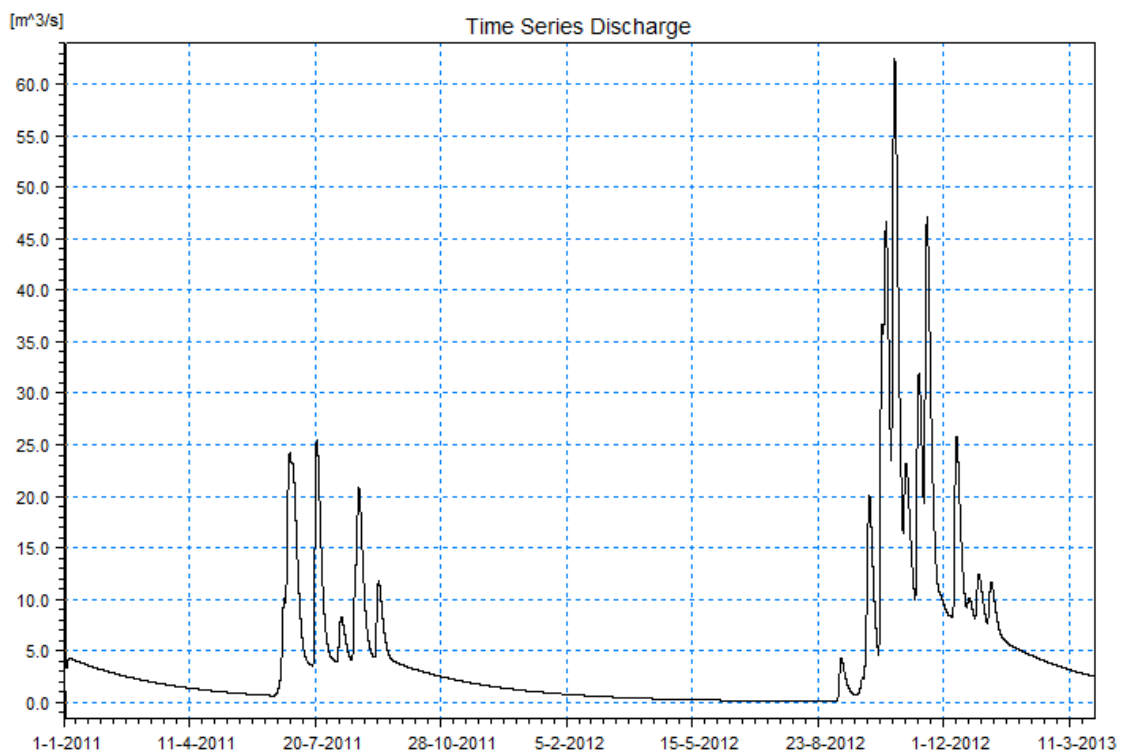


Figure 8-2 Simulated discharge at upstream of Naogaon Town

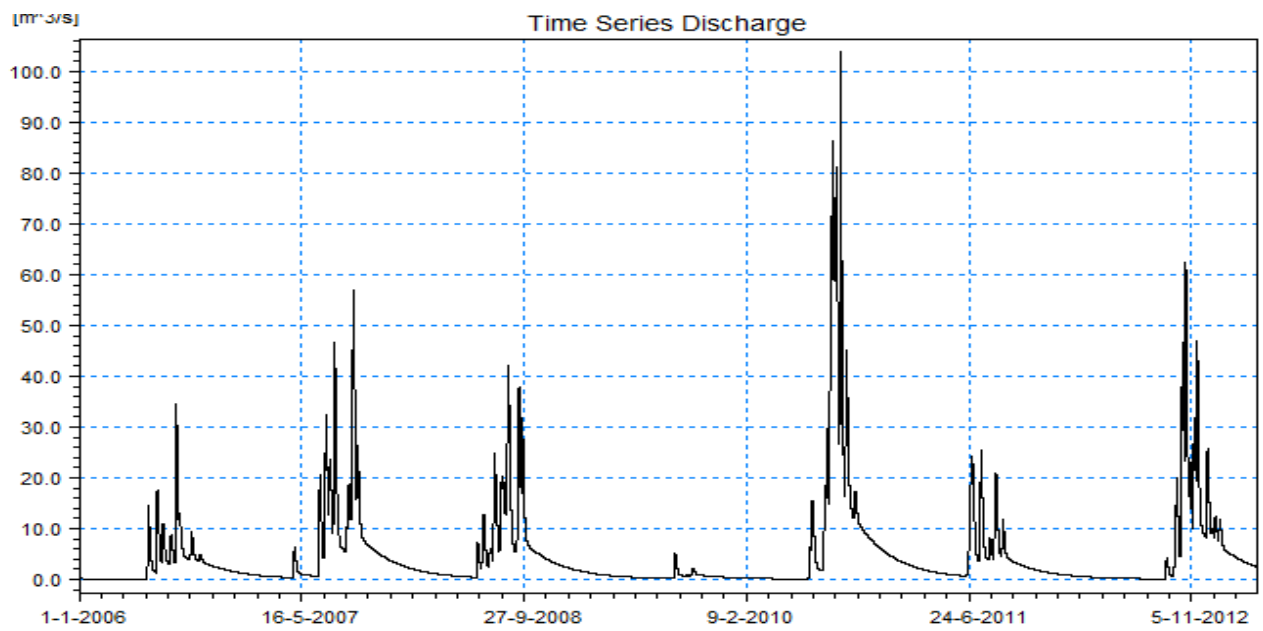


Figure 8-3 Historical discharge of kolong upstream of Nagaon

### 8.3 Water Augmentation from Brahmaputra River

The Kolong River was once a spill channel starting at Jakalbhandha (13km north-east of Silghat town) on the left bank of the Brahmaputra River that conveyed flood flows past the town of Nagaon and returned to the main river some 158 km downstream as Kapili river at Hatiamukh, also watering several beel areas along the Kolong and collecting runoff from several small streams (Figure 8-4).

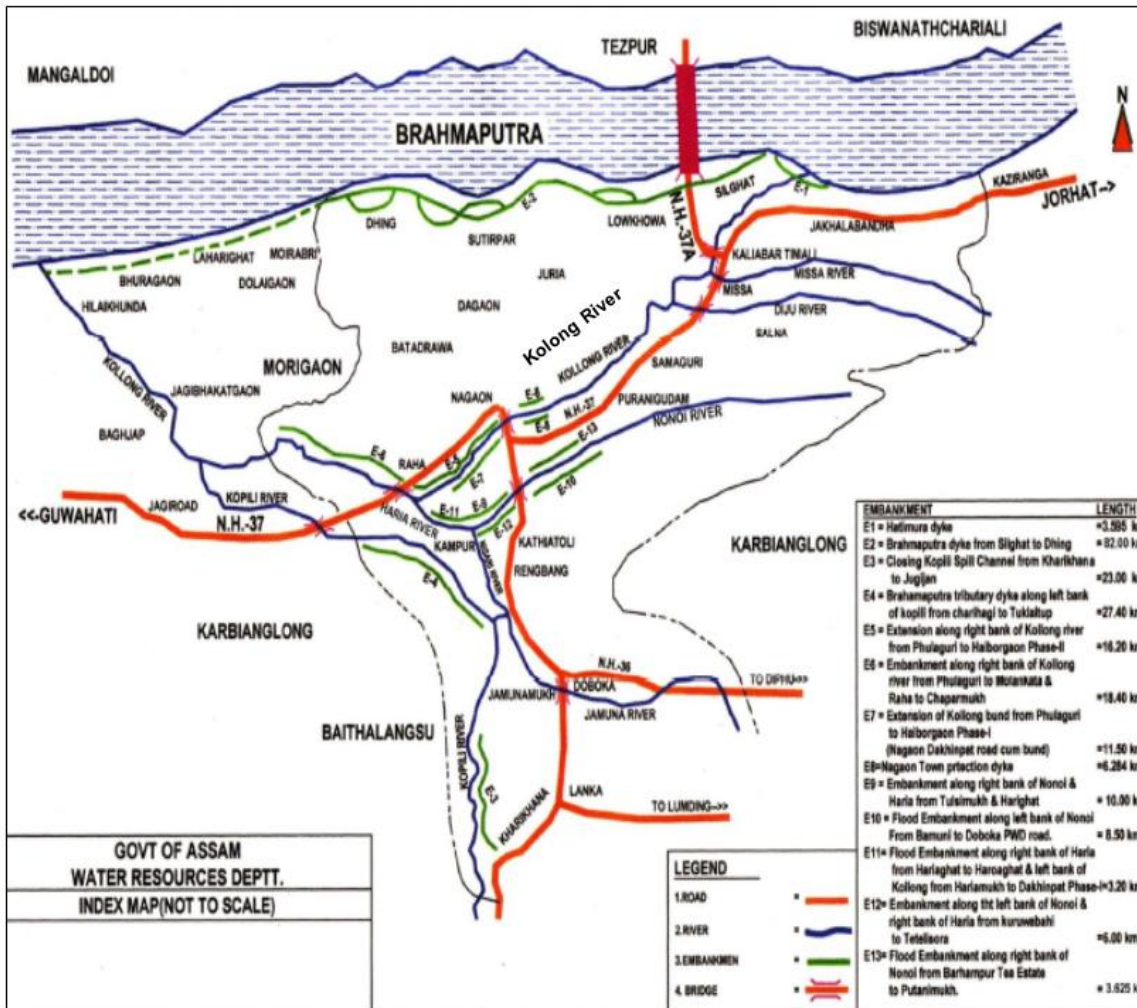


Figure 8-4 Kolong River Links with the Brahmaputra River (source: WRD, Assam)

Since 1962, the mouth of the river has been closed by State Flood Control Department to avoid monsoon floods. The closure of the connection with the Brahmaputra converted the upper reaches of the Kolong into a stagnant pond – presently choked by water hyacinth (Figure 8-5).



Figure 8-5 Upper Reaches of River Kolong Choked by Water Hyacinth (photo: LBG-DHI November 2013)

The river further downstream receives runoff from the Missa, Diju and Nanoi rivers – although the total flow in the Kolong is lower than before the closure of the mouth.

The benefits of flood control were countered by loss of water quality in the dry season and an additional need for irrigation water at the tail end of the rainy season. The need for supplementary irrigation gave rise to a large pump irrigation scheme built in two stages in 1972 and 1977. They are the Kaliabor Lift Irrigation Scheme and Integrated Kolong Project, respectively. The electrically driven pumps (total load 1.6 and 3 MW) were mounted on two barges and with pumping capacity of 280 and 660 cusecs (7.8 and 18.3 cumecs). The barges were tied up alongside two piers situated just downstream of and in the shelter of headland, and connected to the land mounted piping manifold. The two barge mounted pumps discharge the water into one common channel which carries the water via one gated regulator towards the Kolong River bed. The Barges are only active during the monsoon period when there is sufficient water depth to float the barge. During the dry season the barges are resting on the river bed (Figures 8-6, 8-7).



Figure 8-6 Barge mounted pumps at the Brahmaputra River (photo: LBG-DHI Nov 2013)



Figure 8-7 Pumps discharging into the Irrigation Canal (Photo: LBG-DHI Nov 2013)



Figure 8-8 Irrigation Canal Regulator at the old course of Kolong (Photo: LBG-DHI Nov 2013)

Figure 8-9 shows a more detailed layout of the river as it used to flow from the Brahmaputra and the layout of the lift irrigation scheme.

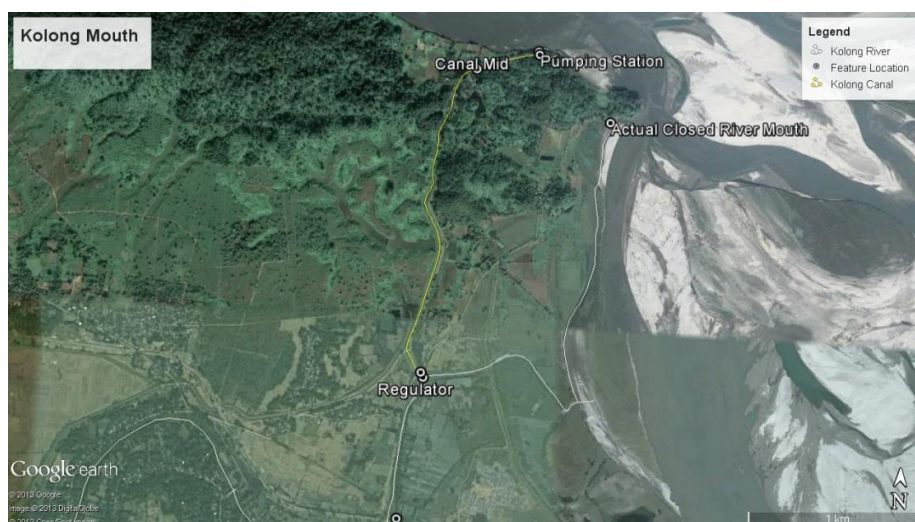


Figure 8-9 Brahmaputra River at the Kolong River offtake

Relevant to this subject is a proposal that is presently before the Water Resources Department to reopen the connection of the Kolong with the Brahmaputra through a gated structure to provide additional irrigation water, a source of good water in the Kolong for providing water supply to villages, for navigation and for improving water quality in the river (which is also compatible with the drinking water issue). The WRD approach would nevertheless be different in emphasis from the present project and

there is no guarantee that the Technical Advisory Committee would approve it at this stage. The difficulties inherent in making a reliable and economic flow connection with the Brahmaputra are connected with two factors – (1) The extreme morphodynamic behaviour of the Brahmaputra, and (2) The large seasonal water level variation in the Brahmaputra.

The braided low water bed of the Brahmaputra meanders over a wide corridor through the years. This would make any flow diversion very problematic in the dry season. There is a narrow section of the river corridor just downstream of the place where the pumping barges are located extending to the Tezpur Bridge. Thus the location of the pumps is at the downstream end of a wide braided reach and marginally more stable than the reach further upstream where the old river mouths were located. Diverting the flow in a controlled way through a gated structure will be different from the original uncontrolled offtake of the Kolong and possibly less likely to remain open without some dredging assistance.

The problem of low water levels in the Brahmaputra during the period that gravity flow into the Kolong is required is also an issue that has to be considered carefully. The bed levels in the re-excavated Kolong is one variable that could control the flow – but eventually it is the Kolong water levels that would determine if this is a viable option.

The alternative approach is using the pumping barges during the dry season. Actually less than half the installed capacity is required. However, since the low water channel of Brahmaputra is at least 100m away from the pumps, a channel has to be dredged every year from one of the barges to the Brahmaputra river channel with a sand bank configuration. A careful study of the morphological history of this site will be required before an estimate of probable cost could be made.

Further considerations on the two possibilities are given below:

1. Direct Offtake from Brahmaputra River

It is not sufficient to try and restore the old natural (pre-1960s) offtake geometry because that will only work for a fully open, uncontrolled offtake. Such an offtake is now considered too hazardous from the point of view of flooding during an extreme monsoon event. The offtake must therefore be gated and operated by the Water Resources Department. A gated structure is subject to rapid siltation upstream during the period when the gates have to be closed, particularly during the recession of the flood. Thus it is necessary to make provision (even annually) for dredging a channel to connect to the gated structure before the gates can be opened (possibly in November). A morphological assessment of the river planform must be made before it is possible to make an estimate of the annual dredging cost. It is possible that the access channel might have to be several kilometres long (in some years) if it is located at the original position. Moving the offtake to a point as close as possible to just upstream of the rocky headland would be the safest way. A study of past satellite images – backed by some morphological modelling would give us a firm idea of its feasibility. Using the Lift Irrigation Scheme already installed.

The barge operated pumps are presently used only during the monsoon when there is sufficient water to float the barges. If the pumps are to be used to pump water during the dry season when the barge is resting on the river bed, it would be necessary to excavate a small pond around the barge and a long channel from this pond to the main channel where river is flowing. The fact that this location is just upstream of a narrow section of the river will mean the lateral movement of the thalweg is much less than in the other reaches of the river that are not laterally confined. However, it is necessary to

assess the practicality of excavating the pond and approach channel (to provide 5 m<sup>3</sup>/s) and for operating the pumps in the regime required for controlling water quality as well as to estimate the lateral movement of the thalweg before the feasibility of the proposal is established.

To assess the feasibility of both the options, a detailed investigation is required including investigations using multi-year satellite imageries and a detailed hydro-morphological model. This needs extensive river morphological data of the offtake including sediment samples (bed material) analysis for at least three years. As an initiation of the study, a series of satellite images were analysed as shown in Figure 8-10. It is proposed to take the following steps before deciding on the method of flow augmentation:

1. A morphological assessment of the two offtake sites (pump location and possible river intake) to determine feasibility/average maintenance dredging costs – which will be based on past river behaviour. Interventions such as deployment of porcupine fields on the opposite bank upstream of the pumping site might be considered – but only after a more detailed assessment
2. The viability of gravity driven diversion to be investigated using the hydraulic model. Alternative diversion quantities and diversion schedules might be assessed.

The final solution will be determined after combining these findings with the overall water quality assessment and cost benefit etc. After a detailed discussion at various stakeholder consultation meetings, it was decided not to pursue this option for the time being. Also it was understood that it is up to WRD to consider this in the long term.

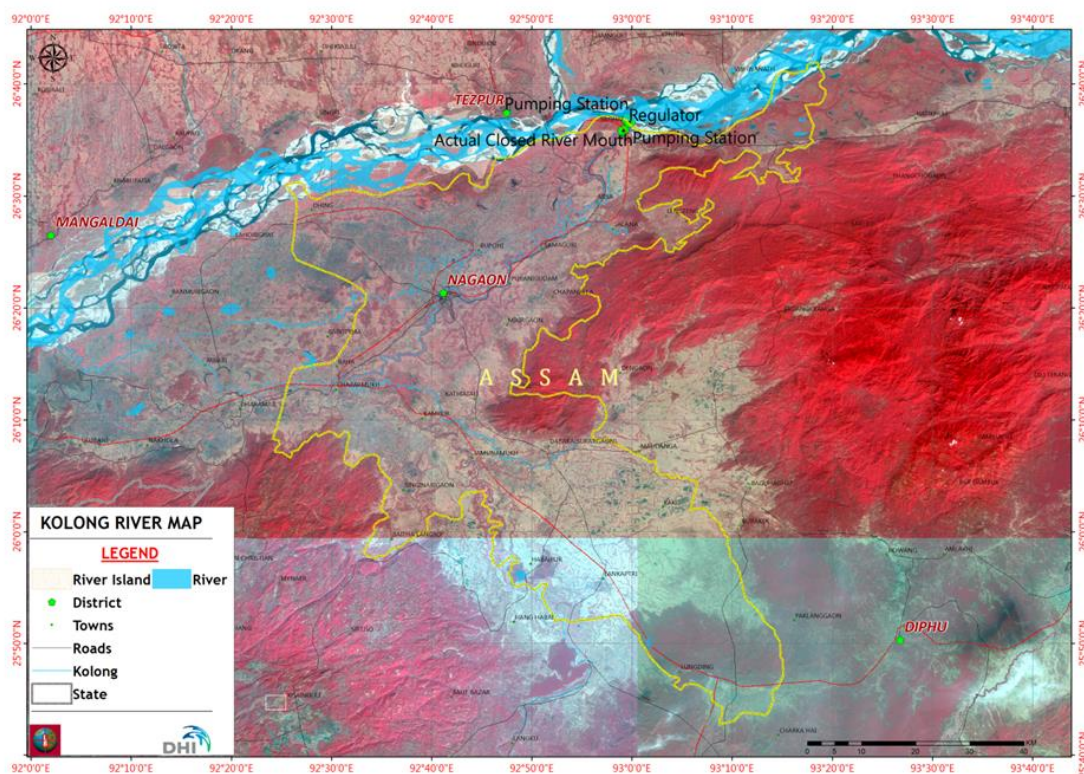


Figure 8-10 Satellite Image at Kolong River Offtake

## 8.4 Water Augmentation by linking Kolong with Beels

It is found that a number of fresh water bodies exist in the catchment area of Kolong, both near Nagaon and Morigaon towns. Some of the beels are shown in Figure 8-11. Figures 8-12 and 8-13 show linking of the beels to the Kolong river.

