Environmental Impact Assessment

Project Number: 50165-002
May 2017

Bhutan: Amochhu Land Development and Township Project

Draft Report (Appendixes 1-15)

Prepared by Construction Development Corporation Limited, Royal Government of Bhutan for the Asian Development Bank.

Environmental Impact Assessment (EIA) Report

For

Amochhu Land Development and Township Project (ALDTP), Phuentsholing, Bhutan

MAY 2017

CONSTRUCTION DEVELOPMENT CORPORATION LIMITED, BHUTAN

Appendix 1:
Terms of Reference

TERMS OF REFERENCE (TOR)
FOR
CONDUCTING ENVIRONMENTAL IMPACT ASSESSMENT (EIA) FOR AMOCHU LAND RECLAMATION AND TOWNSHIP (ALRP)

The Environmental Assessment Report (EA) should cover the following aspects/ details:

1. **Title Page:** The name and location of the ALRP, the name of the proponent, the name, qualification and address of the company

2. **Table of Contents:** the title and page number of all sections, maps, plans, tables, figures, and appendices of the environmental assessment report

3. **Terms or Reference (TOR):** Attached a copy of the NEC Secretariat's approved terms of reference;

4. **Summary:** A brief description of the ALRP in clear, non-technical language including, but not limited to the following:

   a. The name and location of the ALRP and the total area of the ALRP
   b. A summary of all the ALRP-allied activities (approach road, labour camps, dump-sites, sewerage treatment plant, water supply system, storm water drainage and etc.)
   c. An alternatives to the ALRP
   d. Potential environmental impacts of the ALRP
   e. Environmental Management Plan
   f. Executive summary of the ALRP, which summarizes the characteristics, environmental and social issues, and the proposed mitigation measures;
   g. Information about the proponent with following details (a) Name of the ALRP (b) Name of the applicant (c) Present mailing address including telephone number, fax, and email (if any) (d) Name of the environmental focal person (e) Telephone number of focal person;
   h. The justification for the ALRP and consideration of alternative site with reference to environment and social concerns.
   i. ALRP financial statement and the ALRP activity schedule.
   j. Justification of the ALRP highlighting its benefits to surrounding areas and for the economic development of the country as a whole;
   k. Name of the organization/consultant preparing the EIA report, qualifications and experience of experts involved in the EIA assessment and report preparation;

5. **Essential Maps**

   - A map specifying the location of the ALRP along with demarcation of *Dzongkhag, Geogs* where the ALRP is to be executed/ planned.

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- A map indicating the detailed land use pattern of the study area. Also, a satellite imagery of the study area with explanatory note, if large area is considered for tourism ALRP.
- A study area map of 1 Kms marking the presence of migratory corridors, water-body, and occurrence of any endangered/threatened flora and fauna species and/or plants and animals of economic/ecological importance, if applicable.
- Area map of the study area of 1 Kms indicating features such as locations of human settlements and major constructions, roads, or any polluting sources, if applicable.
- A map marking the sensitive zones in the study area, such as forests, fishing grounds, important installations, international border, protected area etc.
- A contour map of the study area with appropriate scale.
- A map clearly delineating the locations of various monitoring stations (ambient air and meteorology, water, noise and soil).
- Coordinates of the ALRP to be demarcated on the topographical sheet.
- The layout plan of the ALRP showing the residential, commercial and administrative area, green belt plan, green space, roads, sewage disposal facilities, and waste disposal communication facilities parking spaces and other infrastructure and urban services including all utilities.
- Diagrammatic sketch and layout of the effluent treatment plant (ETP), waste disposal site and the sewage treatment plant (STP), storm water drainage wherever applicable.

6. Project description

A detailed description and analysis of the nature and location of the ALRP including;

a) *Justification for selecting the proposed location of ALRP*
b) *Details on strategy being followed for development of ALRP*
c) *Type, size, and proposed use of the ALRP*
d) *Objectives and anticipated benefits of the ALRP*
e) *A description of the physical characteristics of the ALRP and its surroundings including the following;*

- Provide the following details, wherever it is applicable (a) Total site area (b) Total built up area (provide area details) (c) Connectivity to the city, utilities and transportation networks and community facilities (d) Area earmarked for peripheral greenbelt and green space with explanatory notes.
- Details of water bodies such as lakes, ponds, springs, streams, natural drains and rivers in the study area and their distances from the ALRP site.
- The boundaries of the nearest human settlement and its distance from the ALRP site.
- Presence of any other existing industries/mines/any other project or proposed industries/mines/hydropower/any other project in the study area, and their details and distances from the ALRP site etc.

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- The flood plain boundary and floodability of the area: The EA should prepare flood hazard zonation mapping indicating flood occurrence frequency, *if applicable.*
- Provide details, if any low lying areas are getting modified from the proposed activity, if applicable.
- Presence of sensitive areas (if any) such as forests, national parks, historical or archaeological sites, residential areas, parks or playing fields, tourist resorts etc. in the study area and their distances from the ALRP site.
- Account of loss of existing houses, infrastructure and cultural or heritage sites, if any (*Refer to Table 1*).

Table 1: Loss and disturbance to existing services, houses, infrastructure and cultural and heritage sites

Type of Loss	(No.)	Description of disturbance
Services (list)		
Houses		
Infrastructure		
Cultural Sites		Distance in m from disturbance
Heritage Sites		Distance in m from disturbance

- Details on the closure or diversion of existing transport routes or infrastructure leading to changes in traffic movements, if applicable.

f) *Resource requirement including;*

- Details of energy sourcing and total energy requirement: If a captive power is proposed, the EIA report should provide the following details: capacity, daily or annual fuel consumption, pollution potential and its management plan.
- Water requirement: This will include sourcing of water, quantities sourced, and daily water consumption in kilolitres per day, quantity of effluents generated, and quantity of wastewater recycled/reused and discharged.
- Quantity of construction materials, its sourcing and mode of transportation, and its impact on environment.
- Expected numbers of quarries to be opened for supply of construction materials and its impact on environment.
- Demolition works, if any, quantity of demolition waste produced and its management plan.
- Technology to be adopted, including details of equipment to be used for reclamation work (*See Table 2*).

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Table 2: Equipment that will be used by the ALRP

Type of machine	Number	Remarks

- Resources and manpower required for ALRP implementation
- Plantations: Where areas are to be replanted/planted the following information should be given: (i) size of the area (ii) number of seedlings to be planted (iii) type of species (iv) source of seedlings

g) *Provide details about ancillary facilities that may be required to support the ALRP including the following;*

- Details of infrastructure development within ALRP.
- Details of the work such as the reclamation work, hill-slope stability, urban planning and preliminary master plan including land-use pattern, commercial areas, residential areas, small-scale/ non-polluting industries, water supply system, sewerage system, drainage system, roads, footpath, walkway, parking etc
- Individual and/or common facilities for waste collection, treatment, recycling and disposal (all effluent, emission and refuse including MSW, and Hazardous wastes)
- Details on use of local building materials.
- Detailed plan of treated wastewater disposal, reuse and utilization/ management.

7. **Baseline Data Collection Methodology and Baseline Data:** Methods used for collection of data/ survey, sampling, analysis etc., sources of collection of primary data should be explained. In analysis of terrestrial as well as aquatic biota, the reference used as guidelines (Forest and Nature Conservation Act, 1995; Nature Conservation Division, Ministry of Agriculture; Forest Offices etc.) should be cited. The land use/land cover pattern of the study area should be determined through remote sensing studies, interpretation of satellite data, topographic sheets coupled with ground truthing.