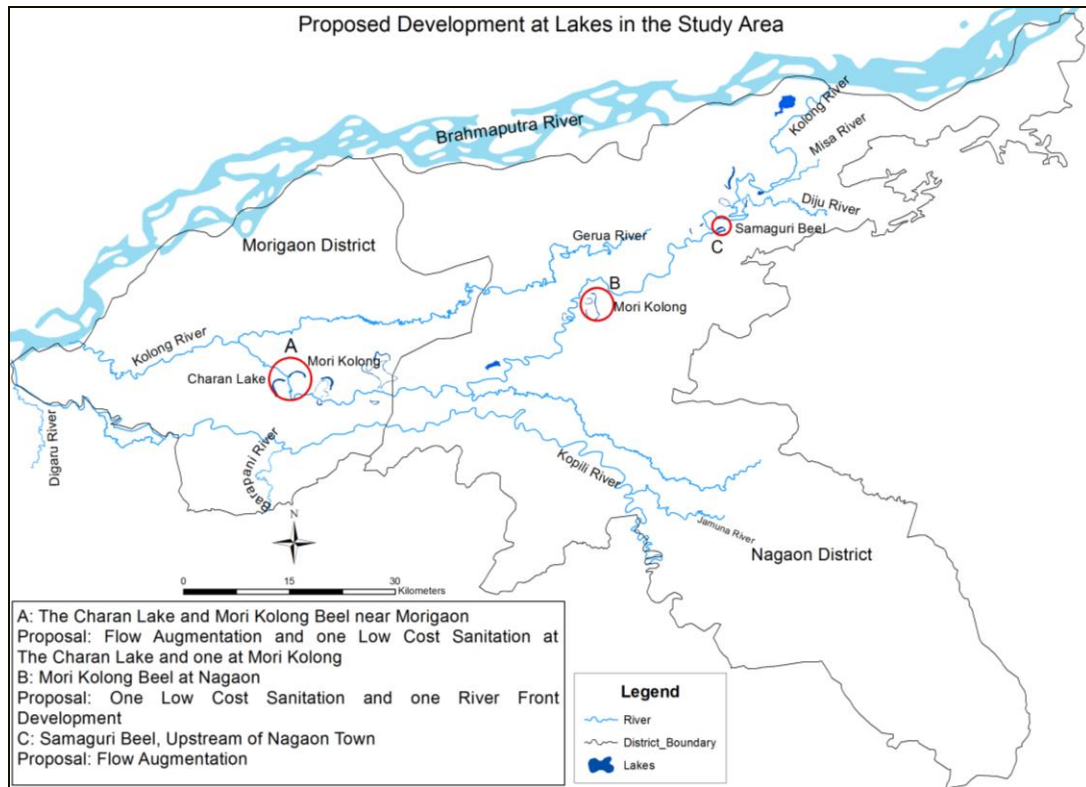


Figure 8-11 Water bodies (beels) around Nagaon and Morigaon

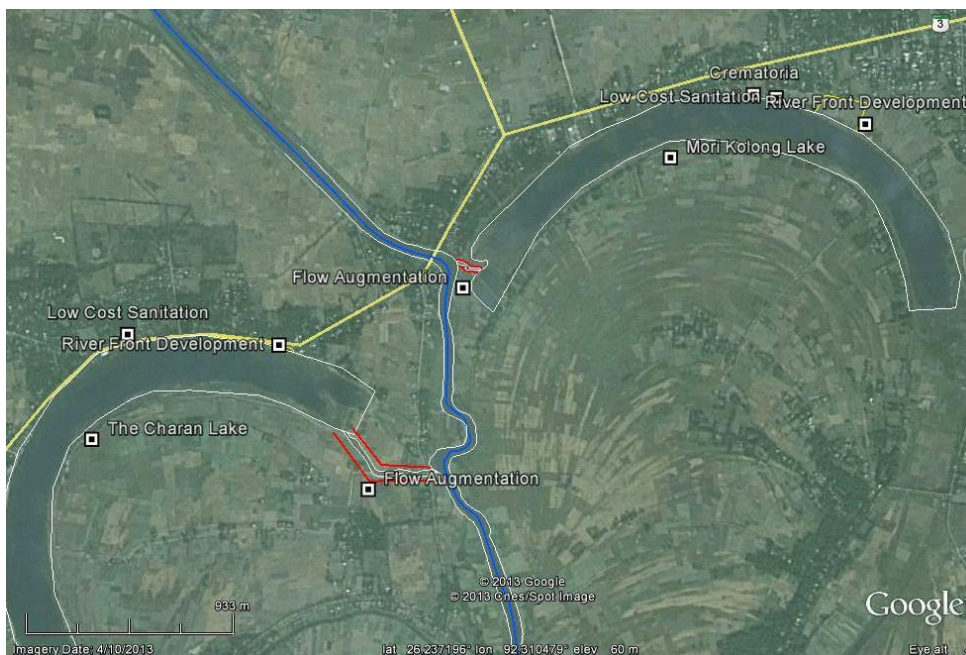


Figure 8-12 Linking of Kolong to beels in Nagaon

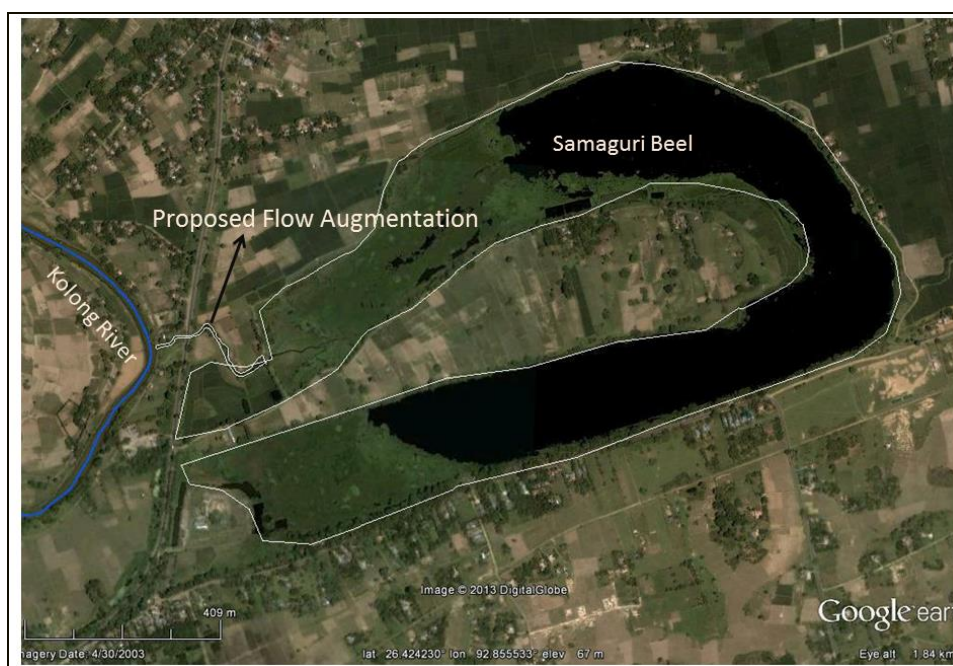


Figure 8-13 Linking of Kolong to Samaguri Beel in Morigaon

## 8.5 Desiltation

In order to improve the conveyance capacity of the Klong River, it is proposed to remove silt deposits for a length of 20 km as shown in Figures 8-14 to 8-17, which show longitudinal profiles of Klong river before and after dredging.



# Water Augmentation and Channel Improvement Schemes

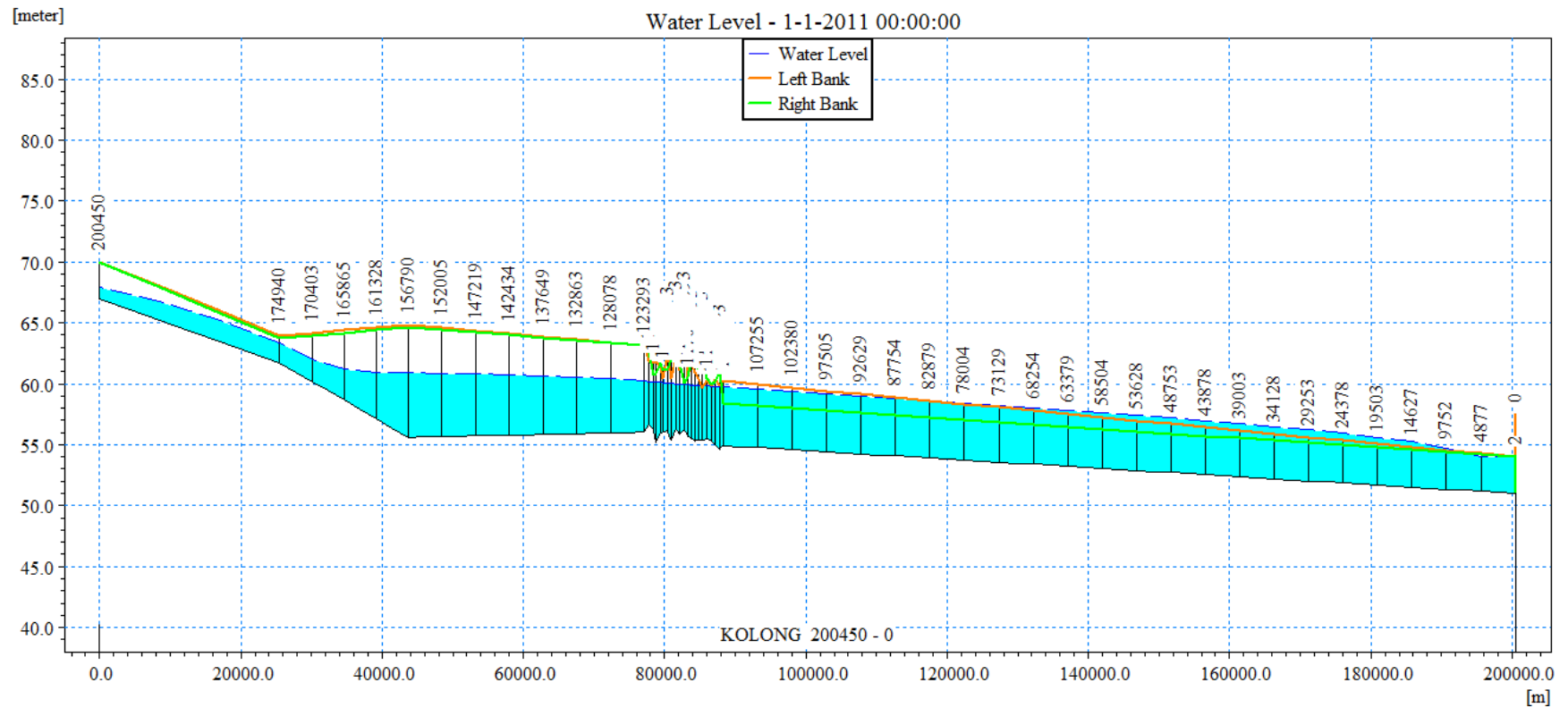


Figure 8-14 Longitudinal profile of Kolong river before dredging

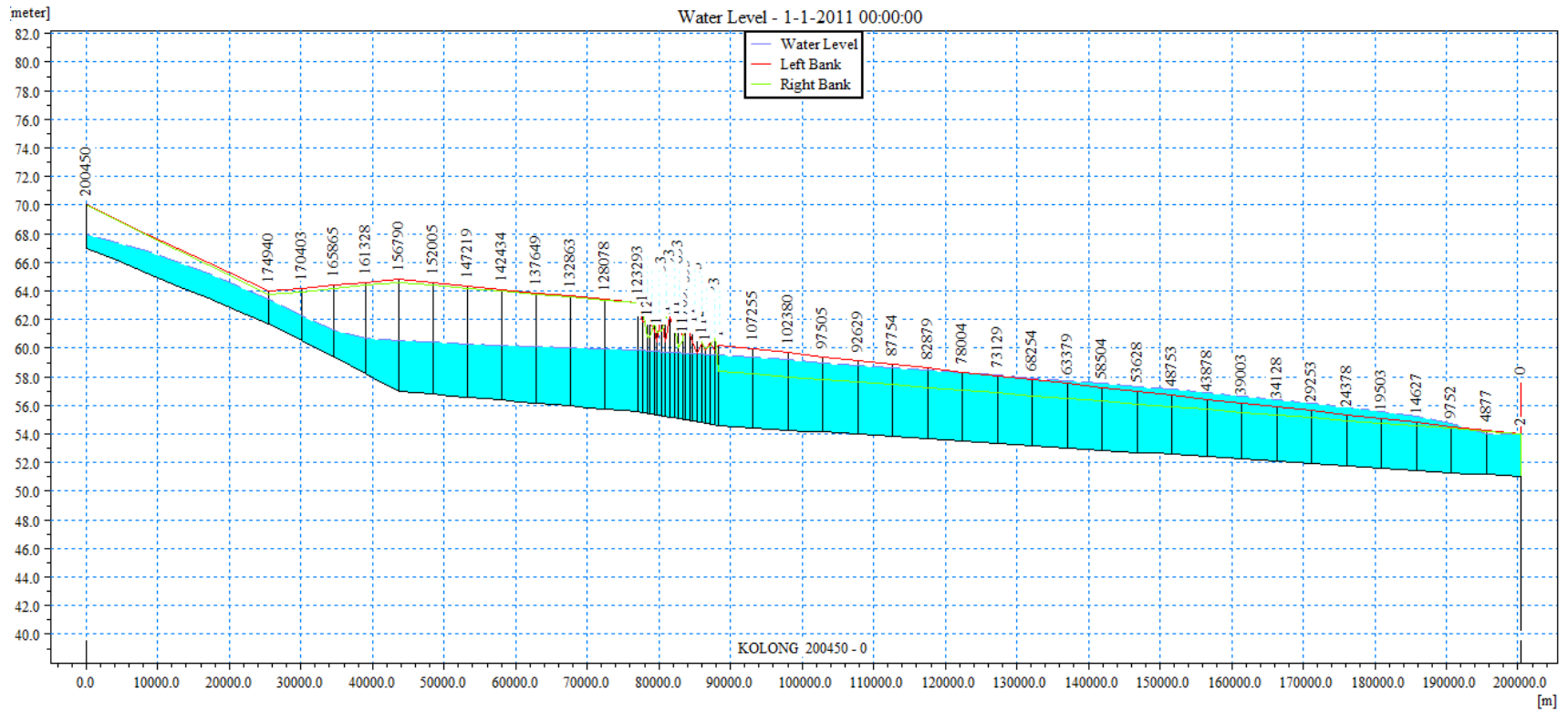


Figure 8-15 Longitudinal profile of Kolong after dredging

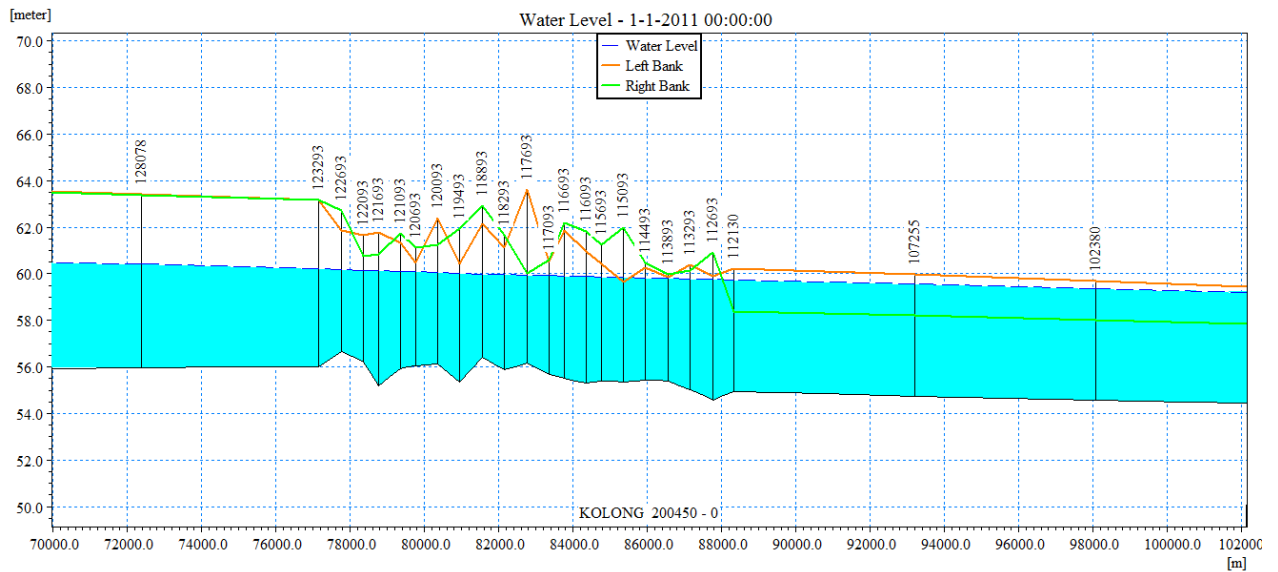


Figure 8-16 L-Profile of Kolong close to Nagaon town (before dredging)

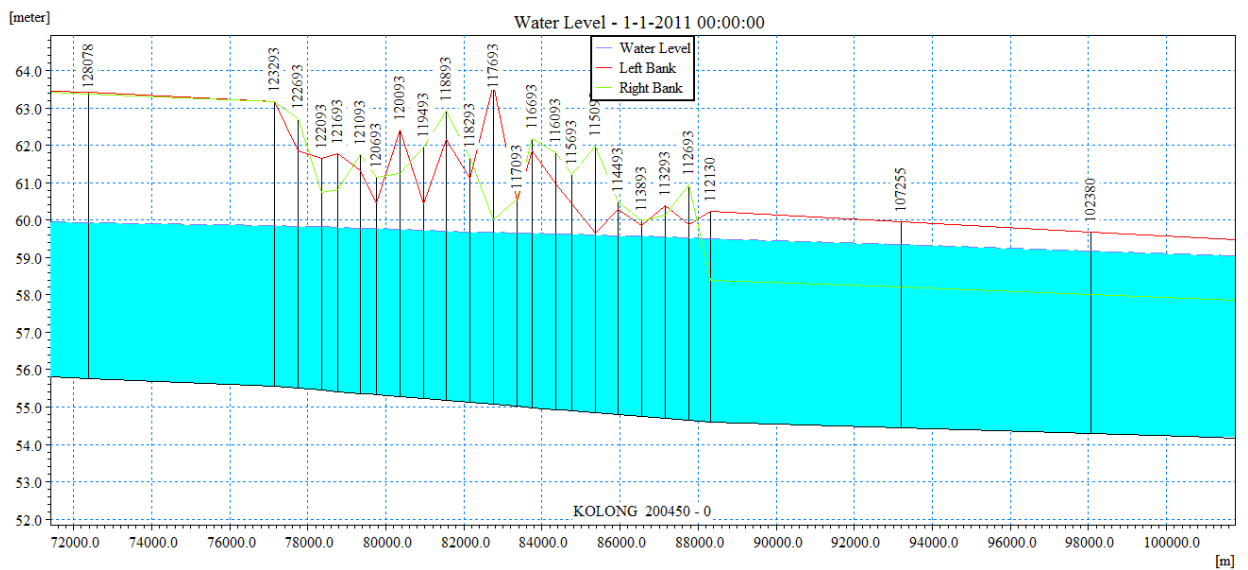


Figure 8-17 L-profile of Kolong near Nagaon town after dredging

Figure 8-18 shows sample cross sections before and after dredging.