A minimum of two season baseline data which satisfactorily represent four seasons of the following parameters wherever applicable:

A) Physical

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- Geological characteristic of the ALRP area
- Seismicity, tectonics and history of past earthquakes in the area
- Details of soil, slope analysis, vulnerability to subsidence/landslides, seismicity etc.
- Characteristics of topsoil, its thickness and estimates of total quantity of topsoil to be produced during land clearing. The EIA should discuss the management plan for topsoil conservation and utilization in the EMP.
- Downstream hazards (available data on floods)
- Baseline data on ambient air quality (PM10, SOx, NOx, CO) and generation of site-specific information on existing meteorological conditions such as temperature, humidity, rainfall, and wind speed, wind direction, wherever it is applicable.
- Generation of ambient noise data by considering noise-prone areas and sensitive receptors.
- The EIA report should provide an overview of the existing hydro-geological setting of the study areas, describing the aquifers, hydraulic characteristics, groundwater quality and the interaction of surface water, if applicable.
- Surface water characteristics in core and buffer areas.
- Detailed information on existing natural drainage/run-off patterns at the ALRP site and in the study area, if applicable.
- Estimation of groundwater flow in the study area, including the depth of groundwater in different seasons and aquifer characteristics, if applicable
- Information on number and distances of water-bodies such as rivers, lakes, streams, springs, wells, etc. present in core and buffer zones, if any.
- In case treated effluents are disposed off in water bodies such as rivers or natural drain, then the water characteristics of the receiving water bodies, including details of downstream competitive users, if applicable.
- If treated effluent discharged in the river, the lists of aquatic flora and fauna present in the river.

B) Biological

- Location of any protected area, National park or sanctuary in the vicinity of the ALRP, if any
- Inventorisation of terrestrial wildlife (consisting of invertebrates, amphibians, reptiles, birds and mammals)
- Endemic, threatened and endangered species including their habitat and associations
- Inventory on tress to be cut down.
- Details of forest land diverted (if applicable).
- Information on estimated quantity and quality of effluents to be generated – quality of both treated and untreated effluents: The data should include information for parameters like Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), heavy metals and toxic chemicals (if applicable).

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C) *Socio-economic and cultural*

- Details of existing socio-economic status of the study area such as population density, human population close to the ALRP, economic profiles, literacy rates, common diseases, and infrastructure facilities available in the study area (such as conditions of roads, hospitals, educational institutes, water supply and sanitation) including displacement due land acquisition, if applicable.
- Existing public infrastructure and social services available to the affected population: education, health, hygiene, communication, network, etc.
- Cultural and Heritage sites that may be affected directly or indirectly by the proposed ALRP including from its ancillary facilities.
- Details of other proposed infrastructures and projects in the study area.

8. **Alternatives to the ALRP:** A description and analysis of all feasible alternatives to the ALRP covering the following:

   a. The alternative of not undertaking the proposed ALRP (i.e. no-build alternative) in absence of any alternative
   b. Description of the ALRP alternatives
   c. Analysis of its potential environmental impacts and mitigation measures
   d. Principle differences among the feasible alternatives under consideration, particularly regarding potential environmental impacts
   e. Reasons for choosing the present ALRP alternative over other alternatives
   f. Description of the cleaner technology and environmental management taken into consideration while selecting the equipment and technology

9. **Public Consultation:** The provision of public consultation is mandatory as per Article 16 of the Environment Assessment (EA) Act 2000, and Section 31 of the Regulation for the Environmental Clearance of ALRPs 2002.

   This section should include:

   - Summary of the report on the public consultation held.
   - Evidences of public consultation held.
   - Highlight any pertinent issues.

10. **Assessment of Impacts:** Identify all positive and negative impacts during construction, operation and decommissioning of the ALRP. For negative impacts, categorize them into direct and indirect impacts. Describe each negative impact in detail. The environmental assessment report should assess (in quantitative terms, to the maximum extent practicable) impacts from all aspects of the ALRP. The assessment should include both short term and long term impacts for all the phases of the ALRP (e.g. acquisition, development, operation and decommissioning) and cumulative impacts of the ALRP.

    The impact assessment should include the following:

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A) Impacts on Land

- Change in land use
- Impact on riverbank and their stability
- Induced erosions problems, land slide and flood scenario
- Potential activities/operations likely to cause an impact on land.
- Impact of solid and hazardous waste on land.
- Impact of ALRP on the hilly terrain due to slope destabilization caused and on the low-lying areas

B) Impacts on water resources and regime

- Impact on local area hydrology and drainage pattern
- Impact of built-up areas on water percolation
- Impact of storm water on water bodies
- Impacts on water availability and quality of ground and surface water resources. If the ALRP discharges its effluents into surface water bodies such as rivers, then the impact of this discharge on the quality of the receiving medium (river) in terms of physical, chemical and biological quality
- Discuss the incremental pollution load from wastewater and sewage disposal generated from the proposed activity.
- Impact of solid and hazardous waste on water sources, if applicable.
- Impact on ground water recharge potential

C) Impacts on Ambient Air Quality

- Change in ambient air pollutants levels and ground air pollutants level due to total emissions from point, line and area sources
- If DG sets are to be used for construction power, then the impact of emissions on the vegetation and air environment
- Impact of expected increase in traffic on ambient air

D) Impacts on noise environment

- Change in ambient noise levels due to noise generated from equipment and movement of vehicles
- Impacts of noise on workers and the local community
- Impact of expected increase in traffic on noise environment

E) Impacts on Biological (Terrestrial and aquatic) environment

- Impact on fauna and flora (including aquatic species if any) due to Landuse Changes
- Impact on rare and endangered species, endemic species, and migratory path/ route of animals, if any
- Impact of fragmentation on the natural habitats (protected or otherwise), if applicable

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- Impact on the riparian vegetation and aquatic fauna
- Indicate the nature, magnitude and extent of any direct, indirect or cumulative impacts on the terrestrial flora and fauna of the protected areas if any

F) Socio-economic impacts

- Impact on the local community including demographic changes and economic status (including food, livelihood etc.)
- Impact on cultural properties
- Risk of spread of new diseases due to migration/influx of tourists and workers.
- If forest land or agricultural land are likely to be diverted, the impact on the availability of fodder, fuel, food and livelihoods
- Impact on the public utilities arising out of the utilities for the project activities.
- Beneficial impacts

G) Occupational Health and Safety

- Impact on human health, hygiene and communicable disease risks
- Impact of the immigrant labour and ALRP personal

H) Others

- Discuss the impact of increased vehicle traffic and requirements for access improvements on roads in the site development area as a result of the ALRP, considering other existing and planned developments and operations in the region including what measures will be taken to reduce traffic and enhance vehicle safety on external roads.

11. Mitigation and Environment Management Plan

A description and assessment of physical, biological and chemical measures and management techniques designed to limit negative environmental impacts, or, to cause positive environmental impacts during development and operation of the ALRP.

The EIA report should specify in detail the measures to be taken by the ALRP proponent to avoid, minimize and mitigate potential environmental impacts; anticipated implementation schedule etc. Need based mitigation measures may be in the form of Environmental Management Plans.

The EMP should discuss the mitigation measures to be taken against each impact, the timeline for completion, the responsible departments for implementation, the plan budget, post-monitoring provisions and the process of reporting to the concerned regulatory authority.

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A) Land

- Selection of suitable local plant species for greenbelt development in and around the sites.
- Details plan for green belt development as well as landscaping
- Sediment Control Plan
- Detailed management plan to reduce flood due to bank erosion.
- Top soil conservation plan and its re-utilization depending on its quality
- Mitigation plan for slope protection
- Detailed management plan for solid and hazardous wastes.