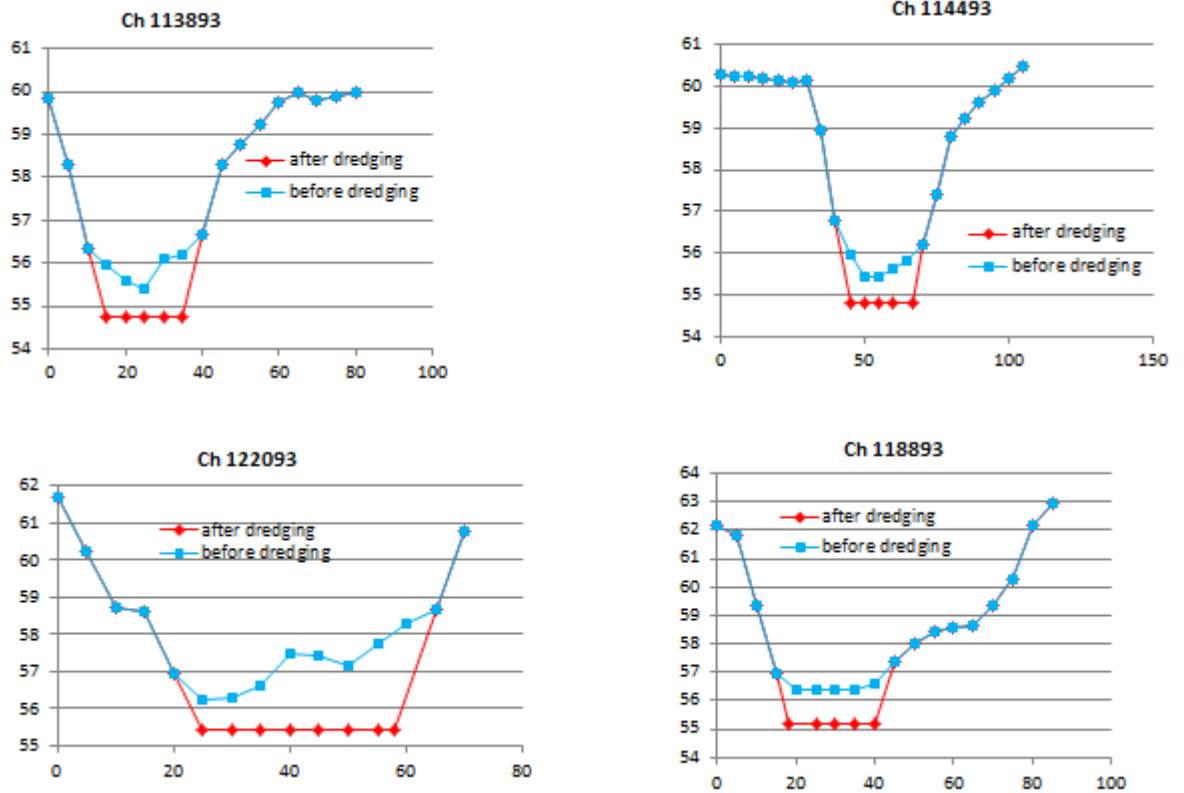


Figure 8-18 Sample Cross sections of Kolong before & after Dredging

## 8.6 Cost Estimate

Table 8-1 shows the estimated quantity of dredging for two different dredging lengths of the river. Tables 8-2 and 8-3 show costs for water augmentation linking and dredging of river Kolong.

Table 8-1 Calculation of Dredging Volume

From	To	Length (km)	Dredging quantity (cu.m)
Approximately 4.5 km upstream of Sesamukh Dimangudi RCC Bridge	Approximately 5 km Downstream of Sensawa Railway Track	20.8	700,606.42
Sesamukh Dimangudi RCC Bridge	Sensawa Railway Track	11.20	326322.94

Table 8-2 Cost estimate of water augmentation (links with beels)

S.No.	Item	Qty	Unit	Rate	Amount
1	Links at 3 places	3	No	3,00,00,000	9,00,00,000
2	Structures	3	No	5,00,00,000	15,00,00,000
5	<b>GRAND TOTAL</b>				<b>24,00,00,000</b>

Table 8-3 Cost Estimate of Dredging

S.No.	Item	Qty	Unit	Rate	Amount
1	Desilting of Kolong River for 20 km (from upstream to downstream of Nagaon), dredged material will be used in bank shaping and river front works	7,00,000	cu.m.	595	41,65,00,000
4	Removal of solid waste from banks close to Nagaon town	12	km	100000	12,00,000
5	Sub Total				41,77,00,000
6	Contingencies			5%	2,08,85,000
	<b>GRAND TOTAL</b>				<b>43,85,85,000</b>



## 9 River Monitoring Schemes

### 9.1 General Technical Concept

The concept of implementation of river monitoring scheme, on which the present technical specifications and special conditions are based intends to combine the advantages of modern Data Collection Platform (DCP), data storage, processing and data communication technologies with the requirements of high availability and sustainability required by such an important project. Preference will be given to robust, reliable technology. Some data collection sites are located in remote areas and should require annual maintenance only, so the selection of equipment and civil design will consider this aspect.

Wherever possible, the data from stations or sensors in close proximity will be gathered using wireless, unlicensed radio transmissions to a single point, then employing GSM/GPRS data communications from that location to SCADA. It is recognized that the maintenance of a monitoring network is often grossly underestimated as well as underperformed task. This leads to reduced life expectancy of the equipment and possibly the collection of misleading data during the period of operation. A strong maintenance plan will be provided for sustaining the monitoring network operation over the expected lifetime of the technology, which is considered to be 10-15 years. The proposed data communication will be through GSM/GPRS. The service provider will be responsible for making all arrangements for the sites requiring GSM/GPRS.

### 9.2 Design Principles

The following basic principles have been applied to the design of the real time hydro-meteorological data acquisition system network for Kolong River basin.

- a) New stations being installed to improve estimations of areal precipitation and mean areal precipitation.
- b) Climate stations will be fully automated and transmit data in real time
- c) Precipitation gauges (Rain gauges) will have the primary function of measuring accumulated precipitation accurately. Rain gauges will be equipped with either a siphon system or software to eliminate over or under-measurement due to varying rates of precipitation being measured by a tipping bucket.
- d) For river water levels radar and stilling well type will be installed.
- e) The discharge measurements will be using current meters

### 9.3 Functional Requirements

Transition to automated observations with real time data communication can lead to a discontinuity in the measurement record if the process is not specified and managed carefully. The benefits of automation with real time data communication include cost

effectiveness, high frequency data, better ability to detect problems with measurements, faster access to data, consistency and objectiveness in measurement, and ability to perform automatic quality monitoring.

The water level and rainfall data will also be measured and logged every 1 hour and transmitted using both self-timed and random transmissions.

## 9.4 Technical Specifications

The technical Specifications of the stations in the monitoring network would be as follows:

### 1. Automated Rainfall Stations (ARS)

The ARS (Figure 9-1) , which will be tipping bucket type, will measure precipitation and transmit this data to data centre through GSM/GPRS communication. The rain gauge will be mounted 0.8 to 1m above the ground and will be located in such a way where the WMO guidelines on exposure are followed (i.e. structures, trees can not be closer than twice the difference between the orifice height and the height of the object). The approximate dimensions required for stations are 7m x 7m. The approximate gauge house building area may be about 5 sq. m. Concrete support block for both the tipping bucket gauge and pole for mounting various accessories etc. will be 0.45m X 0.45m X 0.9m deep approximately.



Figure 9-1: Automatic Rainfall Station.

### 2. Automated River Water Level Stations (ARWLS)

The ARWLS, river stage and transmit this data to data centre through GSM/GPRS communication. The water level measurement technology will either be made from a radar sensor and/or a stilling well/shaft encoder principal. River Water level recording stations will have a gauge house, wherever available or outdoor poles will be used. Figure 9-2 & Figure 9-3.



Figure 9-2: Typical arrangement of radar sensor for bridge sites

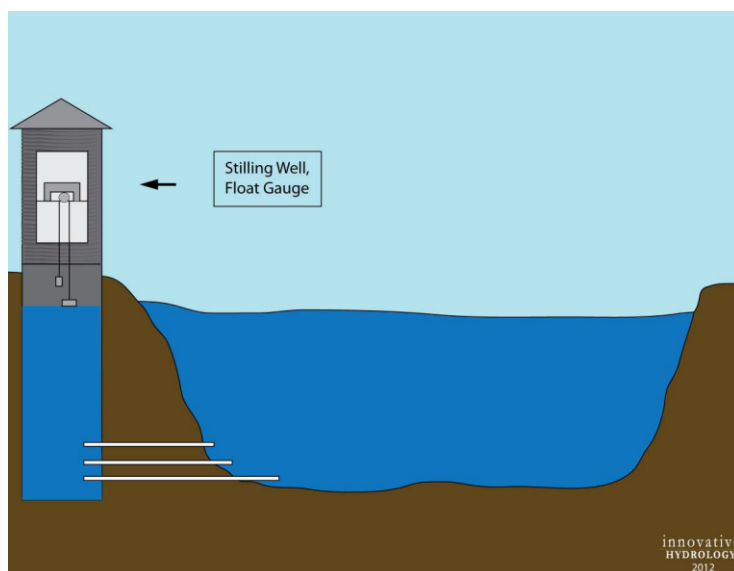


Figure 9-3: Typical arrangement of Stilling Well/Shaft Encoder

### 3. Current Meter for Discharge Measurement

To make discharge measurements over all ranges of flow encountered at newly proposed river water level (stage) sites for establishing stage-discharge curve, the current will be used. The current meters will be able to measure the entire range of flows, typical of measurements made by either Type AA or Pygmy current meters. The typical current meter is shown in Figure 9-4.



Figure 9-4: Typical Current meter

#### 4. Water Quality Stations (WQS)

The various water quality measurements will include the following parameters.

1. pH
2. Turbidity
3. Conductivity
4. Temperature
5. Dissolved Oxygen (DO)
6. Dissolved Ammonia
7. Bio-Chemical Oxygen Demand (BOD)
8. Chemical Oxygen Demand (COD)
9. Nitrates
10. Chlorides

Most of the parameters will be measured using real time sensors and few will be monitored manually and will be incorporated in data base.

### 9.5 Telemetry (GSM/GPRS Communication)

The data communications employed on river monitoring network will use GSM/GPRS radio communications. All stations have had in in-situ radio path survey, where a mobile phone signal was detected.

In GSM(Global System for Mobile Communications) / GPRS(General Packet Radio Service), the transmission is generally with 900 MHz and 1,8 GHz frequencies. It is open for public use and just requires the service agreement with service provider. The area coverage and economy of this option makes it a popular choice.

### 9.5.1 GSM/GPRS Data Collection Station

One GSM/GPRS data collection station shall be established at Project Management Unit (PMU) office in Nagaon. The GSM/GPRS data collection station shall be able to interrogate the DCPs based on a given schedule. The GSM/GPRS Data Collection Station will also be able to receive data sent by the remote stations, whether the data is sent via SMS text or over GPRS internet connectivity.

## 9.6 Data Centre

The objective of establishing of a Data Center is to ensure that the high quality data collection, compilation, processing and analyses are available for monitoring. The data centre will be located at Project Management Unit (PMU) office in Nagaon, and the access to the data will be given to Nagaon Municipal Board (NMB), WRD, Nagaon and PCBA office at Guwahati . The data centre will receive data from the GSM/GPRS enabled remote stations and will store this data in the data base. There will be a minimum of 100 days of data stored.. Figure 9-6 provides a overview of river monitoring system and how the data will be transmitted to data centre. The components of the system include GSM/GPRS communication system and data collection/application servers for the collection, quality control and relay of information. The Web Portal that serves the public authorities want can have the data published on it.

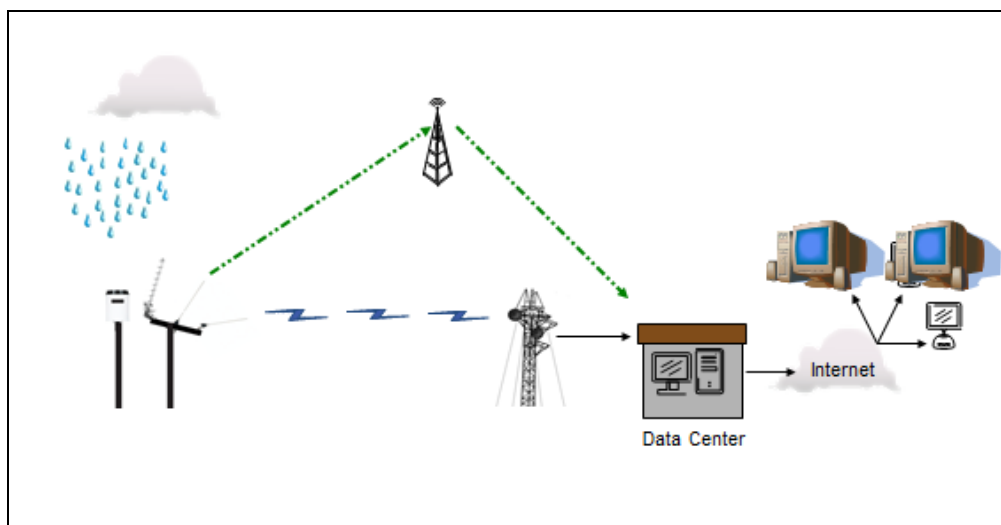


Figure 9-5: Monitoring System Overview .

The data flow will be as follows:

- Each DCP will automatically measure precipitation and reservoir/river water level every regular interval of 1 hour and transmit the data. It will store this observed data in its memory and then transmit it in self timed manner in its prescribed time slot every hour.
- Data communication will be through GSM/GPRS network and received at the ground stations.
- The Real Time Data Monitoring system will be based on Mike Customized s/w, in which the data will be brought into the server. The Mike Customized s/w will

perform the quality control processing and data visualization function. The similar system are successfully implemented and operation in Control Rooms of Bhakra Bias management Board (BBMB) in Chandigarh and Basin Simulation Division, WRD in Pune.

## 9.7 Equipment Specifications

The following equipment specifications will apply for all stations and equipment listed below. All sensors shall have operating temperature from 0 to +60°C, relative humidity 0% to 100% non-condensing and located at an altitude ranging from 200 to 2000 m. The complete tool kit for installation and routine maintenance along with manuals, documentation etc. in English shall be provided.

### 9.7.1 Data Collection Platform

The conditions and constraints of hydrologic monitoring require long periods of autonomy. The Data Collection Platforms shall be capable of unattended operation for upto a year. The continuous power is not available for most of the network, so the power will need to be supplied on-site with the use of solar panels. Figure 9-6 shows the typical data collection platform and online battery charger for solar panel input.



Figure 9-6: Typical data collection platform and online battery charger

### 9.7.2 GSM/GPRS Radio and Antenna

The GSM/GPRS data radio communications equipment shall meet the requirements of regulating agencies in India. The GSM/GPRS technology will allow for on-demand data collection and reprogramming of the data collection platform. The GSM/GPRS antenna shall also meet the requirements of the GSM/GPRS provider and regulatory agencies.

### 9.7.3 Water Level Sensors

As described in 9.4, water level sensing technology includes shaft encoders and radar systems. The sensor shall be compatible with the data collection platform.

**(a) The shaft encoder shall meet the following specifications:**

- Shaft encoder shall have digital readout

- Measuring range: 0 – 80 m water column
- Power supply provided through data collection platform
- Shaft encoder will be compatible with data collection platform input
- Resolution shall be 3mm or less
- All standard accessories shall be included such as floats, wheels, tapes, counterweight and connecting parts
- The sensor shall keep track of rapid water level movements without suffering from missing increments due to too slow operation
- Wheels and tapes shall be metric
- Tape shall be graduated
- Shaft encoder fabrication shall be of high quality using stainless steel or similar material that can resist corrosion
- Shaft encoder electronics are fully protected against ingress of water, moisture, dust etc.
- The Schedule of Requirements gives the numbers to be quoted for and their associated ranges and is provided in Appendix- A. The bidder shall specify for the closest standard range of the offered product with respect to the required measuring range. The quoted range shall be equal or larger than the required range.

**(b) The radar sensor shall meet or exceed the following specifications:**

- Power input: 10 – 15 V DC
- Power consumption:  $\leq 20$  mA Active,  $\leq 10$  mA sleep
- Power should be able to be cycled so that power is only applied prior and during measurement
- Range: 0-30 m water column
- Mounting supports shall be as required
- Accuracy(linearity, repeatability, hysteresis): 0.03% or less
- Resolution shall be 3 mm or less
- The Schedule of Requirements gives the numbers to be quoted for and their associated ranges and is provided in Appendix- A. The bidder shall specify for the closest standard range of the offered product with respect to the required measuring range. The quoted range shall be equal or larger than the required range.

### 9.7.4 Rainfall Sensors

The precipitation/rainfall sensor shall meet or exceed the following specifications:

- Tipping bucket base and collector: durable and rigid of cast metal, moulded thermoplastic, FRP or equivalent; galvanized iron sheet is not permitted
- Rim material: gun metal/ brass/ stainless steel or equivalent
- Rainfall shall be measured using a tipping bucket method and shall be able to record rainfall cumulatively with the data collection platform
- Rainfall sensor shall be of such a design that it operates reliably and accurately under prevailing environmental and weather conditions
- Raingauge is easy to operate and easy to calibrate
- Minimum expected operational lifetime shall be 15 years or greater
- Bucket capacity: 1 mm equivalent rainfall

- Focus on rainfall gauge is the accurate measurement of rainfall totals, not necessarily rainfall rates. The use of a siphon system to normalize rainfall rate to achieve accurate total rainfall is specified, or software which will also normalize varying rainfall rates and errors caused by changing rainfall rates
- Intensity: 0 – 500 mm/hr
- Accuracy: 2% of reading
- Contact system using dual reed switches with varistor protection
- Insect covers on all openings
- Collecting funnel diameter: close to 200 mm internal diameter
- The gauge will have leg adjusters to set the level horizontally
- Certified calibration test document shall be included with every gauge. The calibration may be performed just prior to installation to assure accuracy of certified calibration test.
- Ability to service tipping bucket gauge without re-leveling the gauge.
- Calibration kit for tipping buckets (10 units)
- Necessary cables to connect precipitation gauge to data logger as required

#### 9.7.5 Solar Power and Battery

All systems will rely on solar power charging system and battery backup for extended operation during periods of extended cloudiness or loss of charging system. The solar panel and battery system shall satisfy the following specifications:

- 12V solar photo voltaic system with the capacity to power all equipments associated with the station
- The solar panels shall be capable of not only powering the equipment, but charging the batteries to provide continuous operations
- The battery system must be capable of operating all components of the monitoring station for 20 days without charging
- The solar panel system shall be capable of full charging the battery system that has gone 20 days without charge within 2 days in full sunlight.
- A solar regulator will be supplied at each station to regulate power and maintain optimum battery and data collection platform operation

#### 9.7.6 Current Meters

One set of current meter with all accessories required to make discharge measurements over all ranges of flow encountered at newly proposed river water level (stage) sites for establishing stage-discharge curve. Accessories include Price-type current meters or equivalent. The current meters should be able to measure the entire range of flows, typical of measurements made by either Type AA or Pygmy current meters. The bidder will provide the complete specifications of the equipment as part of the bid.

The current meter accessories will include wading rods, cranes, sounding weights to make measurements from a bridge, cableway or wading. This equipment will be used by the bidder and serviced by the bidder for repair due to malfunction or other equipment breakdown.

### 9.7.7 Water Quality Sensors

The specifications for water quality sensors viz. pH, Turbidity, Conductivity, Temperature, Dissolved Oxygen (DO), Dissolved Ammonia, Chemical Oxygen Demand (COD), Nitrates and Chlorides are described in following sections. The Bio-Chemical Oxygen Demand (BOD) measurements will be done weekly by sample collection manually and lab analysis.