B) Water

- Water conservation within the buildings
- Rainwater harvesting to recharge the ground water
- Water conservation in landscape
- Adequate measures to be adopted for water conservation during construction and operation stage.
- Detailed mitigation measures for the augmentation of groundwater resources, if applicable

C) Air

- Mitigation measures are to be proposed during the construction stage as well as the operational stage of the project. Some measures to be listed include: -
- Mitigation measures during construction phase due to reduce the emissions during excavation, site development, loading, un-loading, transportation and storage of construction materials and excavated earth materials.
- Mitigation measures to reduce the point source emissions.
- Greenbelt development.
- Dust mitigation
- Estimate any environmental implications from transportation (rail, road) related emissions associated with the construction and operational phases and suggest suitable options
- Operation of DG sets

D) Noise

- Identification and adoption of mitigating measures for noise abatement including noise barriers for point sources and line sources as also measures to minimize effect of vibrations due to demolition, site development and while new construction

E) Biological environment

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- Mitigation measures to compensate the loss of vegetation cover / providing green belt development
- Regeneration/Restoration of rare plants of economic importance including medicinal plants species which require protection and conservation
- Identification of measures through scientific conservation plan for protection and conservation of flora, fauna including wildlife, migratory avi-fauna, rare, endemic and endangered species and medicinal plants etc.
- A detailed mitigation plan for biodiversity protection and conservation (if the ALRP is likely to impact biodiversity).

F) Others

- Muck Disposal Plan.
- Restoration and Landscaping of disturbed Areas.
- Solid Waste Management Plan for domestic waste disposal for colonies and labour camps etc.
- Details of mitigation measures for noise control, including noise abatement from equipments, operations and traffic.
- Detailed management plans to improve the road network or existing roads to meet the ALRP traffic densities, if applicable.
- Detailed mitigation measures for the augmentation of groundwater resources (if the ALRP is sourcing groundwater).
- Detailed management plan for solid wastes, including information on design, leachate collection and treatment systems.
- A water assistance plan for the local community, in case it is affected by pollution or scarcity of water resources due to the plant's operations, if applicable.
- Details of the plant storm water collection and treatment system – mitigation measures for storm water is crucial, especially if there is a river, agricultural land or a sensitive area adjoining the proposed ALRP.
- A flood management plan to protect the plant and surrounding areas, if applicable.
- A plan for emergency preparedness, if any – details of the expenditure to ensure safety and occupational health of the workers.
- The organizational set-up and requirement of manpower for environmental, health and safety management, including clear responsibilities.
- Proposed schedule for EMP implementation and environmental monitoring, including post-ALRP monitoring for air, water, soil and noise.
- Documentation of impacts that cannot be mitigated, with proper reasons.
- A summary of cost estimate for all the plans.
- Discuss the steps taken to integrate the needs of other stakeholders into the location and design of access infrastructure to reduce and manage overall environmental impacts from resource development;

G) EMP and mitigation for socio-economic impacts (if applicable)

- Preparation of a Resettlement and Rehabilitation plan (R&R), if displacement is involved. The plan should include details of the compensation provided, including

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land-for-land compensation, employment or money; provisions at the resettlement colony (such as basic amenities including housing, educational facilities, infrastructure and alternate livelihood potential); a clear timeline for implementation; responsibility; budgets; grievance mechanism, etc.

- The R&R plan should analyze and take into consideration the impact of displacement on women and vulnerable communities such as landless labourers, etc., and prepare a detailed management plan to improve their status.
- A detailed compensation package for the community likely to lose their livelihood due to diversion of forest or agricultural land.
- A detailed mitigation plan for improving and enhancing socio-economic condition in and around the quarry site and discuss the budgetary provision for the same.
- A management plan for occupational health and safety of the workers and nearby local community.
- The EMP should also discuss the provision for compensation in case damage to building and infrastructures.

12. Compliance with relevant sectoral guidelines of best practices promulgated by NEC Secretariat or Competent Authorities, if any.

13. Response to Comments: A response to Each comment received on environmental report unless the NEC Secretariat or Competent Authority, has indicated otherwise, the environment assessment report shall contain a copy of each comment either in this section or in a separate appendix, provided that this section clearly explains the location of each comment and the response to each comment.

14. Appendices: A presentation of detailed technical data to the extent necessary to keep the main text of the environmental assessment report clear and readable. The main text of the environmental impact assessment shall refer to and summarize any information contained in any appendix.

NOTE:

- *The Environmental Assessment Report is required to be prepared as per the provisions of EA Act 2000, Royal Government of Bhutan.*
- *The Proponent should maintain consistency and accuracy in the report and no subjective statements shall be accepted.*
- *The Consultant shall carry out Public Consultation as per the provisions of section 31 of the Regulation for the Environmental Clearance of quarry 2002.*
- *The Proponent shall be responsible for undertaking any other related study desired by the NEC during the process of environmental clearance*

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- *Finally, the EIA report should include all other necessary documents such as clearance from respective Dzongkhag Administration, Department of Forest, evidence of public consultation, etc.*
- *A soft copy of the report including all the annexes, maps including Google Earth images/maps, GIS data, etc. needs to be submitted along with the hard copy of the report.*

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Appendix 2:
Analysis of Alternatives

Land Reclamation v/s No Land Reclamation

Undertaking a project of this scale and magnitude only for the function of flood control leads to a very heavy investment with no return. The necessity of setting up a township is pertinent both from the need of Phuentsholing to have a place to expand into, as also recover the investments made in flood control.

Master Plan Zoning Alternatives

This Section explains why the master plan has evolved as it has and the alternatives selection it went through before it was finalized.

The River Training will make about 1146 acres of land available for development. This area will have to be planned to accommodate both, the Township Area and the Special Development Area. The demand estimate for Township Area, requires accommodation of a future population of more than the projected 48,400, as many more people are likely to come from outside or return from Jaigaon for new economic growth and opportunities generated by the township itself. In addition to this, the demand for special developments estimated will also have to be accommodated within the project area.

A set of scenarios were developed using the population estimate for township area and demand assessment for special areas. In addition to this, scenarios also included essential areas that are absolutely necessary for the project, and green areas that are crucial for the project. The main purpose of these scenarios was to develop a broad understanding about the comparative land requirement of each scenario as well as computing land availability for additional development. This helped in identifying which approach should be taken to optimize the benefits from the project.

Demand assessment was arrived at through a chronological sequence which follows various prescribed methods and norms, namely:

Step 1: Prepare scenarios to estimate residential land area required to accommodate the future population

Step 2: Estimate areas under various uses that are required to support the residential population

Step 3: Estimate area required for special development which will trigger and attract the market for development

Step 4: Estimate essential areas including natural outfalls and embankments

Step 5: Estimate green areas which will positively affect the environment

Step 6: Prepare a combined land consumption scenario where all scenarios will depict different assumptions to arrive at those scenarios

Step 7: Identify a preferred scenario which rationally holds the Master Plan together

Step 1 - Estimating Residential Areas

The first step is to estimate the residential area required to accommodate the projected population. For this, three different variables are considered, that is average unit size, average ground coverage, and building typology (e.g. low rise, high rise or mixed), as indicated in the following sub-sections.

Scenario 1

It is assumed that current trends will continue in terms of average unit sizes for various typologies, average ground coverage of 40% and the currently prevalent building typologies with 2 to 5 floors.

Scenario 2

It is assumed that the average unit size will increase by 20% in future due to economic growth and people will prefer to move out of the currently cramped units into larger units. This scenario assumes that current trends of average 40% ground coverage and currently prevalent building typologies with 2 to 5 floors will continue in future.