#### 9.7.7.1 Specification for pH

pH	
Measuring Range	0.0 to 14 units of pH
Accuracy	≤ 0.01 units of pH
Resolution	≤ 0.01 units of pH
Precision	≤ 0.03 units of pH
Response Time	≤ 60 seconds
Operating Temperature	0 to 40°C
Operating Humidity	5 to 95% non-condensing
Power	12 VDC Nominal
Signal Output	Compatible with Data Acquisition System
Cleaning	Self-Cleaning (Automatic)

#### 9.7.7.2 Specification for Turbidity

Turbidity	
Measuring Range	0 to 1000 NTU
Accuracy	≤ 3 % of certified reference standard
Resolution	≤ 0.1 NTU
Response Time	≤ 60 seconds
Operating Temperature	0 to 40°C
Operating Humidity	5 to 95% non-condensing
Power	12 VDC Nominal
Signal Output	Compatible with Data Acquisition System
Cleaning	Self-Cleaning (Automatic)

#### 9.7.7.3 Specification for Conductivity

Conductivity (EC)	
Measuring Range	0.0 to 5000 μS/cm
Accuracy	± 0.1% of full scale
Resolution	≤ 0.01 μS/cm
Precision	≤ 3 μS/cm
Response Time	≤ 60 seconds
Operating Temperature	0 to 40°C
Operating Humidity	5 to 95% non-condensing
Power	12 VDC Nominal
Signal Output	Compatible with Data Acquisition System
Cleaning	Self-Cleaning (Automatic)

#### 9.7.7.4 Specification for Water Temperature

Temperature	
Measuring Range	0 to 40°C
Accuracy	≤ 0.1 C
Resolution	≤ 0.1 C
Precision	≤ 0.1 C
Response Time	≤ 60 seconds
Operating Temperature	0 to 40°C
Operating Humidity	5 to 95% non-condensing
Power	12 VDC Nominal
Signal Output	Compatible with Data Acquisition System
Cleaning	Self-Cleaning (Automatic)

#### 9.7.7.5 Specification for Dissolved Oxygen

Dissolved Oxygen (DO)	
Measuring Range	0 to 20 mg/L
Accuracy	≤ 1% of Full Scale
Resolution	≤ 0.01 mg/L
Precision	≤ 0.02 mg/L
Response Time	≤ 60 seconds
Operating Temperature	0 to 40°C
Operating Humidity	5 to 95% non-condensing
Power	12 VDC Nominal
Signal Output	Compatible with Data Acquisition System
Cleaning	Self-Cleaning (Automatic)

#### 9.7.7.6 Specification for Dissolved Ammonia

Ammonia (NH <sub>4</sub> )	
Measuring Range	0.0 to 100 mg/L
Accuracy	≤ 3% of full scale
Resolution	≤ 0.1 mg/L
Precision	≤ 0.3 mg/L
Response Time	≤ 60 seconds
Operating Temperature	0 to 40°C
Operating Humidity	5 to 95% non-condensing
Power	12 VDC Nominal
Signal Output	Compatible with Data Acquisition System
Cleaning	Self-Cleaning (Automatic)

### 9.7.7.7 Specification for COD

<b>Chemical Oxygen Demand (COD)</b>	
Measuring Range	0.0 to 500 mg/l
Accuracy	± 2% + 5 mg/L of certified reference standard
Resolution	≤ 1 mg/L
Response Time	≤ 60 seconds
Operating Temperature	0 to 40°C
Operating Humidity	5 to 95% non-condensing
Power	12 VDC Nominal
Signal Output	Compatible with Data Acquisition System
Cleaning	Self-Cleaning (Automatic)

### 9.7.7.8 Specification for Nitrates

<b>Nitrates (NO<sub>3</sub>)</b>	
Measuring Range	1 to 50 mg/L
Accuracy	± 2% + 0.5 mg/L of certified reference standard
Resolution	≤ 0.1 mg/L
Precision	≤ 0.25 mg/L
Response Time	≤ 60 seconds
Operating Temperature	0 to 40°C
Operating Humidity	5 to 95% non-condensing
Power	12 VDC Nominal
Signal Output	Compatible with Data Acquisition System
Cleaning	Self-Cleaning (Automatic)

### 9.7.7.9 Specification for Chlorides

<b>Chloride (CL<sup>-</sup>)</b>	
Measuring Range	0 to 1000 mg/L
Resolution	≤ 0.1 mg/L
Precision	≤ 1 mg/L
Response Time	≤ 60 seconds
Operating Temperature	0 to 40°C
Operating Humidity	5 to 95% non-condensing
Power	12 VDC Nominal
Signal Output	Compatible with Data Acquisition System
Cleaning	Self-Cleaning (Automatic)

## 9.8 River Monitoring Network

The real time network of rainfall and river water monitoring is depicted in Figure 9-7: Map showing Monitoring Stations for Kolong River Basin. It is proposed to have 5 rain gauge stations, 1 river water level station and 3 Water Quality stations. The BOD measurements would be taken at these six stations in each week manually. There would be one current meter for discharge measurement.

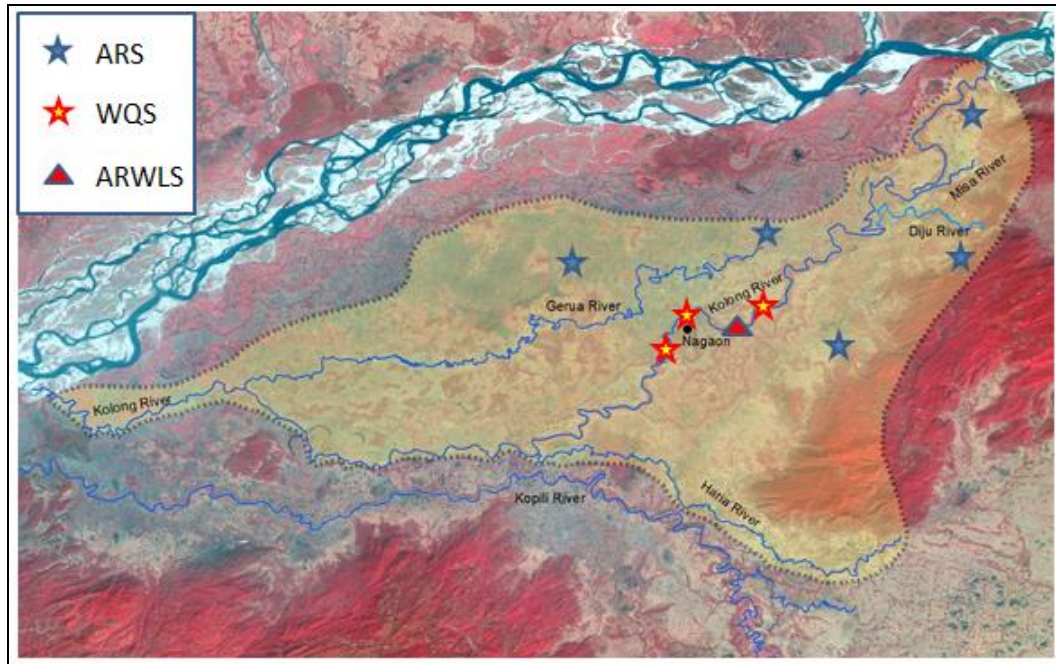


Figure 9-7: Map showing Monitoring Stations for Kolong River Basin

## 9.9 Cost Estimate

Table 9.1 and 9.2 elaborates the Cost estimates for Kolong River including Operation and Maintenance Costs,

Table 9.1 The Cost Estimate for Kolong River

SI No.	Item	QTY	Unit	Unit Cost (INR)	Total Cost (INR)
1	Automatic Rainfall Station	5	No	150,000	750,000
2	Automatic River WL Station	1	No	300,000	300,000
3	Water Quality Stations (excluding BOD)	3	No	850,000	2,550,000
	<b>SubTotal</b>				3,600,000
5	Transport, Transit Insurance, Installation	1	Lot	20%	720,000
6	Establishment of gauge-discharge station	1	No	250,000	250,000
7	Current meter and related accessories	1	Lot	100,000	100,000
8	Database Server	1	No	500,000	500,000
9	High End Desk Tops	5	No	80,000	400,000
10	Display (Plazma 51")	4	No	100,000	400,000
11	SCADA & data base software	1	No	1,200,000	1,200,000
12	Data integration and modelling software	1	No	5,000,000	5,000,000
13	<b>SubTotal</b>				12,170,000
16	Contingencies			5%	608,500
17	<b>subtotal</b>				12,778,500
18	<b>O&amp;M for 5 years</b>				22,545,000
	<b>TOTAL</b>				<b>35,323,500</b>
19	Consultancy for implementation of the monitoring, modelling and warning system - included in the PMC cost	The Consultancy cost of 6 International Mon-months and 24 National man-Months will be included in the budget PMC.			

Table 9.2 O & M Cost Estimate for Kolong River

1	BOD Sampling and lab testing 3 stations, 52 weeks	156	No	1000	156000
2	Other water quality parameters sampling & lab testing (monthly)	36	No	10000	360000
3	Cost of mobile network use	9	No	10000	90000
4	Annual maintenance cost	1	years	10%	360000
5	Flow measurement (weekly) at the G-D station - to be outsourced to hydrologists	52	week	20000	1040000
6	Maintenance of hardware and software at the SCADA Center	1	LS	1000000	1000000
7	Total for one year				3,006,000
8	Total for 5 years (incl. escalation)				22,545,000

## 10 Environment Impact Assessment

### 10.1 Existing conditions of Kolong River, Nagaon town

The Kolong River is a tributary of the Brahmaputra River. It diverts from the Brahmaputra River in the Hatimura region of Jakhlabandha (Nagaon district, Assam), and rejoins the Brahmaputra River at Kolongpar near Guwahati. The River stretch which runs through the town of Nagaon is heavily polluted due to anthropogenic activities. The baseline environmental survey was conducted to assess the present condition of the river stretch which runs through the Nagaon town.

#### 10.1.1.1 Water Quality

Water quality samples were collected at 5 locations starting from upstream to downstream of Nagaon town, map showing the sample locations is given in Figure 10-1., for 3 days during December 5 to 9, 2013. Similarly water quality sampling was carried out in the river downstream near Morigaon for one day on 21 December 2013.

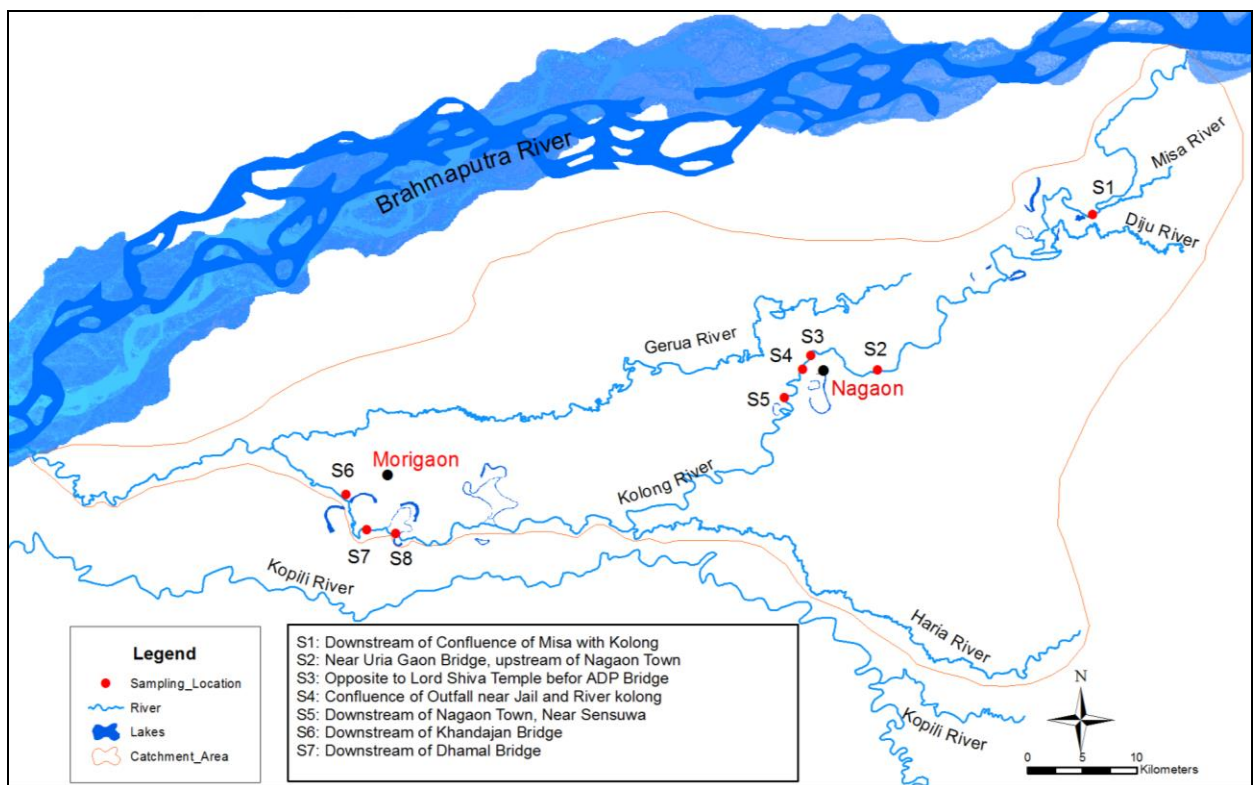


Figure 10-1 Water Quality Sampling Locations around Nagaon and Morigaon

The following parameters Temperature, pH TSS, TDS, Chloride, DO, BOD5, Total Coliform and Faecal Coliform were analysed. The results of the important parameters determining the water quality are provided in the table below. Detailed Laboratory report on the test results is provided in the Annex. It can be seen that the values are much higher than the NRCDC recommended standard for bathing.

Table 10-1: Water quality results of Kolong River, near Nagaon

S.No	Parameter	Value (3 days average)				
		Station 1	Station 2	Station 3	Station 4	Station 5
1	pH	7.4	7.33	7.32	7.17	7.54
2	DO	7.6	7.15	7.36	3.25	7.15
3	BOD5	23.89	30.58	36.9	68.03	43.18
4	COD	480	320	213.33	346.67	400
5	Total Coliform	>1600	>1600	>1600	>1600	>1600
6	Faecal coliform	>1800	>1800	>1800	>1800	>1800

In case of samples taken near Morigaon the water quality is found to be of acceptable standard (Table 10-2).

Table 10-2: Water quality results of Kolong River, near Morigaon

S.No	Parameter	Khandajan	Damal	Tengaguri
		Station 1	Station 2	Station 3
1	pH	6.98	6.81	7.06
2	DO	7.15	7.8	7.15
3	BOD5	3.25	5.2	1.95
4	COD	80	80	160
5	Total Coliform	>1600	>1600	1600
6	Faecal coliform	>2400	>2400	920

### 10.1.2 Fish species in the Kolong River

Assam is blessed with number of wetlands includes swamp, marsh, waterlogged, oxbow and manmade water bodies. These water bodies support number aquatic vertebrate and invertebrates. The list of fishes were found in Kolong River is provided in the table and picture are provided below.

Table 10-3: List of Fish Species observed in Kolong River

Scientific Name	Common Name
<i>Mastacembelus armatus</i>	Tire track eel
<i>Badis badis</i>	Blue perch
<i>Rasbora rasbora</i>	Gangetic scissortail rasbora

<i>Labeo gonius</i>	Kuria labeo
<i>Cirrhinus mrigala</i>	Mrigal carp
<i>Puntius sophore</i>	Pool barb
<i>Pethia conchonius</i>	Rosy Barb
<i>Mystus bleekeri</i>	Day's Mystus

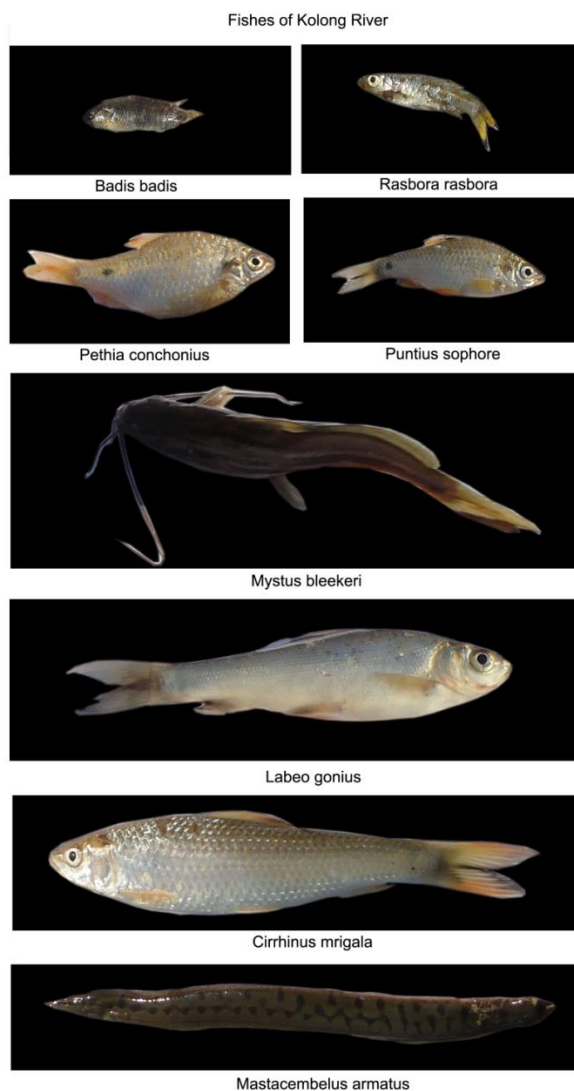


Figure 10-2 Fish Species observed in Kolong River

### 10.1.3 Flora

During our survey we have found the following plant species along the Kolong River at Nagaon. Abundant of hydrophytes is an indicator of excessive nutrient load into the freshwater system. The list includes aquatic as well as terrestrial species.

Table 10-4: List of Plant species observed in and around Kolong River

Scientific Name	Common Name
<i>Ceratophyllum demersum</i>	Hornwort

Scientific Name	Common Name
<i>Limnophila indica</i>	Indian Marsh weed
<i>Polygonum glabrum,</i>	Denseflower knotweed
<i>Ipomea carnea,</i>	Bush Morning Glory
<i>Eichornia crassipes</i>	Water hyacinth
<i>Ipomea aquatica</i>	Water Morning Glory
<i>Datura metel</i>	Devil's trumpet
<i>Ziziphus oenophilia</i>	Common jujube
<i>Colacasia esculenta</i>	Taro
<i>Riccinus communis</i>	Castor oil plant
<i>Aponogeton natans</i>	Floating Lace Plant
<i>Blumea fistulosa</i>	Clustered Blumea
<i>Sagittaria sagittifolia</i>	Arrowhead
<i>Ficus racemosa</i>	Indian Fig Tree
<i>Vallisneria spiralis</i>	Tape grass
<i>Nymphoides hydrophyllum</i>	Tharo-macha
<i>Leucas aspera</i>	Leucas
<i>Dillenia indica</i>	Elephant apple
<i>Ficus hispida</i>	Hairy Fig
<i>Amarphophalus bulbifer</i>	Voodoo Lily
<i>Chromolaena odorata</i>	Siam weed
<i>Solanum torvum</i>	Wild eggplant

#### 10.1.4 Fauna

During our survey we have found the following avifaunal species along the Kolong River at Nagaon. The list of faunal species identified are listed below

Table 10-5: List of Avifauna species observed in and around Kolong River

Scientific Name	Common Name
-----------------	-------------

Scientific Name	Common Name
<i>Acridotheres ginginianus</i>	Bank myna
<i>Bubulcus ibis</i>	Cattle egret
<i>Halcyon smyrnensis</i>	Kingfisher
<i>Motacilla alba</i>	Wagtail
<i>Anastomus oscitans</i>	Asiatic open bill stork
<i>Corvus macrorhynchos</i>	Jungle crow
<i>Streptopelia chinensis</i>	Spotted-necked Dove
<i>Anas platyrhynchos domesticus</i>	Domestic duck
<i>Milvus migrans</i>	Black-eared Kite



*Domestic duck*



*Kingfisher*

Figure 10-3 Showing avifauna species observed in Kolong River

### 10.1.5 Forest and Biodiversity

The State of Assam is a constituent unit of the Eastern Himalayan Biodiversity Region; one of the two biodiversity “Hot Spots” in the country. Though there are no reserved forests around the Nagaon town. Nagaon whole as a district supports variety of wildlife, important biodiversity locations are Kaziranga National Park, Samaguri Beel and Lowkhowa wildlife sanctuary. Kaziranga and Lowkhowa are famous for its endangered Great one horn rhinoceros.

## 10.2 Proposed Actions/structures and Mitigation measures to restore Kolong River

In-order to restore the river water quality, a series of actions proposed. The followings are the key structural schemes proposed under this project for the improvement of Kolong River and Nagaon town.

1. Sewer Network and STPs,

2. River Front Environmental Improvement,
3. Water Augmentation schemes and desilting of river
4. Community toilets/ sanitation,
5. Solid waste management (collection, transport and disposal).

### 10.2.1 Sewage Collection and Treatment Options

Presently there is no centralised sewerage collection and treatment facility in Nagaon largely because most households have either a septic tank or soak pit. A new sewage collection system is proposed to collect all sewage and transport it to a centralised place for treatment. The system, if properly implemented, will significantly reduce pollution loads to the river. Another option which may be considered is to have multiple decentralized STPs located at strategic locations throughout the catchment area.

### 10.2.2 River Environmental Improvement

River front environmental improvement development includes defining the extent of river along its complete stretch and securing it against any possible future encroachment. Implementation of various river front developments works like amphitheatre and jogging track inside the park Pranab Baruah Children Park in collaboration with relevant authorities with a sustainable framework.

### 10.2.3 Water Augmentation schemes

The possibility of connecting the Kolong river with fresh water beels in Nagaon and Morigaon is considered. This is aimed at increasing the dry season flow in the Kolong. The original flow from Brahmaputra has stopped sine many decades due to closure of the offtake due to flooding problem. A morphological study for the off-take at Brahmaputra River should be studied to find solutions for hydraulic improvement of Kolong River.

### 10.2.4 De-silting, De-weeding, and De-sludging

The hydraulic conveyance capacity of the Kolong river will be improved by desilting along a reach of 20 km upstream and downstream of Nagaon town. The river bed material will directly be used in improving the bank shapes and in the river front development works.

### 10.2.5 Community toilets/ sanitation

As part of the project proper sanitation for local population Community toilets are proposed the outlet will be connected to the proposed sewer connection so that no waste is send to river Kolong. This will help in addressing the inadequate sanitation issue. There will be proper community toilets along the selected locations to take care of sanitation issues. Also bathing ghats will be repaired and new ones developed along the river.

### 10.2.6 Solid waste management (collection, transport and disposal).

The town has a major problem in solid waste management particularly along the river banks, solid wastes are dumped along the river banks and pollutes the river environment. The wards along the Kolong River are the major source of solid waste generation pollution.

There are solid waste facilities available but inadequate to meet the demand. Hence it is proposed to have a proper solid waste management system along the River stretch.

### 10.3 Environmental Impact Assessment for the proposed schemes

When identifying the potential impacts of a new project on the existing environment, such as the proposed Restoration of Kolong River, it is necessary that it should be measured against the existing baseline conditions. Construction of sewer line with sewage treatment plant and there after operation of this system, if undertaken without a proper understanding of the relationships inherent in environmental function, can be accompanied by disruptions to the environment, from which it may take a long time to regain equilibrium. In human terms, this may mean that generations must function in a debilitated environment and suffer many possible associated socio-economic hardships and financial losses.

In general, construction of a new sewage treatment plant will have a positive environmental impact on the Town. It is expected to produce a long term improvement in public health of the residents Nagaon town as well as to significantly reduce a source of chronic water pollution in Kolong River of an ecologically valuable portion if the water body where the sewage drains.

#### 10.3.1 Sewerage and Sanitation

##### 10.3.1.1 Construction Phase Impacts

Most of the construction phase potential impacts will be temporary, in the nature of inconveniences to the citizens using the same space for their day-to-day activities, and will eventually withdraw once the construction phase is over. Despite this, the construction stage impacts as identified below need to be addressed and mitigated. Identified types of impact and their tentative mitigation are given as below, which will be further reviewed and elaborated in the DPR stage.

- a) Erosion Prevention – Excavations for laying sewerage collection network needs to be scheduled in such a way that large volume of soil should not remain stacked at site for considerable time especially during the monsoon.
- b) Prevention of dust nuisance – Fugitive dust generation from exposed construction surfaces during dry/windy periods is to be suppressed by light spraying of water or by other suitable means.
- c) Disposal of soil – Major quantity of excavated soil and road crust will be used to fill-up the excavations after pipelines are laid.
- d) Emission and noise from plying vehicles and noise from construction activities – All construction vehicles are to be properly maintained and should have valid 'Pollution Under Control Certificate'. Noisy construction activities should be carried out only during normal working hours and local residents are to be advised in advance of any unusual or unavoidable noise.
- e) Relocation of utility services – Some inconveniences to public, such as temporary dislocation of civic amenities like water supply, drainage and sewerage, electricity, telephone and cable TV connection may be caused for relocation and/or replacement of these facilities.

- f) Prevention of dust and noise during material handling operation – Dust and noise producing activities such as stone crushing, bitumen and cement batching plant etc. are to be located downwind and away from habitation settlement wherever practicable.
- g) Prevention of soil, ground and/or surface water contamination – Silt after dewatering is to be immediately disposed in approved disposal site.
- h) Prevention of waterlogging/ flooding – Dewatering during trenching and water testing of new lines are to be regulated in a manner so that it does not lead to waterlogging of the nearby areas.
- i) Road safety and traffic management during construction – Since many roads in the project area are not wide enough; there may be some traffic congestion during the construction phase. In the narrow sections of road, construction activities may cause traffic disruption. A traffic management plan has to be prepared and approved by the ULB.
- j) Prevention of accidents and damage to property – All necessary precautions has to be taken to prevent accidents and/or damage to property. Unforeseen accidents could result in personal injury and/or damage to private or public property.
- k) Health and safety of work force – All occupational and health and safety requirements for work force has to be adhered to. Facilities of periodic health check up of workers must be available free of cost.
- l) Environmental health and safety at construction camp sites and construction work sites – Camps/ work sites are to be located so that they do not interfere with the existing drainage system. Camps/ work sites should have a suitable drainage outlet, if required.
- m) Prevention of impacts on places of cultural importance – Routing of sewers should avoid places of cultural importance including shrines, temples, maazars, mosques etc. to the extent feasible. Safe access to these places has to be maintained.
- n) Social impacts – Since it is not be feasible to provide complete sewerage coverage in all the areas under the project, it might result in some discontent from public residing in the areas which will not be covered by the project. Consultation with elected representatives, public relations and awareness building exercises including information disclosure through several known means has to be carried out by the project to address this issue.

### 10.3.1.2 Operational Phase Impacts

During the operational phase the environmental impacts are expected to be mostly positive. Provision of complete sewerage system under this project would minimize wastewater stagnation and waterborne disease propagation in the service area and ensure better sanitation practices. This is expected to lead to abatement of nuisance and public health hazard in the service areas, for instance, improved sanitary conditions is expected to result in reduction in incidence of parasitic infections, hepatitis and various gastrointestinal diseases including cholera and typhoid which occurs either through direct contact with fecal material or contamination of water supply and food.

Other potential adverse impacts during the operational phase are identified, along with their mitigation measures, as follows:

- a) Due to lack of control there may be discharge of hazardous industrial effluents from existing industries. Regulatory activities being carried out by the Assam Pollution Control Board (APCB), such as strict enforcement of treatment regulations of existing industrial discharge and regular monitoring activities carried out by the APCB would ensure that untreated or inadequately treated effluent from any industry is not discharged into the proposed sewer system.

- b) There is a potential health hazard to workers engaged in sewer maintenance works. These workers are likely to be exposed to toxic gases and hazardous materials present in the sewage and are likely to contract communicable diseases from exposure to pathogens present in the sewage.
- c) There can be some stretches where there will be difficulty in achieving self-cleansing velocity during operational stage. To minimize the siltation problem, the operating agency should undertake continual and routine maintenance of the system.
- d) Lack of proper operation and maintenance of the system could cause overflow of sewage, which would be a nuisance and health hazard to public.

### 10.3.2 Pumping Stations

In general, potential adverse environmental impacts from this sub-component are likely to arise from: (a) augmentation/renovation of existing pumps (if any); (b) civil construction of new pumping stations; (c) disposal of silt, soil and debris due to the construction of inlet and outlet channels and other civil works of the pump houses; and (d) safety, security and occupational hazards during construction and operation phases.

#### 10.3.2.1 Construction Phase Impacts

Construction activities will inflict short-term minor adverse impacts on soil, surface water, air, noise, ecology of the area and quality of life values of nearby habitants and work force. In order to mitigate these impacts, construction phase activities related to earth work has to be scheduled in the dry season so that chances of flooding, inundation, waterlogging and surface erosion become minimal. Exposed construction sites have to be adequately covered to reduce erosion, surface runoff, air pollution, and construction spoils has to be suitably disposed of.

#### 10.3.2.2 Operation Phase Impacts

Overall operation phase impact is expected to be positive as the proposed pumps have been designed to transmit DWF to next pumping station or STP and will significantly reduce the inadequacy of sanitation facility in the service area. Siltation of the pump houses is a potential impact, which may be mitigated by adequate operation and maintenance of the pumps with regular desiltation.

### 10.3.3 Sewage Treatment Plant

#### 10.3.3.1 Design Phase Impacts

The proposed STP is expected to be located in relatively low land. Adequate drainage provisions have to be made in the design of the STPs to avoid flooding during incidence of rain. In addition, the following features have to be built into the STP designs, for both new STPs and the STP upgrades, in order to minimize adverse impacts on the environment:

- a) Provision of adequate capacity in the canals to receive the expected treated water discharge,
- b) Proper choice of specification of the pump(s) from the point of view of design capacity and operation at low noise level,
- c) Proper design of the pump house so as to contain noise within the pump house,
- d) Provision of a peripheral green belt, and

- e) Provision of 15-20% open space within the complex to improve scenic quality of the STP area.

### 10.3.3.2 Construction Phase Impacts

There may be minor air pollution from dust generation during construction of new STP. Excavations during the construction phase may produce surplus earth and spoil material and these are to be disposed in the designated areas. In order to mitigate these impacts, the following measures are to be adopted:

- a) Provision of fencing around the construction site with GI sheets all around to prevent encroachment and to ensure community safety,
- b) Use of construction machineries to the extent practicable so as to limit deployment of labourers and avoid accident,
- c) Provision of safety training to the construction labourers and ensuring the provision and use of adequate protection gears for their safety,
- d) Storage of excavated earth separately for future use in greenbelt development and landscaping,
- e) Step cutting of earth or timber/metal shoring to be provided during deep excavation to protect against earth sliding,
- f) Settlement of construction wastewater carrying suspended solids like earth, cement and sand in a brickwork basin; decanted water may then be let into public drains,
- g) Avoidance of night time work; if at all needed, safety provisions and proper lighting arrangements are to be provided, and no noise generating construction activity is to be undertaken,
- h) Storage of all construction materials within the fenced area and absolutely not on public thoroughfare,
- i) Dispose of all construction debris and wastes in the low lying areas, and
- j) Spraying of water to prevent dust generation as and when required.

### 10.3.3.3 Operation Phase Impacts

Noise due to operation of the pumps and moving systems is to be confined to the plants. The noise level of the equipment should meet the standard from occupational health point of view (with 85 dBA at a distance of 1.5m from the source). The discharge flow quantity from the STPs has been accommodated in the designed capacity of the receiving canals. Therefore over bank flooding of the canals due to increased discharge is not expected.

During the operation stage, continuous attention has to be paid for maintenance of the environmental improvement brought about by implementation of the sub-components. The STP site should remain all the time neat and clean i.e. with the highest order of housekeeping. Adequate operation of the outlet pump(s) is to be ensured so that there is no overflow of untreated or partially treated wastewater from the STP. In case of failure of the pump(s) or prolonged power cut alternative arrangement of power has to be made.

Noise from the operation of the outlet pumps and other moving parts is not expected to add significantly to the ambient noise level if appropriate maintenance of the pumps and regular checking are carried out. Each individual operator may use ear plugs for which provisions will be made.

Special provisions of fresh water must be made to treat operators affected by accidental spillage from chlorinator plant. Sewage water should not be touched by the operators. Adequate soap and detergent are to be kept for washing of hands.

STP may cause bad odour principally by the release of H<sub>2</sub>S formed by limited anaerobic reduction of sulphate by sulphate reducing bacteria. Recommended design loading should not be exceeded and sulphate (SO<sub>4</sub>) concentration in the raw wastewater should not be allowed to exceed 300 mg/litre so that only odourless HS is produced instead of H<sub>2</sub>S by the reduction process if at all formed. 'No smoking' signboard will be prominently displayed and carriage of match box or lighter should be prohibited to prevent fire hazard in case bio-gas (methane) is generated.

### 10.3.4 River Front Environment Development

#### 10.3.4.1 Construction Phase impacts

**Air Pollution:** The major temporary air pollution is dust generated due to site clearance and excavation. The overall impact may be rated as direct, short-term, adverse, and reversible.

**Water Quality:** The proposed water front developments will improve the link between the river and community, during the construction phase the impact on water quality are expected to be minimum.

**Noise Pollution:** The construction activities will generate noise during the constructional phase due to activities of excavation, material handling and machine operation equipment & vehicular movement. Impact of noise level may be categorized as direct, short-term, adverse, reversible and of low to moderate magnitude.

**Solid Waste:** Solid waste generated during site preparation and construction work would include cut vegetation and typical construction waste (e.g. wasted concrete, steel, wooden scaffolding and forms, bags, waste earth materials, etc.). This waste would negatively impact the site and surrounding environment if not properly managed and disposed of at an approved dumpsite.

#### 10.3.4.2 Operation Phase impacts

During operational stage solid wastes are expected from water front development activities amphitheatre, walking path and other activities related developments. Solid waste has to be collected by placing collection bins at strategic locations and disposed at the existing solid waste facilities of Nagaon town.

Amphitheatre may produce noise during screening of play and other entertainment activities, the level of impacts are minimum and temporary. The impacts on air, water and noise environment are expected to be minimum.

#### 10.3.4.3 Water Augmentation - Hydraulic Improvements

#### 10.3.4.4 Construction Phase impacts

**Air Pollution:** The major temporary air pollution is dust generated due to site clearance and excavation. The overall impact may be rated as direct, short-term, adverse, and reversible.

**Water Quality:** The formation of the proposed connectivity will facilitate improvement of water flow in to the Kolong River, during the construction phase the impact on water quality are expected to be minimum.

**Noise Pollution:** The formation of the proposed connectivity may generate noise during the constructional phase due to activities of excavation, material handling and machine operation equipment & vehicular movement. Impact of noise level may be categorized as direct, short-term, adverse, reversible and of low to moderate magnitude.

Solid Waste: Solid waste generated during site preparation and construction work would include cut vegetation and typical construction waste (e.g. wasted concrete, steel, wooden scaffolding and forms, bags, waste earth materials, etc.). This waste would negatively impact the site and surrounding environment if not properly managed and disposed of at an approved dumpsite.

#### 10.3.4.5 Operation Phase impacts

The water quality of along the Kolong River will be improved due to the continuous flow of water in the River. This will have positive impact on the agricultural and fisheries sector thereby improving the livelihood opportunities of the people along the river. There are no significant impacts on air and noise environment.

#### 10.3.5 De-silting, De-weeding, and De-sludging

##### 10.3.5.1 Construction phase impacts

Huge quantity solid waste in the form of silt, sludge and plant materials will be generated. The Solid wastes generated are to be collected and disposed with the existing solid waste facilities of Nagaon town. Impacts on water, air and noise environments are expected to be minimal and temporary. The river bed material will be used in reshaping the river banks as well as in the construction of river front development works. Therefore, no environmental impacts are foreseen.

##### 10.3.5.2 Operation phase impacts

The regular maintenance of channel involves De-silting, De-weeding, and De-sludging, which will result in solid waste generation. Solid wastes generated are to be collected and disposed with the existing solid waste facilities of Nagaon town. Impacts on water, air and noise environments are expected to be minimal and temporary.

#### 10.3.6 Community toilets/ sanitation

##### 10.3.6.1 Construction phase impacts

Impacts on air, water and noise environments are expected to be short-term, adverse, and reversible. Solid waste generated during site preparation and construction work would include cut vegetation and typical construction waste (e.g. wasted concrete, steel, wooden scaffolding and forms, bags, waste earth materials, etc.). This waste would negatively impact the site and surrounding environment if not properly managed and disposed of at an approved dumpsite.

##### 10.3.6.2 Operation phase impacts

Solid and liquid waste will be generated and it will be connected to the proposed sewer system and sent to STP for further treatment.

### 10.3.7 Solid waste management (collection, transport and disposal)

#### 10.3.7.1 Construction phase impacts

During construction of landfill sites, temporary impact may be seen in terms of dust and mud in the surrounding area. There is no impact in placing storage bins in the collection sites.

#### 10.3.7.2 Operation phase impacts

Proper collection and disposal of solid waste will have significant positive impact on the river ecosystem. Health and Sanitation will be improved.

### 10.3.8 Cultural and Socio-Economic Impacts of the proposed activities

- The construction of proposed Sewer network and sewage treatment plant is a mark beneficial socio-economic aspect since it leads to safe and hygienic disposal of the treated effluent.
- It enhances the existing environment as the untreated raw sewage disposal will be ceased.
- Also, the project will provide employment to the people during the constructional and operational phase hence creating a positive impact due to this project.

The resulting of pollution free River will help in the livelihood improvement of traditional fishermen's of Kolong River.

## 10.4 Concluding Remarks

The Environment Impact Assessment gives the following facts.

- The impacts arises due to the proposed activities are temporary and minimal during construction phase.
- The proposed activity will not result in any significant negative impact to Environment. Instead, various beneficial impacts include aesthetic, water quality, biodiversity, socioeconomic and health and hygiene.
- The proposed measures will give a positive impact in all sectors/segments and will help to improve the River water quality to a great extent.
- Most development activities are expected to have a beneficial effect on human health by increasing the resources available for food, education, employment, water supply, sanitation and health services. Proper management of solid waste should have minimum effects on environment and health impacts.



## 11 Stakeholder Consultation

The success of development largely lies in adopting an integrated or holistic approach that takes into account the considerations of the stakeholders, especially the people for whom it is primarily intended. Accordingly a participatory approach was used during the preparation of the DPR both at the field level and institutional levels. Specific attention was given to the people living near the river banks. Figure 11-1 illustrates a common interests form three key sectors – Public, private and the civil society/community.

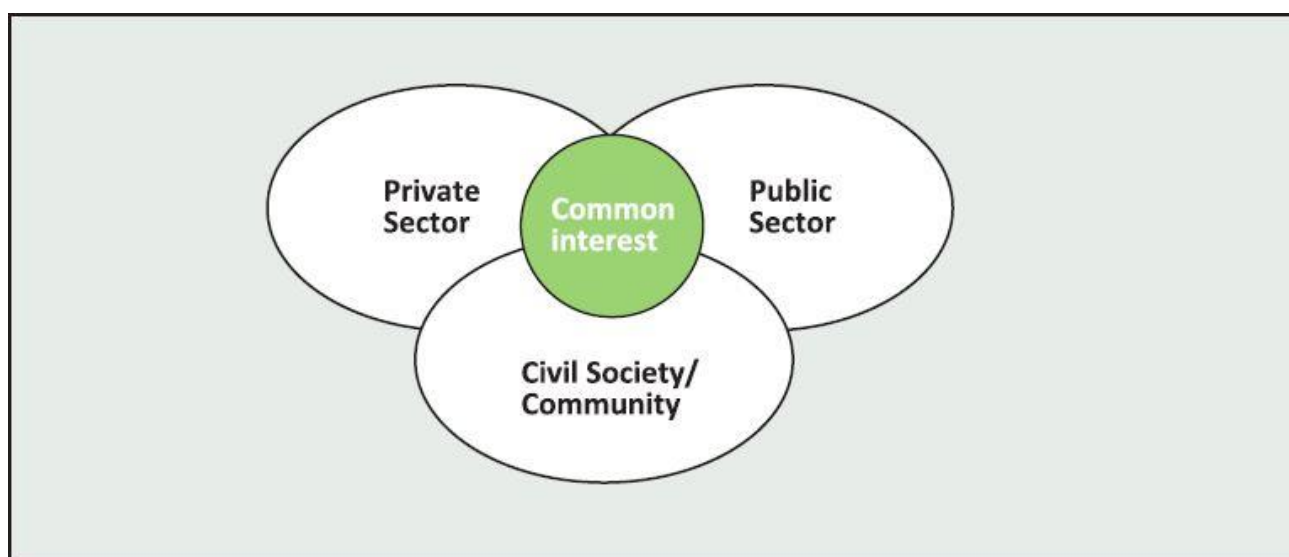


Figure 11-1 Common Interest sectors for river restoration

### 11.1 Initial fact finding meetings

After the contract signing, consultants visited various departments and local authorities to collect the data and information about the project. The discussions also were help with the locals.

- Pollution Control Board
- Water Resource Department
- Nagaon Municipal Board
- Town and Country Planning
- Nagaon College
- Local Community.

## 11.2 Community consultations

During the field visits to Nagaon town, in upstream areas along the Kolong River and downstream of Kolong river from Nagaon upto Morigaon, the team interviewed and had discussions with local people about problems of the Kolong River water quality, sanitation, drinking water supply and solid waste. **Error! Reference source not found.** and Figure 11-3 demonstrates the discussions with local people at the upstream mouth of the Kolong River and also the discussions with local people at Misa. Most of the people in the area have soak pits and the waste water is not discharging into the river. They use the Kolong River for mainly for the purpose of bathing and washing.



Figure 11-2 : Interaction with local people during field trips in the town



Figure 11-3 Consultation with people

The field visit was also taken to Morigaon town, and in upstream areas of Morigaon town along the Kolong River. River Kolong is about 4 km from Morigaon town and the town does not dump any waste directly or indirectly into the river. During the interviews and discussions, the local people expressed their views on the Kolong River water quality, sanitation, drinking water supply, and solid waste. **Error! Reference source not found.** shows the pictures taken during the discussions with local people of Morigaon.



Solid Waste Management at Morigaon Town

Figure 11-4 Interaction with local people during field trips in the Morigaon town

### 11.3 Inception Workshop

The inception report was presented in the Inception Workshop held on the 4<sup>th</sup> of December, 2013 to the Pollution Control Board. The workshop was chaired by Mr. Dubey, Chairman, Pollution Control Board Assam. Table 11-1 provides the list of participants who attended the Inception workshop.

Table 11-1: List of stake holders who attended the Inception Workshop on the 4<sup>th</sup> December 2013.