Scenario 3

It is assumed that the average unit size will increase by 20% in future due to economic growth. With this, it also assumes that the new developments will be better planned and will better utilize the ground coverage, increasing it from present average of 40% to about 65%.

Scenario 4

It is assumed that the average unit size will increase by 20% in future due to economic growth, and the new developments will be better planned and will better utilize the ground coverage, increasing it from average of 40% to 65%. At the same time, this scenario also assumes some new high rise building typologies with ground plus 09 floors will be added in the current mix of typologies with 2 to 5 floors. Table 9-1 summarizes the variables assumed for each of the four scenarios.

Table 9-1: Variables assumed for each scenario

SN	Variable	Scenario 1	Scenario 2	Scenario 3	Scenario 4
1	Increased Unit Size	NA	Increased by 20%	Increased by 20%	Increased by 20%
2	Increased Ground Coverage	NA	NA	NA	Increased by 65%
3	Increased Number of Floors	NA	NA	NA	Increased number of floors to 10
4	Available Land for Future Development	28 Ha	0 Ha	0 Ha	85 Ha

Based on the above assumptions, the four scenarios yield four different size of land areas for residential use, as indicated in the table Table 9-2 below.

Table 9-2: Comparisons between various scenarios (Ha)

Land-use Distribution	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Residential	170	208	132	100

Step 2 - Estimating total area for Township

Now, for the township to function as a complete town on its own, it would require the residential areas to be served and supported by various other functions and services. They would include commercial, institutional, recreational, civic amenities, mixed use, utilities and infrastructure, transportation, neighborhood parks etc. Therefore, the next step is to estimate the total area required to accommodate full set of support functions and their land uses for each of these residential area estimates Table 9-3 illustrates the land use distribution derived from various studies, used to estimate land requirements for other land uses in the township.

These studies include:

- Land use distribution in Local cities of Bhutan;
- Land use distribution in International cities;
- Land use distribution as per Notional guidelines.

Table 9-3: Concluded land use distribution after studying various cities and guidelines

S. No.	Land-use Distribution	% Distribution
1	Residential	45 %
2	Commercial	3 %
3	Mixed Use	2 %
4	Industrial	3 %
5	Institutional	8 %
6	Utilities	4 %
7	Recreational	10 %

8	Transportation	25 %

Using this land use distribution, the area estimates for the full set of major land uses are derived under each of the four scenarios. Table 9-4 also shows the total land area under development.

Table 9-4: Total land requirement for township development in various scenarios

SN	Land-use Distribution		Scenario 1	Scenario 2	Scenario 3	Scenario 4
1	Residential	45 %	170	206	132	100
2	Affordable housing		50	50	50	50
3	Commercial	3 %	11	14	9	7
4	Mixed Use (Commerce with Residential)	2 %	8	9	6	4
5	Industrial	3 %	11	14	9	7
6	Institutional, Public/ Semi-public	8 %	30	37	23	18
7	Recreational	10 %	38	46	23	22
8	Utilities	4 %	15	18	12	9
9	Transportation	25 %	94	114	73	56
10	Land occupied for development	100 %	427 Acres (172 Ha)	508 Acres (205 Ha)	343 Acres (138 Ha)	273 Acres (110 Ha)

Step 3: Estimating area under Special Development

Special development areas include various developments that are typically not part of township development, but will help generate revenue, or will influence the economy, growth and development at a larger scale. These developments may include large institutions, educational campuses, business and office parks, hotels, convention centers, biodiversity parks, golf course etc.

The area estimates provided for these developments are preliminary at these stage and will be refined upon further, more detailed assessment.

Step 4: Estimating Essential Areas

As per Master Plan River training establishes certain land requirement in Embankment and Natural outfalls, balance land should be well distributed between Township Area, Special Area, and Green area. This areas are absolutely necessary for the project to exist and function in a cohesive manner. They include areas like Natural Outfalls and Embankments.

Step 5: Estimating Green Areas

These category proposes primarily two land uses:

1. Riverfront Park - provides recreational and leisure facility along the riverfront for the citizen as well as tourists.
2. Buffer Zone - essential zone between township development and protected Kaileshwar hill, which will also protect the proposed development from landslide from the hills. This zone is extremely important as response to environment conditions.

Step 6: Preparing Combined Land Consumption Scenarios

As discussed above, the project will have to include all the above mentioned four categories of areas to be able to function in coherent manner. Below in Table 9-5 are four different land consumption scenarios, prepared by combining this four type of areas discussed in the previous steps. As discussed under Step 1, each of these scenarios reflect different assumptions explained in the scenario descriptions. These scenarios are mainly developed for comparative analysis of the amount of land areas required for various uses; and they do not represent their location choice, adjacency and inter-relationship.

Step 7: Identifying a Preferred Scenario

The four scenarios illustrated in Table 9-5 result in different development areas. For example Scenario 2, which assumes 20% increase in unit size, but continues with current low percentage (40%) of ground coverage and current low rise typologies, consumes the most amount of land area to accommodate future population. This scenario does not leave any area for future development.

Compared to this, Scenario 4 assumes 20% increase in unit size, with better planned development consuming 65%1 of ground coverage and including a large number of units in high rise building typology. This scenario will consume the least amount of area to accommodate the same future population. This scenario leaves the highest amount of area for future growth and development, and therefore is more desirable than Scenario 2. However, this scenario may be a bit too compact and a bit too far compared to the current situation.

Therefore it may be necessary to develop another - a hybrid scenario which is more rationalized than, not as compact as scenario 4, and have less number of residential units (30%) in high rise building compared to Scenario 4. Additionally it assumes a number of units in villa typology, which makes it a bit more relaxed compared with Scenario 4. This Hybrid Scenario can be called as Preferred Scenario and is illustrated in Table 9-5 in comparison with other scenarios.

The alternative selected then derives the various zoning transport and infrastructure configurations from norms//standards/professional/experience.

Technology and other options

As discussed, during project preparation, various alternatives for the project components were proposed, screened, and studied against technical, economic, social, energy efficiency and environmental criteria. The primary objective with respect to environmental criteria was to identify and adopt options with the least adverse environmental impacts and maximum environmental benefits.

The range of alternatives considered depended on the project components and sub-components and their characteristics. The “do nothing” or “no-build alternative” option is not viable as the project associated advantages of controlling the flood damages, arresting of soil erosion and loss of valuable land, and improving the overall environment of the site will not take place. The comparison of ‘No Build’ and ‘Built’ alternatives as also various technology alternatives is further detailed in Table 9-6

Table 9-5: Comparison between scenarios established and identifying the preferred scenario