S.No.	Name	Designation, Organisation
1	Mr. R M Dubey	Chairman, Pollution Control Board
2	Mr. R.M.Das	Consultant, GMDA
3	Mr. Dutta	Consultant, PCBA
4	Mr. Gokul Bhuyan	Executive officer, River and Lake conservation cell
5	Prof Chandan Mahanta	Professor, IIT Guwahati
6	Dr Guna Nidhi Paudyal	Managing Director, DHI (India)
7	Mr. Subrata Mazumdar	Vice President, The Louis Berger Group (India)

## Stakeholder Consultation

8	Dr Flemming Jakobsen	Technical Director, DHI (India)
9	Mr. Louis Ragozzino	Waste Water Expert, The Louis Berger Group
10	Mr. Harshad Dhande	Waste Water and Sewerage Expert, DHI (India)
11	Mr. Rajiv Sinha	The Louis Berger Group, Inc.
12	Mr. Lalit Mohan	Remote Sensing Expert, DHI(India) Water and Environment
13	Mr. Rupesh Gupta	Project Coordinator, DHI(India) Water and Environment
14	Prof. Tarun Acharya	Solid Waste Management, The Louis Berger Group
15	Mr. Ayan Dey	Cost Estimation Expert, The Louis Berger Group

The agenda of the workshop, in addition to discuss the Inception Report, was to review the overall progress of the project, identification of pollution sources and possible solutions to conserve the river as per NRCD guidelines. The suggestions of the committee members and experts present in the work shop are provided below:

- All experts from PCBA mentioned that the opening of the mouth of the Kolong River along the Brahmaputra River is a good option, but needs detailed study and due consideration to the flooding risks should be given.
- For the short term measures (first 5-10 years), the stretch of the river length flowing through the town should be considered. However for Long term measures (20-30 yearsthe longer river stretch should be considered.
- As Nagaon town faces frequent power cuts, the same should be considered while planning the measures.
- Flooding due to rains in Nagaon town is also important and should be considered.

### 11.4 Stakeholder Consultation Workshop

After the submission of City Sanitation Plan for Nagaon town covering Kolong river stretch, the stakeholder meeting was held on 19<sup>th</sup> December, 2013 by Pollution Control Board Assam (PCBA) in Nagaon to discuss various option proposed by consultant and the findings during the study. List of stake holders who attended the meeting is given in Table 11-2.

Table 11-2: List of stake holders that attended the meeting on the 4<sup>th</sup> December 2013.

S.No.	Name	Designation/Department
1	Manjul Chandra Lakhan	PCBA
2	Rajesh	PCBA
3	P Sivakumar, IFS	Forest Department

4	Dr. Manik Kar	Nagong College, Nagaon
5	Dipak Bayan	Water Resource Department
6	Bhagwan Patan	Water Resource Department
7	Alkog Kumar Deka	Water Resource Department
8	Sahajananda Ojah	SSEAEP, M G Road
9	Kishor Kr Deka	SSEAEP, M G Road
10	Jayanta Kr Saran	SSEAEP, M G Road
11	Diganta Bhagwati	GYPSY'S care
12	Gokul Bhuyan	PCBA
13	Moloy Bora	Joint Secretary, Forest Department
14	R M Dubey	Chairman, PCBA
15	R M Das	Consultant, GMDA, Member NRCC
16	Dr Guna Nidhi Paudyal	DHI
17	Dr Dhananjay Pandit	DHI
18	Subrta Mazumder	Louis Berger Group
19	Raed EL Farhan	Louis Berger Group
20	Deepak Awari	Louis Berger Group
21	Rupesh Gupta	Louis Berger Group
22	Lalit Mohan	DHI
23	Sandeep Gupta	DHI
24	N Anand, IFS	DFO, Nagaon
25	Jitendra Kumar, IFS	ACF, Nagaon
26	Sumy Chaudhry, IFS	ACF, Nagaon
27	Dilip Kumar Sarmah	Executive Engineer, Water Resource Department
28	Jakir Husain	Executive Engineer, Water Resource Department
29	Mr. Uppal	Town and Country Planning, Nagaon

Stakeholder meeting started at 11.00am and Chairman, PCBA explained the project to stakeholders and also requested to give their opinion on the options proposed by consultants for waste water and solid waste management in City sanitation Plan. After

## Stakeholder Consultation

that Dr. Guna from DHI presented the problems of Kolong River and various measures planned for Kolong river conservation. His presentation focused on the following points.

- 1) Sources of pollution the river Kolong.
- 2) Solid Waste Management along the Kolong river stretch in Nagaon
- 3) Possible measures for restoration of Kolong river.

During the discussions, the Stakeholders from Nagaon expressed their keen desire to conserve the Kolong river in a sustainable manner. Chairman, Nagaon Municipal Board suggested the river front development in the Nagaon town along the Kolong river would be an important option.

It was also decided that during this project the opening of Mouth of Kolong river will not be considered. However, this would be taken up by Water resource department in holistic way. The representatives of WRD endorsed this decision,



Figure 11-5 Stakeholders Meeting at Nagaon

## 11.5 Public Consultation Workshop

Public consultation workshops are planned to be held on 3 January 2014 at Nagaon and on 4 January 2014 at Morigaon to discuss the draft DPR and obtain feedback from

public. The Draft DPR has been published in the PCBA Website ([www.pcbassam.org](http://www.pcbassam.org)). PCBA has published a general information in newspapers (Figure 11-6) informing the public about the DPR's availability in its website as well as about the public consultation meetings on the 3<sup>rd</sup> and 4<sup>th</sup> January 2014. Findings of the consultation meeting will be incorporated in the Final DPR.

## 11.6 Consultation with other officials and individuals

The formal and informal discussions were held with the government officials from NMB, WRD, Forest Department, Agriculture Department, Town and Country Planning department, NE Council for Science and Technology, etc. The discussions also held with academicians from IIT, Guwahati, Assam Engineering College, Guwahati University, College of Fisheries. The informal discussions were held with the renowned retired personalities of government departments and academic institutions in Assam.

**RIVER AND LAKE CONSERVATION CELL  
POLLUTION CONTROL BOARD: ASSAM**

BAMUNIMAIDAM : GUWAHATI - 781021  
Ph. No.: 2652774 & (M) 9435343530 Fax: 0361-2550259  
[www.pcbassam.org](http://www.pcbassam.org)

No. PCBA/RLCC/G-1/13-14/143 Dated Guwahati, the 20<sup>th</sup> Dec., 2013

**PUBLIC NOTICE**

**Sub: Stake Holder Meeting on DPRs for Conservation and Restoration of Bharalu & Kolong Rivers.**

As a special initiative of Hon'ble Chief Minister, Assam and the Environment and Forest Minister, Govt. of Assam the task of preparation of DPR for revival/conservation of Bharalu & Kolong rivers for seeking funding from National River Conservation Directorate (NRCD), Ministry of Environment & Forests (MoEF), Govt. of India has been entrusted to Pollution Control Board, Assam (PCBA).

In pursuance to the above, Pollution Control Board, Assam has engaged the Joint venture of "The Louis Berger Group, INC (USA) & DHI (India) Water and Environment Pvt. Ltd." as consultants for preparation of DPRs as per guidelines of NRCD.

The consultants have prepared the 1<sup>st</sup> part of the DPR i.e. City Sanitation Plans (CSP) for Bharalu and Kolong catchment which are uploaded in the PCBA's website [www.pcbassam.org](http://www.pcbassam.org) and draft DPRs will be available in Board's website by 31<sup>st</sup> December, 2013.

The Board and the Consultants held inter-departmental consultation on CSP on 18<sup>th</sup> & 19<sup>th</sup> December, 2013 at Guwahati and Nagaon respectively.

The Board invites the opinion/suggestion from all concerned citizens, Non-Governmental Organizations, Govt. Departments and Civic-Society Organizations for incorporation in draft or making necessary amendments in CSP and draft DPR so that a technically sound and people friendly DPRs strictly in accordance with guidelines of NRCD could be presented before them for funding. The suggestions may kindly be sent by email to [chairman@pcbassam.org](mailto:chairman@pcbassam.org) or [membersecretary@pcbassam.org](mailto:membersecretary@pcbassam.org) within 06-01-2014.

The Board has further decided to hold series of Stake Holders meetings as per Schedule given below and invites Civic Society Members, Senior Citizens, NGOs, Voluntary Agencies, Govt. Departments etc. having knowledge & expertise useful in formulating the DPRs for conservation and restoration for these two rivers for discussion-

Sl. No.	Date	Time	Venue for Stake Holders Meeting
1	03.01.2014	11.00 AM Onwards	Shwahid Bhawan, Nagaon
2	04.01.2014	Do	Zila Parishad Conference Hall, Morigaon
3	06.01.2014	Do	District Library Auditorium, Dighali Pukhuri, Guwahati

The Board solicits the presence of all the distinguished citizens to share their views to help it in formulating a technically sound and people friendly conservation and restoration DPRs for the said two rivers.

Sd/-  
(Dr. R.M. Dubey)  
Chairman

Figure 11-6 Public notice issued by PCBA

## 12 Education and Public Awareness Schemes

### 12.1 Introduction

Any river conservation project to be implemented successfully, public awareness is of utmost importance. Unless the public are made aware about the irreversible damage and pollution caused by indiscriminate littering and dumping of waste and garbage in drains and water bodies connected to Kolong River, the project cannot be implemented in true sense of the word to achieve conservation. Some members of the communities are already aware that there is a need for Kolong conservation programme and that they will benefit from it. Hence, it should be ensured that;

- The communities are effectively involved in all the stages of the project cycle from conceptualization, to preparation, to finalization, to implementation and finally O & M.
- Public Awareness & Public Participation should be a front-end activity of the project.
- The entire programme of conservation should be conceived, formulated, implemented, monitored and evaluated in close consultation with the stake holding communities.

Therefore, education and awareness programmes are key to the sustainability of the various components implemented as part of the river restoration project.

#### Enhancement of public awareness & public participation

The Kolong river pollution is a manmade crisis which calls for concurrent initiative and intervention by several quarters including the public. The following activities will be carried out.

- Sensitization of local population on the environmental crisis they have brought upon themselves in the form of polluting the Kolong river.
- Educating the public in scientific but simple terms about pollutants, untreated sewage and noxious matters in the Kolong river and their impact on flora and fauna.
- Educate the people on health problems (skin diseases, gastro-intestinal infection etc) arising out of using the polluted and dirty waters of Kolong.
- Educate the people and make them aware of the health hazards involved in the consumption of milk and meat products from animals that drink polluted water, as well as the consumption of vegetables grown on the beds and banks of polluted Kolong river.
- Educate the people and motivate them to segregate domestic waste and to use bio degradable packaging products.
- Work with religious leaders to educate people regarding risks of immersion of idols in the rivers.
- Provide information on STPs in different locations and other planned technical works, as it is likely to motivate them to adopt pollution prevention practices.

- Low income households may be informed about low cost sanitation and stop open air defecation.
- Organise extensive media campaign for different target groups, devise messages, and choose medium, format and time slot so as to maximize campaign's reach and impact. The campaign may draw upon traditional media (puppet show etc.) as well as modern media (street play, video clipping etc) to reach the message of river restoration. Develop procedure to obtain feedback of the presentations under the campaign, both in quantitative and qualitative terms so that mid course corrections are introduced and desired impact is obtained.
- Organise exposure visit for community leaders, NGOs and civil society members to other states to observe best practices adopted in river restoration, hygiene and sanitation improvement.

In order to carry out the above activities successfully partnership will be required to be developed with NGOs and civil society including community based organizations (CBO). Therefore, a cost component is included in the project budget for these activities.

## 12.2 Education and awareness based on issues

Education and awareness programmes can be effective if they are conducted focussing on specific issues rather than on general aspects. In the conservation of the Kolong River the public awareness and education will focus on the following issues:

- To address the sources of pollutants causing the degradation of the Kolong river. The most pressing issue is disposal of garbage into the river and its banks. Therefore, major efforts related to community education will be focussed on stopping the disposal of garbage near the river.
- Development, improvement, use and maintenance of river front walkways, parks and other amenities. For example, the river front facilities may be flooded during monsoon. The community should be prepared on the flooding issues by installing a flood warning system. After the floods, the communities should be motivated to repair the facilities and clean them off accumulated sediments, debris and waste.
- To remove existing encroachments and refrain from new encroachments in the river banks.
- To utilize the open space along the river and organise socio-cultural and business activities.

## 12.3 Education and Awareness for solid waste management

### 12.3.1.1 Introduction

Management of solid wastes, an essential service and an obligatory administrative function of urban bodies, has to be given a top priority. Unscientific handling and disposal affects the environment and the health of the citizens. With continuing urban growth the situation has become critical. Low financial or human resources, institutional weakness, poor technology and public apathy towards cleanliness are often cited as the reasons for unclean cities. The Segregated

Solid Waste Management Scheme proposes to develop a scientific system of waste segregation, collection, and disposal in the city. The key to the success of solid waste management system in any city is the cooperation of the citizens. Citizens must be fully involved in proper storage, collection and safe disposal of waste and should also be made aware of health risks associated with improper solid waste management. Strategy proposed to be followed for effective implementation of public awareness programme is presented in Figure 12-1. It is proposed that the public awareness activities should continue for a period of three years unless the objective is achieved before that time.

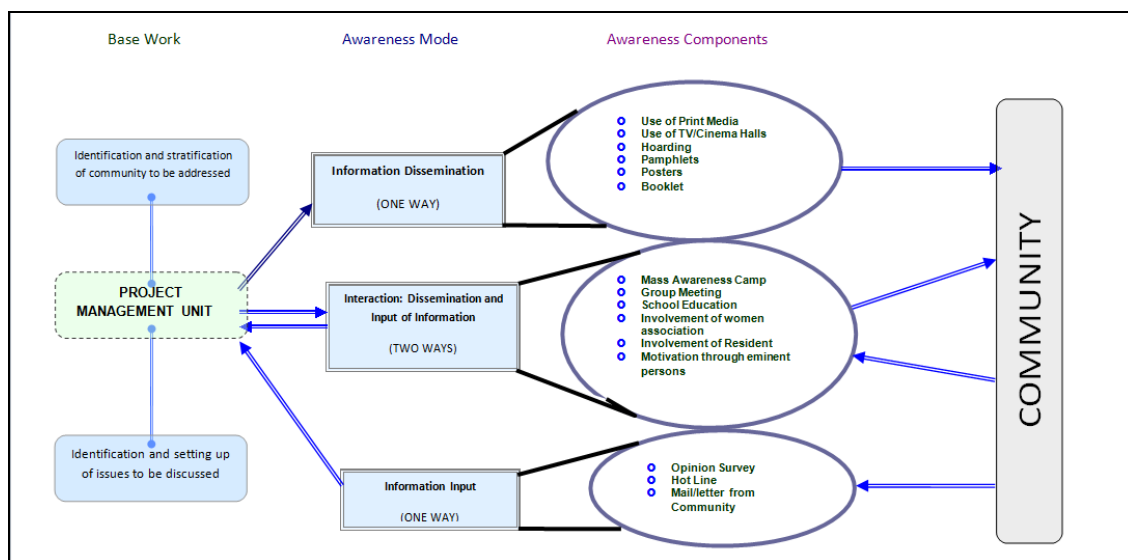


Figure 12-1 Strategy of awareness programme against solid waste dumping

There is no system of primary collection from doorstep of MSW as per MSW rules 2000. There was no awareness programmes have been conducted in the past for sanitation improvement or for waste segregation. Thus, making proper reduced, segregated waste collection, there is a great need of public awareness and their involvement. Along with this, the Municipal Solid waste collection, handling and processing the staff of the NMB should be trained and sensitised. For this purpose need of Information, Education & Communication (IEC) Plan and Training & Capacity Building of Nagar Palika Parishad staffs responsible for Solid Waste Management have been noticed.

The major objectives of the IEC are as follows:

- To bring attitudinal and behavioral changes about the garbage segregation and sanitation practices, among the residents of the city.
- To sensitize the residents about the benefits of source segregation and clean and green environment and Environmental improvement.
- To reduce the amount of solid waste at the source to be disposed to the landfill to get the clean, healthy and green areas.
- To sensitize and motivate the sanitary staff about their responsibilities and accountability for the sanitary work.
- To improve the garbage management in the area.
- To improve the service delivery.

- Making the scheme sustainable and improving the working conditions of the Cleaning Brigade.

### 12.3.1.2 Information, Education and Communication (IEC) Plan

The basic approach of IEC plan is to create effectiveness of the Solid Waste Management System. Its operational efficiency can be improved through Information, Education and Communication (IEC) techniques. The approach will be to emphasize on communication with target groups, local community for the implementing programme of Solid Waste Management in respective areas. IEC plan should be designed and developed in sequence of planning, intervention and evaluation for developing and managing an IEC program. This will include Baseline Data Collection, Identification and Segmentation of Target Group, Need Assessment Study, Research Intervention & Preparation of IEC Plan and Monitoring and Evaluation.

The basic approach of Information, Education and Communication Plan is to make aware the public about the need of reduction and segregation of waste from the households along with the collection system of waste to take public cooperation to make hygienic structure of the area.

Attitudinal and behavioral changes of the residents are important for the success of the segregated waste collection and its sustainability. For this purpose, communication with the residents is required through various techniques and modes.

#### Communication:

Communication Planning is an integral part of planning for sustained development. The development of human society has largely been due to its ability to communicate information and ideas with each other and to use such information and ideas for progress. First attempt would be a public campaign, which is the objective of the IEC Plan, will be launches to raise awareness about cleanliness.

#### Door to Door Campaign:

For door to door information spreading, involvement of health workers (Sanitary staff) would be easy and speedy along with the volunteers. It will also create a platform for a better communication management among public and sanitary staff. The volunteers and health workers will lead to spread the project information with the help of support material which will be helpful for providing effective information along with time saving.

#### Public Address Meeting:

Interpersonal and community meeting is a great tool to share the information, views and direct interaction for the effective involvement and awareness among the residents. The message and information and people commitment can be taken for the segregation and better management for the Segregated Solid Waste Management Scheme. Some workshop and seminars will also lead to inform the stakeholders at a time with proper preparation and communication and their participation and cooperation for sanitary improvement.

#### Media Support:

## Education and Public Awareness Schemes

Media support is essential and a very important part of IEC programme to inform, educate and aware the masses. Media support includes the use of television, radio, print media and folk theatre therefore, accords priority for the promotion of non-formal sanitary improvement education and creation of awareness among all sections of the society through diverse activities using traditional and modern media of communication. The media should be informed and involved for each programme which would be conducting according to the IEC plan.

### Folk Programme:

Street play which is an important tool for creating entertained information, education and basically aware the lower income group and lower middle income group residents. The street play theme should be to the point on the IEC plan and in local point of view to realize the residents as of their part. Mass media should also be encouraged for their support in public awareness program.

### Social Mobilization:

For the social mobilization, attitudinal and behavioral changes of the residents' involvement of major and social stakeholder is essential. For this purpose institutional and other organizations involved in social activities be a great awareness center for the social mobilization and public awareness as indicated below:

- Educational Institutions (Schools and Colleges etc.)
- NGOs/ CBOs/ Societies Support
- Sr. Officials/ Administration Officers / Sr. Citizens
- Ministerial Supports etc.