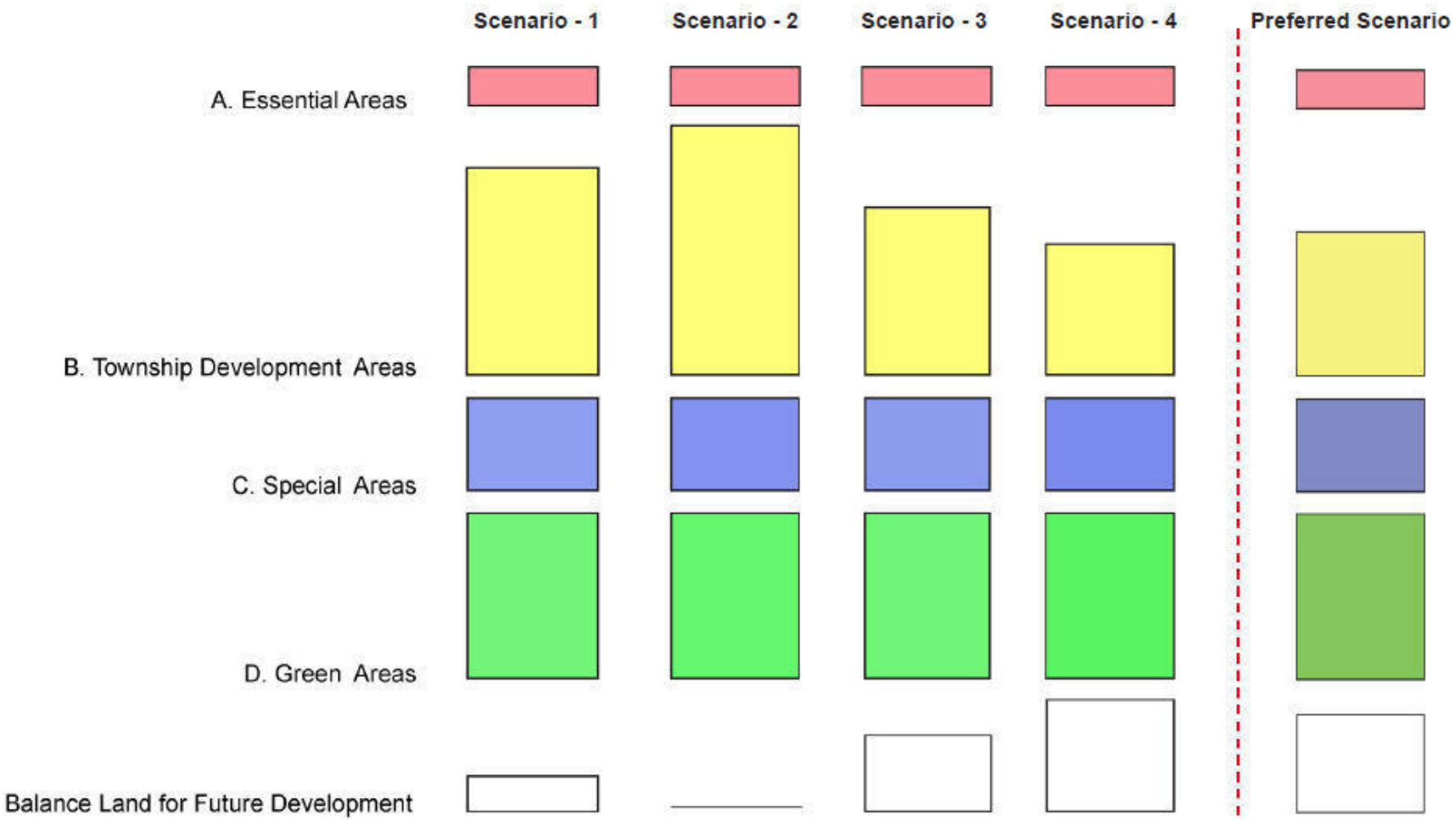


Table 9-6: The comparison of 'Without Project' and 'With Project' Scenario

Alternative	Flood Impact	Soil Erosion	Economic Impact	Social Impact	Projected Population/Housing Reclamation	Environmental Impacts
"Without Project"	Western part of Phuentsholing Town that abuts Amochhu River is vulnerable to floods especially between the months of July and September. Recently, due to the uncontrolled River flow, on July 1, 2015, seven families were left homeless, a brick factory, two excavators and three school buses were flooded. The Phuentsholing Samtse highway will be left vulnerable to floods every year. (Assessment Report on Flood at ALDTP on July 1, 2015 by DHI-INFRA).	The uncontrolled River flow is a major contributor to the loss of valuable flat land along western limit of Phuentsholing Thromde due to sedimentation and erosion. (Assessment Report on Flood at ALDTP on July 1, 2015 by DHI-INFRA).	Damage is caused to Phuentsholing town due to flood, erosion and sedimentation impacts. There is excessive load on Phuentsholing's infrastructure and housing availability. The loss of valuable land impacts the Town's overall real estate market negatively as there is no other area left for the town to expand. Amochhu has been washing away properties and valuable equipment of settlements near Amochhu.	Social Impact Assessment survey indicates that due to lack of housing, locals are moving out and living across the border in Jaigaon.	As per population projections, by 2046, about 48,392 people will need to be accommodated in Phuentsholing Town. Today, due to lack of space and high rental values, many locals live in Jaigaon. With no expansion, Phuentsholing will not be able to accommodate the growing population.	Although the Riverine conditions will remain unaffected, the eroding town's vulnerable western edge will negatively impact Phuentsholing's geomorphology.
With Project	100-year return flood has been considered for designing the embankment protection structures,	RCC diaphragm wall will be used to protect the riverbed from scour & erosion. RCC and stone	Apart from protecting the town from flood disasters and erosions, additional land will be available for building a	Social Impact Assessment survey indicates that the project would be beneficial to Phuentsholi	The proposed township is designed not only to accommodate 48,392 people but also floating population in various other land uses (commercial zones, light	The River will be trained as per Hydraulic, hydrological, geotechnical analyses and will include elements recommended by

	thus, making the proposed township resilient to floods.	retaining walls will be constructed to protect the riverbanks from erosion.	new township. Based on urban planning projections, this township will be able to accommodate approximately 48,392 people including locals who are currently living in Jaigaon. The project will provide space for expansion of economic activities of Phuentsholing and creation of new economic activities, which will benefit the entire country. All such activities will help in creating jobs for the market.	ng town, its people and country as a whole. It would solve the housing problem and will provide better infrastructure.	industrial, recreational, hospitality, educational, etc.).	landscape & environmental experts, thereby, ensuring minimal to no harm to environment.
Justification of Selection: Thus, based on the above listed criteria, the Build alternative of the Amochhu Land Reclamation & Township Project will be preferred as it will not only make the town resilient to floods, but also, provide the desperately needed land for accommodating the growing local population.						

Description of the ALDTP alternatives

Various alternates are described in Table, Table 9-8,Table 9-9,Table 9-10,Table 9-11, Table 9-12, Table 9-13 and Table 9-14

Table 9-7: Analysis of Alternatives for Location of the ALDTP project

Alternative	Cost	Socio-economic	Environmental Impacts
Project takes place at the identified location	Undertaking embankments and land reclamation works would be expensive, however, good project financial planning & phasing would help earn back project costs and sustain itself in the	Proposed project will comfortably accommodate 48,392 people thereby, relieving load from existing Phuentsholing town. To build the township, very high quantity of soil will be utilized for reclamation. However, this will make the township as well as	Developing ALDTP at the proposed location will protect Phuentsholing town from floods, bank erosion and other related disasters. Overall, environmental status shall improve, as presently the site is polluted due to riverbank stone quarrying, temporary industries, etc. Landscape and ecology of

	future.	existing Phuentsholing resilient to 100-year floods.	the area shall also improve.
Project takes place at a location other than the identified location	The issues of this site would remain unresolved	The issues of this site would remain	Due to absence of any land for development in Phuentsholing the project will not be able to be developed elsewhere
Justification of Selection: Thus, based on the above listed criteria, the alternative of locating the project at the identified location is preferred as no land is available in Phuentsholing for the proposed development.			

Table 9-8: Analysis of Alternatives for Embankment Design

Alternates	**Cost**	**Feasibility w.r.t. study area and conditions**	**Durability, Better flood protection**	**Ease of construction and maintenance**	**Cost – Construction, maintenance**	**Environmental Impact**
1. RCC retaining wall	Expensive as it would require form work, shuttering and other ancillary construction components.	Feasible	Durable, to weathering and aging	Advanced construction technology hence faster to construct	Less maintenance	Solid waste generation. Emission during transport of construction materials
2. Stone retaining wall	Stones used are locally available and so it will not be as expensive. However, it will require skilled labour, making the total cost almost same as RCC retaining wall.	Feasible	Durable, relatively less effective compare to RCC Retaining Wall	Time consuming, high maintenance	High maintenance	Locally sourced, hence less impact.
3. Natural embankment	No cost for construction, however, it will require high maintenance.	Not feasible due to nature of river and its condition during high flood Not feasible for habitable area/development	Not durable	Easier, as there is not much construction activity involved	Cleaning required for overgrown plant species, less compare to engineered alternatives	Low impact

4. Stones in wire crates with vetiver grass	This will be most expensive, as it will not only require most number of components, but also, high skill of labour.	Feasible, local material available locally	Durable, Vetiver grass strengthen the embankment to withstand high flood	Time consuming, as it requires sequence of construction of various components	High maintenance required	Low impact, material available locally
5. PCC blocks	Almost same as stones in wire crates example as the PCC blocks will require to be cast. However, PCC blocks will prevent growth of vetiver grass, thereby balancing overall cost.	Feasible	Durable	Easier to construct compare to stones in wire crates	Less maintenance compare to stones in wire crates	
6. Combination of systems – 1, 2 & 4.	Overall cost will be high as junction between different systems will have to be designed ensuring safe and robust details between different materials.	Feasible for the project condition	Durable	Easier as advance construction technology will be used		
Justification of Selection: Thus, based on the above listed criteria, combination of systems 1, 2 & 4 is selected because any one type of embankment design is not suitable at all places in the project. Different types of embankment designs are preferable at different places.						

Table 9-9: Analysis of Alternatives for Buffer Zone Creation

Name	**Cost**	**Feasibility w.r.t. study area and conditions**	**Advantages**	**Environmental Impact**	**Barrier effect**
No buffer, natural condition	The cost of repairing the damage caused by flooding due to annual precipitation from the valleys	Not feasible in the long term as it can undermine the geological stability of the proposed development.	No significant advantage.	Continuous annual erosion of the project boundary areas.	None.

	straddling the project site will be enormous and will not a sustainable option.				
With buffer	Creating buffer zones will mitigate the annual damage caused due to erosion resulting from annual precipitation. It is a sustainable option that protects the project development from the damaging effects of soil erosion and silt and boulder deposition in the site.	Creation of boundary buffer zones is feasible along the entire site boundary.	Protection of bio-diversity. Barrier zone for preventing entry of alien species. Creation of detention ponds to check the seasonal discharge from outflows. Offsetting loss of riparian habitats. Lifestyle activities such as biking and jogging trails.	Positive impacts: Offsetting and protection of bio-diversity, Sustainable erosion and sedimentation control.	Highly significant: Protection against alien species. Visual and aesthetic protection to the development. Detention ponds create a barrier to mitigate annual flooding.
Conclusion/Justification of Selection: Creating buffer zones all along the site boundary has significant ecological and environmental advantages and has been strongly incorporated in the master-planning.					

Table 9-10: Analysis of Alternatives for Landscape Design

Name	**Cost**	**Feasibility w.r.t. study area and conditions**	**Feasibility w.r.t. Project design**	**Aesthetics**	**Advantages**	**Environmental Impact**
Soil type Use existing soil at site	It is cost effective it negates the need to bring in any fresh soil from foreign burrow pits. The problem of identifying such large burrow pits and the cost of transportin g the material is	Very feasible. It is envisaged that the Top Soil available at site be reused for landscape purpose. The soil type present in the riparian plains is sandy silt deposited by the river. It is suitable for soft scape	Very feasible. The top soil volumes of the volumes present in at the site and the total requirement of top soil for the soft cape areas show parity. No additional top soil will be required for the landscape development Boulders and large pebbles	Neutral impact.	Positive. The usage of existing site resources completely within the development is ecologically sustainable. Ecological footprint will be zero.	Positive. Low carbon footprint.

	avoided.	establishment in the development. The process involves the scrapping of the topsoil to the depth of 300mm and storing in a dump heap on-site at locations that will be free of structural development. The soil heaps can be redistributed once the soft scape areas are ready. Some amendment of organic matter will help the top soil quality.	can be removed while spreading the top soil. These will be used as stone mulching and ponds and channel surfacing to prevent scouring of seasonal flooding from the valley outflows.			
Soil type Use imported soil to site	The cost transporting such huge volumes to site will be significant.	Difficult. Identifying burrow pits outside the site to excavate such huge volumes of top spoil will prove to be a formidable challenge	Feasible. Imported soil can be directly dumped in the soft cape areas.	Neutral impact	No need for creating storage soil heaps on site. Exhaust emission during the transportation will add to the carbon footprint of the project.	Negative. Large carbon footprint. Imported soil can introduce alien microbes as well as invasive species
Rock and Gravel type at site	Using locally available site materials saves cost of both cart away and the cost of import of foreign material	Very feasible. Large amount of rocks, boulders and gravel are varying sizes are available at the site. They will be used to the maximum extent possible in the project site itself.	Very feasible. Rocks and gravel form an integral part of the aesthetic elements of the hardscape. Rocks will be used for decorative walls, retaining embankments, protection against river	Important component for aesthetic landscaping	Positive. Using resources available at site fully in the project creates a sustainable solution without leaving an environmental footprint.	Positive. Low carbon footprint.

		The project envisages that rocks, boulders and gravel will be utilized fully at the site itself. Cart away of such site material is not envisaged.	scouring and as decorative elements			
Rock and Gravel type imported from external sources outside the project boundary	The cost transporting to site will be significant. Exhaust emissions for the transport will contribute to the carbon footprint	Feasible. The hardscape elements such as rocks and boulders do not occur in a wide variety in the region. Basically they are the derivatives of glacial erosion that are washed down the valleys by seasonal rain. These type of rocks which available at the site are the same available elsewhere in the region.	Feasible. In case, rocks and gravel are brought to site from distant foreign sites, then a greater variety of stones can be imported.	Accent boulders, sculptural rocks, paving stones and rip-rap rocks from important hardscape features	Import of non-local varieties of stones and rocks for the hardscape requirements will create and environmental footprint. Exhaust emission during the transportation will add to the carbon footprint of the project.	Negative. Large carbon footprint
Conclusion/Justification of Selection: Topsoil requirements will be met fully from existing soils at site. Rocks and gravel at site will be utilized for creating hardscape elements. The project envisages using the soil and hardscape materials available at site completely without need for cart away. Using the materials at site fully for development is environmentally sustainable and leaves a low carbon footprint for the development.						