### 12.3.1.3 Identification and Action

Identification and selection of target groups plays a key role in creating effective awareness in residential. For solid waste management, it becomes more important as the source of MSW starts from houses due to which target starts from household female head, youths and children who requires some form of role model or different methods to influence their behaviour. It is a very important aspect which could be at waste generators level and may reduce, reuse and recycle their waste. The other part of target groups may be waste collector and waste managers. These types of target groups are directly involved with the solid waste management. Along with this, there are other groups which can be helpful for the better management of MSW segregated waste collection, operation, handling and proper disposal. The major target groups are as following:

Sr. No.	Target Groups	Target Group Details	Action Plan
---------	---------------	----------------------	-------------

1	Waste Generator	Residential Areas (Women (household), Maids, children and Youths) Commercial Areas (Shopping areas, Vegetable markets, Offices, Hotels, Restaurants) Institutional Areas (Jr. High Schools, Colleges)	Holding locality-wise meetings, seminars, targeted community meetings with self help groups, through street plays, technical and pictorial presentation along with aware them about health hazards and remedial measures and sanitation improvement. Informing and suggesting them about the segregated waste management and their important role.
2	Waste Collector	Sweepers Rag pickers Waste loaders Truck drivers Landfill supervisors	They all should be involved and sensitise about the need of segregated waste collection and sanitation improvement. The waste collection, transportation and disposal of the waste in proper timing so that waste could not be overflow. The waste collector should be trained about the collection of segregated waste.
3	Waste Managers	Administrators and supervisors Control and monitoring team Complaint handlers Computer software operators and specialists	Presenting them about the Rules and Regulation and updating them about the ongoing activities and techniques for MSW management. Training programmes for the technical staffs Providing the reviews of progress and monitoring activities
4.	Leaders	Political Leaders (Local MLA, MP) Religious Leaders Community Leaders	These leaders can be motivated to participate actively in promotional efforts of community involvement in segregated solid waste management.
5.	School Teachers and Students	Primary Schools Jr. High Schools Public Schools	School teachers can be informed and involved in the segregated solid waste management scheme and can be motivated to educate the children for the sanitary improvement. The students can be educated and trained for the segregated waste management system and they can be great awareness creators for the societies. Some groups of students can be created as monitoring and awareness team for sanitation improvement which will make a great impact on societies and communities.
6.	Media	Print Media Electronic Media	Launching mass campaign for educating and motivating local communities and families about the need of segregation of Solid Waste and its management for sanitation and hygienic improvement.
7.	Elite groups or social	NGOs, Societies CBOs	Sensitise and motivate local influential people like Sr. citizens, leading businessmen, social club

	organizations	Sr. citizens Association Rotary Clubs/ Lions Club	members, NGOs and CBOs etc. to undertake or sponsor such activities for solid waste management for effective strategy of public participation and awareness.
--	---------------	--	--

Once the target groups have been identified, the responsibility lies in developing the approach for educating these groups. For successful implementation of any program involving public at large, it is essential to spell out clearly and make them know the manner in which the problem is proposed to be tackled to keep area clean and improve the quality of life. The communication material should be developed and must be utilized in public awareness program through the tools of publicity. The use of various publicity tools as public address meetings, workshops, School Activities, Street Plays, Distribution of Handbills, Pamphlets and Handbills etc. can be used.

#### 12.3.1.4 Training and Capacity Building of ULBs for MSW management

For creating effectiveness of the Solid Waste Management System and its operational efficiency of sanitary staff of NMB is a great need of training & capacity Building programme is required. This will not only refresh their knowledge but also there would be a substantial and essential attitude changes. They should be motivated as well as improving their accountability and responsibility of the sanitary tasks. The following task may be taken in to consideration while making training and capacity building plan:

- There should also be a baseline data collection through questionnaire survey, discussion with the sanitary officials and Sanitary staffs which will give an impression to identify and segmentation of Target Group.
- On the basis of the findings of the study training programmes and training schedule of Health officials would be prepared and Capacity Building component, the primarily focus would be on the institutional development aspect of the study.
- It is proposed to study the existing institutional framework along with the respective roles and activities of each stakeholder. The identification of roles and activities of employees of implementing unit and stakeholder would help us to identify and develop various alternatives for the institutional framework for the sustainability of the system.
- These objectives could be achieved by a core group of trainers needs to be organized for continuous in-house training of the manpower to be deployed and other sanitation staff of NMB.
- For the success of this program, it is essential that training and orientation cause be planned for all the people involved in various activities of solid waste management at different levels.
- Well-equipped devices will be required to make these awareness campaigns/training programs successful. First of all, sufficient place/venue for conducting these programs needs to be finalized. Well-trained trainers will be required to deliver these training programs. A group of experienced trainers who have similar kind of experience in conducting the awareness campaigns/training programs should provide training to the target group on municipal solid waste management practices.
- During the training program, participants should be given questionnaires, which must be used to collect feedback from the participants. This will help to review the success of the program.

### 12.3.1.5 Awareness Schedule:

The tentative Mode of implementing Campaigns for Target generator Segment for a period of one year is detailed in the table given below:

Table : Awareness Schedule

S. No.	Activities	Implementation Period
<b>IEC Activities</b>		
1	Door to door campaign : one to one interaction (Health workers & NGO field staff)	Thrice a year
2	Public Address meetings/ workshops (Focus group meetings, corner meetings)	5 Workshops and 100 Community meetings in a year
3	School Programmes (Lectures, Essay, painting, poster, debates, quiz competitions/ Introduce projects, games and role play & Rallies through students)	70 activities in a year
4	Print Media for 10 months (Newspapers, Magazines, Flyers, etc.)	
	a) Newspaper Articles	Weekly and as per ongoing activities through Nagar Palika, media meeting etc., media meetings etc.
	b) Advertisements	Twice in year in the leading Newspaper etc.
	c) Flyers	Once per month
5	Electronic Media for 10 months (Cable/ TV channel, Radio, Cinema Slides)	
	a) Cable/TV Channel/Cinema Slides	
	News coverage	As per the activities ongoing
	Advertisements (at least 2 months)	1 month at initial and 1 month at the end continuously
6	Support Materials : (Posters, Hoardings, Banners)	Displayed continuously in each ward
7	Folk Media : (Road Show, Nukkad Nataks, Exhibitions, puppet shows, magic shows etc.)	50 plays in a year

## 12.4 Partnership for education and awareness programmes

Partnership will be developed with a number of local and national agencies to plan, implement and coordinate the education and awareness programmes. Some of the known agencies are: Centre for Environment Education, Nature's Beacon, Environ, Aaranyak,

TERI (Northeast). Local community organizations like the Mahila Samity, Rotary club, Lion's club, are also identified with a view to involve them on issues relating to protection and improvement and cleaning of the Kolong River, and its sub-drains. A massive program of environment education and awareness is imperative for saving the Klong River from further degradation.

### 12.5 Monitoring

There will be monitoring of social issues like public awareness, and public participation in the project both at the initial stage and during the course of its progress. It is mostly seen that often in projects, success depends mainly on active participation of the public as well as their awareness and compliance to the specifications set out in the project. Although initial enthusiasm by the public is noticed in many projects, at the later stage, unless sufficiently monitored, public often becomes negligent and their interest fritters away. To sustain public awareness and participation, periodic monitoring is a must and whenever necessary, awareness campaign has to be undertaken.

### 12.6 Cost Estimate

The total cost for this component is estimated at INR 300.00 lakhs for the following sub- components

1. Development of IEC materials
2. Public awareness programmes including media campaigns
3. Partnership programmes with local and national resources centers, cultural groups etc.
4. Engagement of NGOs for 3 years
5. Exposure visits for community leaders, CBO and NGO staff



## 13 Capacity Building and Training

### 13.1 Introduction

According to UNDP (2007), capacity is defined as “the ability of individuals, institutions and societies to perform functions, solve problems, and set and achieve objectives in a sustainable manner.” Following this definition, three levels of interventions are considered in terms of capacity building for river restoration in Assam in general and for the conservation of Kolong in Nagaoni, in particular. As shown in Figure 13-1 and Table 13-1 the three key levels of capacity building are environment, organisation, and individual.

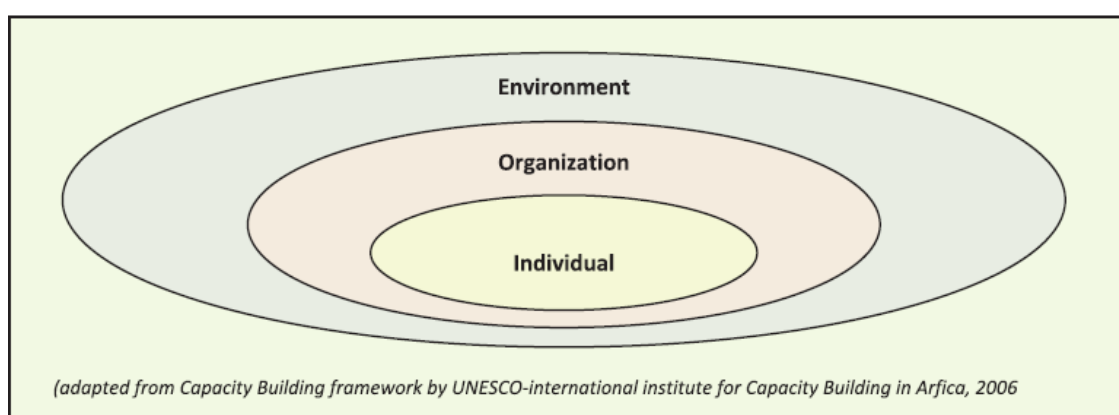


Figure 13-1 Levels of Capacity Building

the river conservation and restoration interventions required at the environmental level include legal and policy frameworks. Other environmental level factors such as economic, social, cultural, political and administrative are also important for the success of a river restoration programme. Therefore, these should be considered when designing and implementing the capacity building programmes. In this group of environmental-related factors, good governance plays a critical role.

Table 13.1 Levels of Capacity Building

Levels of Capacity	Definitions of capacity & elements on which capacity is based
Environmental level	<p><b>The environmental conditions necessary for demonstrating capacity at individual and organisational levels.</b></p> <p>This includes systems and frameworks necessary for the formation/implementation of policies &amp; strategies beyond an individual organisations. These are various dimensions of the environment, such as allocation of tasks to different organisations, administrative, legal, technological, political, economic, social and cultural, that impinge on the effectiveness and sustainability of capacity building efforts.</p>

Organizational level	<p><b>It refers to anything that will influence an organisation's performance.</b></p> <p>It includes: human resources (capacities of individuals in the organisation); physical resources (for example, facilities, equipment and materials) and capital; intellectual resources, management, process management (for example, problem solving skills, decision-making process and communications.); inter-institutional linkages (for example network and partnership); incentive and reward systems; organisational culture and leadership.</p>
Individual	<p><b>(or Human Resources Development) Level. The will and ability of an individual to set objectives and achieve them using one's knowledge and skills.</b></p> <p>Individual capacity building is also referred to as human resources development. It includes knowledge, skills, values, attitude and health, and awareness. It can be developed through various ways such as formal, non-formal and/or informal education, training and on-the-job-training.</p>

During the DPR preparation, two broad principles of capacity building were considered: i) emphasizing the ownership by organisations; and ii) recognising capacity building as a long-term process.

## 13.2 Institutional Arrangement

Many times there is an overlap in the roles of several bodies with the result that the efficiency with which the function should be performed suffers. The state Government needs to resolve such overlaps. The role of each institution involved needs to be very clearly specified. As the Kolong River flows through diverse landscape, catering to various needs, multiple agencies can be having different roles in its management. That is why, an umbrella organization with core overall responsibility coordinating with all such bodies listed below will be necessary to avoid overlap or any conflict of interest.

- Pollution Control Board of Assam
- Nagaon Municipal Board
- Public Health Engineering Department, Assam
- Town and Country Planning Department, Assam
- Water Resources Department, Assam

The institutions that are involved in the conservation programme of the Kolong River and the towns on its bank suffer from certain weaknesses that need to be overcome. Major among them are:

- Lack of adequate and trained manpower
- Lack of sufficient technical knowledge and awareness
- Lack of decision making capacity
- Lack of tools and utilities
- Lack of coordination between concerned departments
- Absence of an established institutional mechanism

It is expected that with the formation of a dedicated agency with adequate devolution of power, most of the above shortcomings can be addressed.

### 13.2.1 Project management Unit

For the implementation of the project, a Project Management Unit (PMU) will be established under PCBA, which will take care of funds related to the project and manage the planning and implementation of the project. PMU will ensure a clear allocation of funds for the management of the activities related to the project and will orient the internal organization towards an integrated functioning of the project. Such board form of management will ensure a clear cut budget and allocation of expenditures, allows better management of tasks and integrated planning, execution and maintenance of the project. PMU will also coordinate with all the departments connected with the project and the general stakeholders. PMU will be supported by a Project Management Consultant (PMC) during the project implementation period. Capacity building needs of PMU include, but not limited to the following:

- **Administrative:** Administrative capacity building would focus on strengthening of administrative functioning of the project and also to ensure accountability and transparency.
- **Legal:** Legal capacity building initiative would include adherence to all regulations pertaining to river water pollution.
- **Project management:** For the Successful project management, manpower skills would be enhanced through sufficient and relevant training, and sufficient physical and financial resources would be generated during the course of the project to deal with all the aspects mentioned above in all the phases of the project.
- **Human resources:** Human resources are increasingly recognized as a key asset of any successful and visionary project plan. Poorly trained human resources leads to poor performance and functioning of the project and will lead to ill management and poor quality in performance. Human Resources Development will deal with appropriate skill development in the organizations involved in the planning, design and management of the project. The main activities are listed below.

### 13.3 Capacity Building Framework

Figure 13.2 presents a capacity building framework used for designing and implementing capacity building programmes.

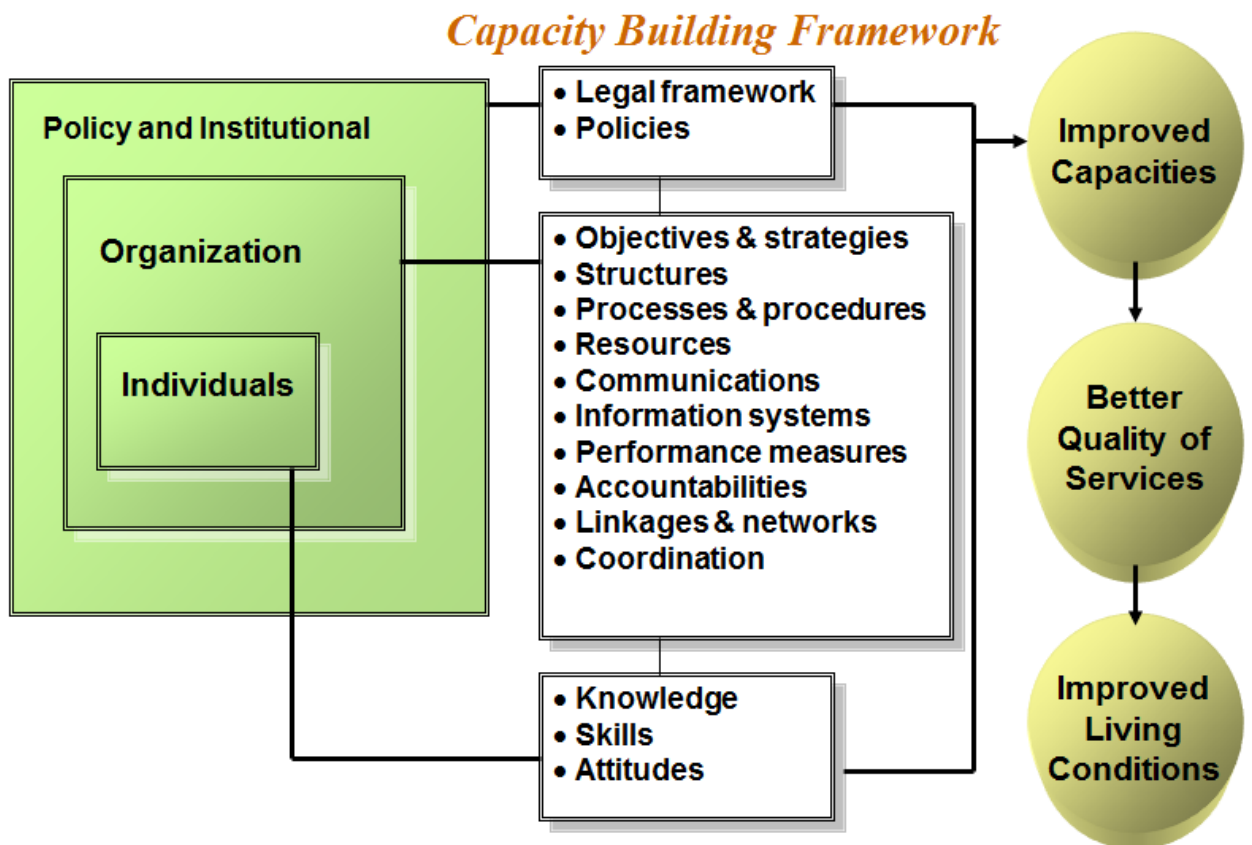


Figure 13-2 Capacity building framework

## 13.4 Training needs Assessment

Human resources and related training needs are different for different fields. For example, for a sewerage system, there is the necessity of identifying the manpower training needs in managing the sewerage plants, power stations, in monitoring water quality and maintenance of equipment. Skilled manpower is needed, particularly for maintenance of developed works, equipment and manning of the sewerage and pumping stations. For the handling of various instruments, special training is needed as good handling of the machine increases their lifespan; moreover, regular wear and tear of the machinery can be rectified and repaired by the project manpower if they are trained appropriately. This will go a long way in reducing unnecessary overhead costs.

Presently, different organizations viz. PHED, AUWS&SB and NMB are responsible in different areas of Nagaon city for the issues related to Sewerage. Though most of the employees of the existing organizations are qualified by education required for the O & M of the Sewerage system, they are not trained to handle and properly operate and maintain, the latest equipment of drain cleaning. They are not aware of preventive maintenance, resulting in reoccurrence of flooding in same place during monsoon. Training on Concept of separate sewerage system and its merits and demerits is required.

Recruitment of trained engineering personnel for management of sewerage works is an important issue confronting the organizations in Assam. Special efforts to impart in-service training or continuing professional education should go along with employment of such personnel. In view of the rapidly changing pace of technology, engineers need to get

## Capacity Building and Training

updated periodically about newly incorporated instruments and technologies through training and workshops. Enhancement of knowledge, both operational and theoretical will help in running such services smoothly.

Training employees at different levels is recognized as an essential aspect in any public utility agency. However, training cannot end with just one course. To be effective, it has to be a continuous process. In Nagaon, due to lack of sufficient training of field staff, maintenance personnel and engineers, public utility systems like the NMB do not function satisfactorily. It is therefore necessary to provide intensive training to the operation staff which may include:

- Dealing with public and stakeholders
- Importance of proper and efficient sewerage
- Importance of proper and efficient sewerage system
- Advanced training of handling instruments and other accessories required for maintenance work
- Training on maintenance of instruments and works
- Emergency restoration work after flooding and choking of drains
- Efficiency in record keeping
- others

The outcome of the training will include

- Increased efficiency with advanced knowledge
- Organizational uplifting including economics
- Improvement in quality of Sewerage system;
- Improved public relations; and
- Improved public health conditions due to superior quality and efficient maintenance by trained O & M staff

The following training needs have been identified for the operational staff

- Basic principle of Sewerage, catchment areas, runoff etc.
- Basic Knowledge in the working of Sewerage cleaning equipments.
- Reasons of blockage of drains
- Reasons of Flooding & Flood mitigation methods
- Preventive maintenance of electrical and mechanical equipment
- Attending to minor repairs, major repairs – procedure to be followed
- Log books – maintenance & upkeep of records
- Importance of keeping good health and hygiene
- Management crises in the operation & Maintenance

Local agencies are capable for providing technical training for operational staff. Some of them are:

- Industrial Institute of Technology, Guwahati – This organization can conduct training for field staff
- Government Engineering College, Guwahati conduct can short term courses for Sewerage
- Institution of Engineers (India), Guwahati Center, can also conduct training course for O & M for field staff
- The Indian Institute of Technology, Guwahati
- State Resource Centre, Department of Public Health and Engineering, Guwahati
- Staff College

These Institutions, which have an interest in the subject, may be asked to develop training modules required for specific needs of the project. They should be involved on a long-term basis so that they develop expertise in all the aspects of this programme. They should be involved in various aspects and activities of the programme.

## 13.5 Training Programmes

Code	Training module	Organisations	Staff
T-1	Concepts and advances in river restoration and conservation	PCBA, NMB, MOEF	Senior administrative officials
T-2	Effluent monitoring & management (enforcement)	PCBA, PHED	Senior technical and managerial staff
T-3	Operation and maintenance of STPs, Pumps	PCBA, NMB, PHED	Technical operational staff
T-4	Maintenance of sewerage network including structures	PCBA, NMB	Technical operational staff
T-4	River monitoring and operation of water augmentation structures	WRD, PCBA	Technical staff
T-5	Maintenance of river front works	PCBA, private sector	Managerial and maintenance staff
T-6	Public awareness and educational programmes	PCBA, NMB, NOGs, civil society members	All levels
T-7	Solid waste management	Handlers of solid waste (Sweepers, collectors, loaders, drivers etc.)	All levels
T-8	Project Management	PCBA, GMDA, GMC	Administrative and managerial officials
T-9	Exposure, knowledge	PCBA, NMB	Attending national & international

## Capacity Building and Training

	enhancement		seminars & conferences
--	-------------	--	------------------------

The above training programmes will be conducted in Assam, India and abroad.

### 13.6 Cost Estimate

Code	Training module	No. of training (one week duration)	Training venue	No of trainees in one batch	Total Cost (lakhs)
T-1	Concepts and advances in river restoration and conservation	2	Thailand, Singapore	6	20.00
T-2	Effluent monitoring & management (enforcement)	2	India/ NEERI	6	10.00
T-3	Operation and maintenance of STPs, Pumps	1	Europe	6	5.00
T-4	Maintenance of sewerage network including structures	2	Guwahati (IIT, AEC)	10	8.00
T-4	River monitoring and operation of water augmentation structures	1	Europe	6	22.00
T-5	Maintenance of river front works	2	Guwahati	10	5.00
T-6	Public awareness and educational programmes	2	Guwahati	10	5.00
T-7	Solid waste management	6	Nagaon	25	10.00
T-8	Project Management	2	Guwahati (Staff college)	6	10.00
T-9	Exposure (seminars & conferences)	2 (national)		6	25.00

		2 (int'l)			
	Total				120.00

## 14 Project Implementation Plan

### 14.1 Project Management Unit

The Kolong River Conservation project will be implemented by Project Management Unit (PMU) to be established at PCBA in Nagaon immediately after the DPR is approved. PMU will be headed by a Project Director appointed by the Government of Assam. The Project Director will be assisted by other officers and staff deputed to PMU by PCBA. One of the key staff will be an Accounts Manager. Additional support staff will be hired from the project budget for the duration of the project, which is planned to be of 42 months. The first six months will be used for preparation of detailed designs, fine tuning of the conservation schemes, further consultation with stakeholders, site fixing, preparation of tender documents, obtaining required government approvals etc. Some of the planned capacity building activities will also take place from the beginning. The implementation of the conservation schemes will be completed in 3 years. The estimated cost of the Project Management Unit is given below.

Table 14.1 Cost estimate for the Project Management Unit

S.No.	Item	Qty	Unit	Rate	Amount
1	Office Rent in Nagaon	42	month	25000	10,50,000
1	Office furniture	1	LS	1000000	10,00,000
2	Computers & peripherals	1	LS	1000000	10,00,000
3	Vehicles	3	nos	1200000	36,00,000
4	local transportation	42	month	20000	8,40,000
5	Support staff	294	manmonths	40000	1,17,60,000
6	Review committee meetings	10	nos	10000	1,00,000
7	Travel of officers	10	trips	100000	10,00,000
8	Seminars and conferences	6	LS	500000	30,00,000
9	Communication	42	month	15000	6,30,000
10	office maintenance, supplies, operation, utilities	42	month	100000	42,00,000
11	Sub Total				2,71,30,000
12	Contingencies			5%	13,56,500
13	<b>GRAND TOTAL</b>				2,84,86,500

### 14.2 Project Management Consultancy

The PMU will be supported by a Project Management Consultancy (PMC) in all its activities related to the implementation of the Project. The work of PMC is expected to commence from the beginning of the 42 months period. Activities of PMC will include, among others, Fine tuning of the plans and designs, detailed investigation required for

some engineering conservation measures, preparation of engineering designs and specifications for construction, preparation of tender documents, assisting PMU in pre-qualification and selection of contractors and suppliers for various project components, check invoices and process payments, assist in management of accounts and assisting PMU in all other activities as required. PMC will be responsible for quality control of all works and will ensure timely completion of the project. PMC will also include the provision of expert services international and national experts for setting up the river monitoring and warning system.

The PMC will be headed by a Project Manager/Team leader supported by adequate number of staff.

### 14.3 Review and approvals

The Government of Assam will appoint a project committee to review and approve various documents, designs and tenders. The Project Director will be the member Secretary of the committee.

### 14.4 Monitoring and Evaluation

Periodic monitoring and evaluation will be carried out by PMU with the support of PMC, who will engage a separate team for monitoring and evaluation. The monitoring and evaluation reports will be reviewed and approved by the project committee.

### 14.5 Completion Reports

Completion reports will be prepared by PMC for all components and for the whole project for review and approval by the project committee and ultimately by the government of Assam.

### 14.6 Schemes Implementation Plan

A GNAT Chart showing implementation plan of the schemes is presented in Figure 14-1.



# Project Implementation Plan

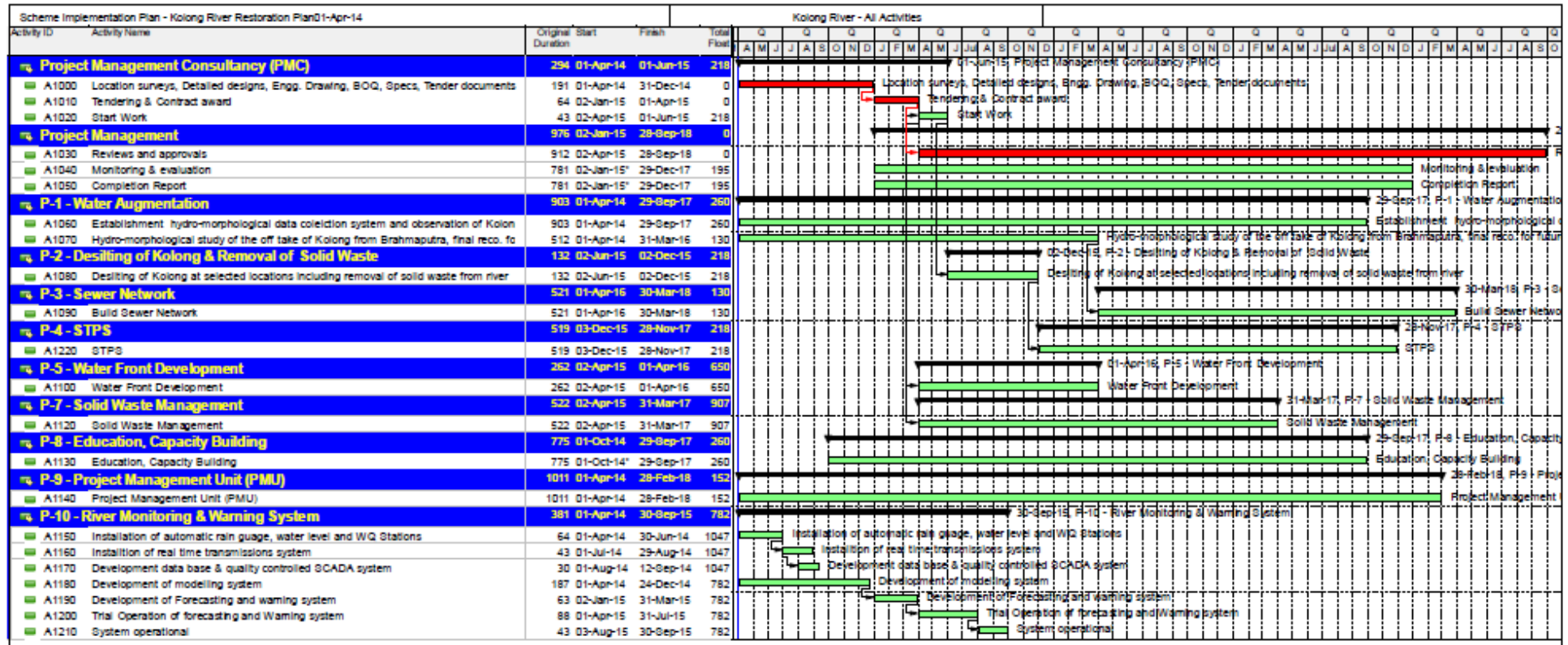


Figure 14-1 Project Implementation Plan



## 15 Cost Estimate

### Kolong DPR Summary of Cost

package No.	Package / Scheme Name	Scheme description	Estimated Cost (in crore)	% of cost
1	Water Augmentation	Linking of Kolong with Beels at Naogaona and Morigaon	24.000	8.04
2	Desilting of Kolong River	Desilting of Kolong River at selected reaches	43.859	14.70
3	Sewer Network	bla bla	89.416	29.97
4	STPS	Decentralised STPS, with standard bio reactor type compact units	47.967	16.08
5	River Environmnet Improvement	River front development, greenways and parks	47.100	15.78
6	Community sanitation and access	Development of bathing ghats, community toilets etc.	4.836	1.62
7	Solid waste management	Management solid waste directly affecting nthe Kolong River	8.499	2.85
8	Education, Capacity building	Public awareness, capacitybuilding, training, stakeholder engagement	4.235	1.42
9	Project Management Unit (PMU)	Establsihment of project management unit, operational costs, O&M for 5 years	2.849	0.95
10	River Monitoring & warning System	Establsihment & operation of a river monitoring and warning system	3.532	1.18
	Sub total		276.293	92.59
11	Project Management Consultancy (PMC)	PMC incl. detailed design, tendering, construction supervision, support to PMU, & consultants for modelling of river monitoirng and warning system @8% of total project cost	22.103	7.41
	<b>GRAND TOTAL (Crore Rs.)</b>		<b>298.396</b>	<b>100.00</b>

Package No.  
Scheme Name

P-1  
Water Augmentation

S.No.	Item	Qty	Unit	Rate	Amount
1	Links at 3 places	3	No	3,00,00,000	9,00,00,000
2	Structures	3	No	5,00,00,000	15,00,00,000
5	<b>GRAND TOTAL</b>				<b>24,00,00,000</b>

Package No.

P-2

Scheme Name

Desilting of Kolong River

S.No.	Item	Qty	Unit	Rate	Amount
1	Desilting of Kolong River for 20 km (from upstream to downstream of Nagaon), dredged material will be used in bank shaping and river front works	7,00,000	cu.m.	595	41,65,00,000
4	Removal of solid waste from banks close to Nagaon town	12	km	100000	12,00,000
5	Sub Total				41,77,00,000
6	Contingencies			5%	2,08,85,000
	<b>GRAND TOTAL</b>				<b>43,85,85,000</b>

Package No.  
Scheme Name

P-3  
Sewer network

S.No.	Item	Qty	Unit	Rate	Amount
1	Trunk Mains	32000	m	1550	4,96,00,000
2	Laterals	54600	m	9300	50,77,80,000
3	Pumping Mains	8400	m	6200	5,20,80,000
4	Pumping Stations	20	No	20,00,000.0	4,00,00,000
5	Utility Relocations	11940	m	7625	9,10,42,500
6	Subtotal				74,05,02,500
7	Contingencies			5%	3,70,25,125
	Total				77,75,27,625
11	O&M for 5 years				11,66,29,144
12	<b>Grand TOTAL</b>				<b>89,41,56,769</b>

O&M for 5 years  
@5% for each

11,66,29,144

## Cost Estimate

Package No. P-4  
 Scheme Name STPS

S.No.	Item	Qty	Unit	Rate	Amount
1	Decentralised STPs including supply of compact biporeactor units, installation, contractors' fees all complete				
	2 nos. of 5 MLD modular units	10	MLD	2,37,30,000	23,73,00,000
	1 MLD modular unit	1	MLD	2,37,30,000	2,37,30,000
	1 MLD modular unit	1	MLD	2,37,30,000	2,37,30,000
	Total				28,47,60,000
	Contingencies			5%	1,42,38,000
2	O&M costs	1	LS	18,06,75,000	18,06,75,000
15	<b>Grand TOTAL</b>				<b>47,96,73,000</b>

O&M costs @ rs. 4000/MLD/day for 5 years with escalation 2,40,90,000.00  
 18,06,75,000.00

Package No. P-5  
 Scheme Name River front Environment development

S.No.	Item	Qty	Unit	Rate	Amount
1	12 km walkway on both sides (green way), including retaining walls and bank protection	24	km	10000000	24,00,00,000
2	Lighting (Solar)	1	Lot	2500000	25,00,000
3	Green park	1	No	50000000	5,00,00,000
4	Amitheater	1	No	100000000	10,00,00,000
5	Subtotal				39,25,00,000
6	Contingencies			5%	1,96,25,000
7	O&M cost for 5 years @ 2% of capital cost per year adjusted to escalation factor				5,88,75,000
	<b>Grand TOTAL</b>				<b>47,10,00,000</b>

Package No. P-6  
 Scheme Name Community sanitation and access

S.No.	Item	Qty	Unit	Rate	Amount
1	Community toilets	11	No	200000	22,00,000
2	Community Kiosks	6	No	100000	6,00,000
3	Repair of Crematoria (in Nagaon)	1	No	500000	5,00,000
4	New Crematoria (1 in Nagaon and 1 in Morigaon)	2	NO	1000000	20,00,000
5	repair of existing bathing ghats	3	No	5000000	1,50,00,000
6	New washing & bathing ghats	2	No	10000000	2,00,00,000
7	Subtotal				4,03,00,000
8	Contingencies			5%	20,15,000
9	O&M @2% of capital cost per year, for 5 years escalation factor adjusted				60,45,000
10	<b>Grand TOTAL</b>				<b>4,83,60,000</b>

Package No.  
Scheme Name

P-7  
Solid waste management

S.No.	Item	Qty	Unit	Rate	Amount
1	Secondary storage bins (1.1 cu.m. capacity)	63	No	28500	17,95,500
2	Transportation equipment 8( cu.m collector)	4	No	1335000	53,40,000
3	Other equipment for workers	63	set	10000	6,30,000
4	Landfill site development	1	Set	40664636	4,06,64,636
5	Subtotal				4,84,30,136
6	Contingencies			10%	48,43,014
7	Contractor's fees			10%	48,43,014
8	Contractor's tax			10%	48,43,014
9	Total				6,29,59,177
10	O&M costs for 3 years (during project duration only)				2,20,32,540
11	Grand TOTAL				<b>8,49,91,717</b>

**O&M Costs per year**

1	Collection & Transport system	Qty	Unit	Rate	Amount
	maintenance of containers	63	No	1425	89775
	Cost of drivers	48	mon	8000	384000
	loaders	96	mon	5000	480000
	fuel etc (3 trips, 50 km each)	45000	Lit	60	2700000
	maintenance (5%)	4	no	66750	267000
	Sub total				3831000
2	Landfill site O&M				
	Professions staff (chemist, manager) 2 nos	24	mon	12000	288000
	Assiatnts, helpers (3 nos	36	mon	5000	180000
	Drivers 2 nos	24	mon	6000	144000
	Chemicals	12	mon	3000	36000
	Elctricity	12	mon	3500	42000
	fuel etc	12	mon	12000	144000
	Daily Cover (@214 cu.m./mon)	2568	co.m.	90	231120
	Sub total				1065120
	Total O&M for 1 years				48,96,120
	For 3 years (incl. escalation)				2,20,32,540

MNB will take up full ownership aftre 3 years

Package No.  
Scheme Name

P-8  
Education, Capacity building

S.No.	Item	Qty	Unit	Rate	Amount
1	Development IEC materials	1	LS	2500000	25,00,000
2	Training of PCBA, GMC, GMDA and other stakeholders	1	LS	1,20,00,000	1,20,00,000
3	Public awareness programs, including media campaigns	3	Years	2500000	75,00,000
4	Partnership with local and national resource centers, cultural groups etc	3	Years	2500000	75,00,000
5	NGO staff for 3 years	3	Years	2500000	75,00,000
6	Exposure visits for community leaders, CBO and NGO staff	3	yaers	500000	15,00,000
7	Subtotal				3,85,00,000
7	Contingencies			10%	38,50,000
8	<b>GRAND Total</b>				<b>4,23,50,000</b>

## Cost Estimate

Package No.

P-9

Scheme Name

Project Management Unit (PMU)

S.No.	Item	Qty	Unit	Rate	Amount
1	Office Rent in Nagaon	42	month	25000	10,50,000
1	Office furniture	1	LS	1000000	10,00,000
2	Computers & peripherals	1	LS	1000000	10,00,000
3	Vehicles	3	nos	1200000	36,00,000
4	local transportation	42	month	20000	8,40,000
5	Support staff	294	manmonths	40000	1,17,60,000
6	Review committee meetings	10	nos	10000	1,00,000
7	Travel of officers	10	trips	100000	10,00,000
8	Seminars and conferences	6	LS	500000	30,00,000
9	Communication	42	month	15000	6,30,000
10	office maintenace, supplies, operation, utilities	42	month	100000	42,00,000
11	Sub Total				2,71,30,000
12	Contingencies			5%	13,56,500
13	<b>GRAND TOTAL</b>				<b>2,84,86,500</b>

Package No.  
Scheme Name

P-10  
River Monitoring & warning System

SI No.	Item	QTY	Unit	Unit Cost (INR)	Total Cost (INR)
1	Automatic Rainfall Station	5	No	1,50,000	7,50,000
2	Automatic River WL Station	1	No	3,00,000	3,00,000
3	Water Quality Stations (excluding BOD)	3	No	8,50,000	25,50,000
	<b>SubTotal</b>				36,00,000
5	Transport, Transit Insurance, Installation	1	Lot	20%	7,20,000
6	Establishment of gauge- discharge station	1	No	2,50,000	2,50,000
7	Current meter and related accessories	1	Lot	1,00,000	1,00,000
8	Database Server	1	No	5,00,000	5,00,000
9	High End Desk Tops	5	No	80,000	4,00,000
10	Display (Plazma 51")	4	No	1,00,000	4,00,000
11	SCADA & data base software	1	No	12,00,000	12,00,000
12	Data integration and modelling software	1	No	50,00,000	50,00,000
13	<b>SubTotal</b>				1,21,70,000
16	Contingencies			5%	6,08,500
17	<b>subtotal</b>				1,27,78,500
18	<b>O&amp;M for 5 years</b>				2,25,45,000
	<b>TOTAL</b>				<b>3,53,23,500</b>
19	Consultancy for implementation of the monitoring, modelling and warning system - included in the PMC cost				

#### O&M of the monitoring system

For one year

1	BOD Sampling and lab testing 3 stations, 52 weeks	156	No	1000	156000
2	Other water quality parameters sampling & lab testing (monthly)	36	No	10000	360000
3	Cost of mobile network use	9	No	10000	90000
4	Annual maintenance cost	1	years	10%	360000
5	Flow measurement (weekly) at the G-D station - to be outsourced to hydrologists	52	week	20000	1040000
6	Maintenance of hardware and software at the SCADA Center	1	LS	1000000	1000000
7	Total for one year				30,06,000
8	Total for 5 years (incl. escalation)				2,25,45,000

## 16 Financial and Economic Analysis

Being Carried Out



## 17 References

1. Municipal Solid Waste (Management and Handling) Rules, 2000.
2. Census of India 1991 data.
3. Census of India 2001 data.
4. Census of India 2011 data.
5. Ministry of Minority Affairs Government of India (20xx) "Baseline Survey of Minority Concentrated Districts, District Report, Nagaon", Prepared by Omeo Kumar Das Institute of Social Change and Development: Guwahati.
6. Department of Environment & Forest, Government of Assam (2012) "Assam State Plan on Climate Change, 2012-2017". 101 pages.
7. Pollution Control Board, Assam (1993) "A report on Polluted river stretches in India: The Kalong system along Nagaon town, Assam. May – June, 1993", Prepared by Pollution Control Board Assam for Central Pollution Control Board, June 1993. 87 pages.
8. Pollution Control Board, Assam (2010) "DPR for Restoration and Conservation of the Kolong River, Assam", Prepared by Centre for the Environment, Indian Institute of Technology, Guwahati, October 2010. 207 pages.
9. Pollution Control Board, Assam (2013) Personal communication, Water quality data for Kolong in the period 2008-2013.
10. Khan, I.I. and Arup, K.H. (2012) "Study of some water quality parameters of Kolong riverine system of Nagaon, India". The Clarion Volume 1 Number 2, pp 121-129.
11. Nagaon Official Website: <http://nagaon.nic.in/econ.html>.
12. Department of Animal Husbandry and Veterinary, Nagaon official website: <http://www.nagaonvety.org/>.
13. NRCD (Ministry of Environment & Forests, National River Conservation Directorate, New Delhi). 2010. Guidelines for Preparation of Project Reports under National River Conservation Plan and National Ganga River Basin Authority. Prepared by Alternate Hydro Energy Centre, Indian Institute of Technology (December 2010).
14. PCBA, City Sanitation Plan (CSP), Louis Berger Inc. and DHI (India) Water & Environment, December 2013.
15. PCBA, Project Feasibility Report (PFR) for Sewerage Scheme, Louis Berger Inc. and DHI (India) Water & Environment, December 2013.
16. UNDP, May 2007: Capacity Assessment methodology User's Guide.

## Annex -1: Water Quality Test Reports

Annex- 2: Maps

## Annex- 2: Maps

## Annex- 3: Drawings

(Presented in a separate Volume)

## Annex- 4: Detailed Calculation of Dredging

## Annex- 5: International and National Best Practices