Table 9-11: Analysis of Alternatives for embankment landscaping

Name	**Cost**	**Feasibility w.r.t. study area and conditions**	**Feasibility w.r.t. Project design**	**Aesthetics**	**Advantages**	**Environmental Impact**
Sloped river embankment stabilization using hardscape only	Installation cost will be high. The integrated design for the sloped embankment	Limited feasibility. There will be recurring costs whenever high flood happens and	Feasible as the site offers a large quantity of the pebbles required.	Low aesthetic appeal.	No need for daily maintenance. Inert in nature compared to soft cape.	Neutral

	for river training has concrete cells 250mm deep. These can be filled with large pebbles 350-150 mm size to prevent high flood erosion	the pebbles are displaced. Re-positioning these on both sides of the bank over a 7.5 km stretch will be a physically demanding maintenance operation.				
Sloped river embankment stabilization using Vetiver grass stabilization	Low installation cost. Nature of vetiver grass is that of very low maintenance	Feasible. The climatic zone and the physical requirements for erosion control can be met with use of Vetiver grass.	Vetiver is the only plant species that can be established in 250 mm soil depth, but have roots that can go 3mts below into interstices between the boulders in the gabion crates below.	Very high. It mimics the grassland habitats normally found alongside rivers.	Role of Vetiver grass in slope stabilization has been proven in several ADB projects. Vetiver grass has proven usage where it has shown high effectiveness in reducing the flood velocity as well as tenacious regeneration after the flood recedes. Vetiver stabilization is cost effective, aesthetically appealing and very sustainable in the long run.	Positive impact for harboring bird and animal bio-diversity. It will control the heat islands formation on the river embankments during the summer
Conclusion/Justification of Selection: Use of Vetiver grass for stabilization of the sloped embankments of the trained river is sustainable, and has a positive ecological impact. It is a better solution than having the entire embankment installed as hardscape						

Table 9-12: Analysis of Alternatives for Social/Affordable Housing plan of ALDTP

Name	**Proximity from Phuentsholing**	**Accessibility**	**Housing & transportation affordability**	**Quality of housing**
Locating within the project site	Proposed location of affordable housing component abuts existing Phuentsholing town. Thus, making it an extension of	By abutting Phuentsholing town, the affordable housing component is easily accessible to everyone using	Since these units will be part of Phuentsholing Thromde's affordable housing policy and as per housing needs assessment report,	Since this project will be built on unencumbered land using the best possible construction and building

	the existing town itself	existing road networks.	these new units will be priced at affordable rates. Since employment centers are proposed in the township, the transportation distance and cost of people living here would be minimized.	technologies, the quality of housing and infrastructure would be of highest possible standard.
Accommodating affordable housing components to existing town	Due to lack of space in existing Phuentsholing town, accommodating the additional units within it would lead to excessive loads on the infrastructure potentially leading to a disaster.	If the units are accommodated within existing Phuentsholing town they would be easiest to access.	Even though housing would be in existing Phuentsholing town, maintenance of the overloaded infrastructure would make living here expensive and unsustainable	The condition of water and drainage infrastructure of existing Phuentsholing town is already at capacity thus adding more units would potentially increase its vulnerability and worsening overall quality of housing for all.
Locating away from the project site	This would increase its proximity from existing town and negatively impacting the socioeconomics	Since Phuentsholing is already built to capacity, the affordable housing units would have to be located further eastward of PUA making it hard to access for all.	Even though housing provided could be affordable the transportation costs would be high due to remoteness of the site	Since this project will be built on unencumbered land using the best possible construction and building technologies, the quality of housing and infrastructure would be of highest possible standard
Conclusion/Justification of Selection: It is beneficial for the affordable housing to be located within the site as it encourages equitable socioeconomic development and enhances happiness in the region. It also reduces hardship of the people of lower income group currently forced to live in Jaigaon due to economic conditions				

Table 9-13: Analysis of Alternatives for STP Design

Name	**Feasibility w.r.t. project area and condition**	**Efficiency of treatment**	**Cost – construction and maintenance**	**Environmental impact**	**Energy/ Resource requirements**
Anaerobic Treatment Process: UASB	Land requirement is more. The plants in the nearby vicinity are not working efficiently. Bacteria require substrate (food) for energy and growth.	Lower efficiency as compare to Aerobic process. Degree of the treatment is moderate (65-90%) Process stability is moderate for toxic compounds	Capital Cost (construction cost) is less as compare to the other treatment.	Handling issue of Gases generation in the form of H2S may lead to foul smell.	Less energy requirement. Require more space. Potential odor problems. Biogas production can be used

Name	Feasibility w.r.t. project area and condition	Efficiency of treatment	Cost – construction and maintenance	Environmental impact	Energy/ Resource requirements
	It is not feasible for sewage having temperature less than 15°C. The biogas generated can be used effectively for heating the reactor to improve the performance. The sludge production is less (0.1 kg VSS / kg COD removal) It takes long time to get it operational. Start-up time could be up to 90-120 days. It has low nutrient requirements.	& loading rate.			for energy.
Aerobic Treatment Process: Like ASP, MBR, MBBR, SBR	The land requirement is less as compared to the other treatment processes. The reduction in temperature by 10° C will reduce the reaction rate by a factor of two. The sludge production is less (00.5 kg VSS / kg COD removal) The technology is proven & widely used all over the world. The outlet parameters are assured. The recycled water can be used for non-domestic application. Easily get commissioned start up time (2 to 4	Efficiency of the treatment is far better & more as compared to Anaerobic process. Degree of the treatment is moderate (95%) High process stability to toxic compounds & loading rate. Can absorb shock loads easily.	Capital cost is more due to electro-mechanical installation. Operation cost is more.	No necessity to handle the Gas. The sludge can be recycled and used as manure / fertilizer for the landscape development within the premises.	Energy requirement is more. Require lesser space. Less odour generation.

Name	Feasibility w.r.t. project area and condition	Efficiency of treatment	Cost – construction and maintenance	Environmental impact	Energy/ Resource requirements
	months)				
Conclusion/Justification of Selection: The alternative of Aerobic Treatment process like Sequential Batch Reactor is preferable as the foot print area is less and construction cost is very low, the operation and maintenance cost is very low, the system can be easily integrated with the advancement like SCADA and the MLSS values are more up to 4500 to 8500.					

Table 9-14: Analysis of Alternatives for Solid Waste Management

Name	Feasibility w.r.t. project area and condition	Efficiency of treatment	Cost – construction and maintenance	Environmental impact
Landfill	The landfill method has been used in the vicinity. Possibility of contamination of natural resources like Air / Water/ Soil	Decomposing will take time, hence the space requirement is more. Methane is generated by decaying organic wastes (methane is greenhouse gas many times more potent than carbon dioxide, and can itself be a danger to inhabitants of an area)	The capital cost is low (but the land cost is high). The operation & maintenance cost is low.	Possibility of contamination of ground water table by the leachate exists. Possibility of unhygienic smells and breeds various types of insects and infectious organisms. It is not recommended, as the ground water table is high and possibility of contamination of ground water source is strong Possibility of spreading of disease vectors such as rats and flies, particularly from improperly operated landfills.
Recycle	As the proposed township is developed on SMART concept it is recommended to have a full-fledged recycle & reuse strategy for Solid waste. Less possibility of contamination of Natural resources. A good quality, nutrient-rich and environment friendly manure is formed which improves the soil conditions and fertility. Composting is a biological process in which microorganisms, mainly fungi and bacteria, convert	Better efficiency & outlet parameters are assured.	Capital & Maintenance costs are more, but payback period is shorter.	The positive impact on environment, so this technique is advisable. The ground water table and soil will not get contaminated. The organic fertilizers produced are recommended as compared to chemical fertilizers as it supplies all the elements to the plant to grow.

	degradable organic waste into humus like substance. This finished product, which looks like soil, is high in carbon and nitrogen and is an excellent medium for growing plants. Two biological processes are recommended for the treatment of the solid waste: aerobic & anaerobic.			
Conclusion/Justification of Selection: Reuse, recycling and energy recovery technologies are suitable technologies. Land-filling is the last option of the hierarchy that involves controlled (with proper arrangement for prevention of leachate) interment of the residual waste which has no further use on or in the earth's mantle.				

Appendix 3:
River Training

Appendix 3: River Training

Based on the 100-year flood discharge, the width of River training along with the type of trained section is to be determined.

Parameters for deciding River Training width

For channelizing the River impact of 100-year flood discharge is considered on:

- Depth of scour
- Velocity of channelized River
- Level of embankment top

Different channelization widths and cross section types are tested by various models in HEC - RAS, against the above listed factors and the best possible alternative is recommended.

Finalizing River Training width

Simulation for various widths of trained river are tested: 200m, 250m, and 300m. For each of the River channel widths, the total area of land available for development is compared and the optimum solution is recommended.

Furthermore, the velocity changes, scour depths caused due to various River channel widths are compared and it is noted that training of stream would cause:

- Excessive scour
- Deeper foundation
- Heavy embankment protection works.

These will not be cost effective and based on detailed assessment of Flood carrying capacity, available width of Project Area, and Construction Feasibility, the width of River channel for entire stretch from Doyagang Bridge to Bhutan-India border considered is 300m with a side slope of 2 : 1 (Horizontal to Vertical) with intermediate berm of 2.5m width above frequent flood level. This River width of 300m provides approximately 1,146 Acres of land for development.

Proposing a Uniform Riverbed

Amochhu Riverbed is uneven due to boulder deposits and sedimentation causing random afflux. Also, at the sharp curvature location excessive silting may take place during receding flood in inner edge. This kind of Riverbed aggradation during high flood and degradation during receding flood continues unchecked. This uneven River flow results in excessive scour, siltation and Riverbank erosion.

To maintain a controlled River flow and prevent random afflux, a uniform Riverbed gradient is proposed. This will remain intact in straight portion of the River, however in curvature portion (around the bend of Kaileshwar Hill) due to scouring on outer edge and siltation on inner edge during and after flood, the bed gradient may change slightly. This can be made uniform by periodic dredging.

The uniform Riverbed is proposed within the embanked section of the Project area. The Riverbed levels at both points (upstream start point and downstream end point) are matched with existing bed levels to prevent any significant change in the River's flow condition upstream and downstream of the embanked parts.

This also ensures constant height between top of embankment and the Riverbed level to accommodate the frequent and 1 in 100 year flood discharges safely within the embankments.

Evaluating Embankment options

Once the trained width is fixed, and the Riverbed made uniform, the type of cross section of the embankment needs to be determined.

This could be done using a trapezoidal or rectangular cross section based on the following factors:

- Cost and durability of embankment
- Availability of land behind the embankment
- Velocity and force of the River along the embankment
- Urban design and master plan layout

Based on these factors a combination of trapezoidal and rectangular cross sections are proposed in this Project.

Rectangular cross sections such as RCC or stone retaining walls can be constructed under constrained area conditions and can withstand high forces and velocities of River flow. Bend of Amochhu around Kaileshwar hill is one of the locations where such a section is proposed.

Trapezoidal cross sections are sloped embankment structures constructed using stones in wire crates or PCC blocks. They are proposed where there is ample development space behind the embankment, and river flow velocity is not dangerously high. Slope of the trapezoid is fixed at 1:2 in order to maintain stability and protect the embankment. Stones in wire crates of weight equivalent to large stable boulders on site are placed at 1:2 slope up to height of 1m (freeboard) above the highest flood level. On top of these stones in wire crates, RCC precast paver blocks are fixed.

Therefore, a combination of RCC and stone retaining walls and sloped embankment using vetiver grass is proposed for Riverbank protection along the Project area.

Once the Riverbed and Riverbank protection techniques are finalized, the River alignment along the Project area can be fixed.

Finalizing River alignment

The existing alignment of river is determined as a result of natural contours, the River's velocity, its flood discharge, and sedimentation deposits. That is called regime condition of river created by nature. Considering same configuration and alignment of existing river, High Flood Level/ Water Surface Elevation for maximum probable flood and design flood is worked out on mathematical model.

To design the River alignment using arc method, the following parameters are considered:

- Historic meandering pattern of the River.
- Obstruction to the flow of River during flood situation due to sharp sediments and debris deposited on Riverbed.
- Challenges during construction of embankment.
- Excessive thrust on diaphragm wall and embankment, especially around bend of Kaileshwar Hill that could damage the structure.
- Kinks or sudden afflux in river profile which would lead to cross currents or eddies in the flow endangering the embankment.
- Maintaining a streamlined flow of the River.
- Minimizing any negative impacts downstream or upstream of the Project area.
- Optimal area available on both sides of the embankment for developing the Township.
- Preserving the Himalayan character of the River and not compromising it by constructing a narrow trained channel.

Based on those parameters the River is trained and the total area of land potentially available for development is calculated. It adds up to a total of 1,146 Acres approximately. Additionally, the alignment also helps define the embankment termination points ensuring both, safety of the embankment and undisturbed streamlined flow of the River. The total embanked length is approximately 14.7km.

To align the River, following essential components need to be considered:

Termination points of embankment: There are 4 points in the Project area where the embankment terminates - Upstream termination points are at foothill of Toorsa Tar and across the Riverbank at foothill of Kaileshwar Hill near mouth of Purbe Khola. Downstream termination points are at South West tip of Phuentsholing's STP and near Bhutan - India border pillar in Zone C. The exact termination points are determined by geotechnical conditions, availability of space and flow pattern of River. The termination points are designed as diverging guide banks, thereby, ensuring durable and robust end points.

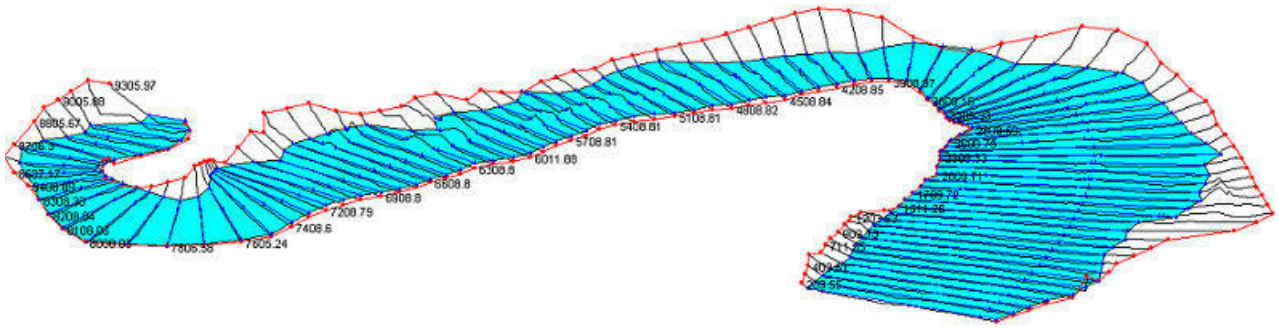
Confluence point of major tributary: Location where Omchhu River meets Amochhu is designed to prevent Amochhu River flowing upstream of Omchhu and flooding Phuentsholing City.

Vulnerable locations with high thrust of River flow: Amochhu River's flow is most threatening while going around the bend of Kaileshwar Hill. The Trained River Embankment's alignment at this location must not only be robust, but must also be smooth and seamlessly curved to allow a streamlined flow of the River.

The aligned River Embankment in totality will help streamline the flow of Amochhu River, protect developments around from floods and provide much needed accessible, vibrant and livable public space.

The 3D model of Amochhu River generated by HEC RAS software is given in figure 1 below:

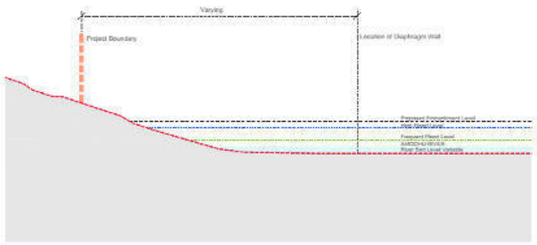
Figure 9-1: 3D model of Amochhu River generated by HEC RAS software



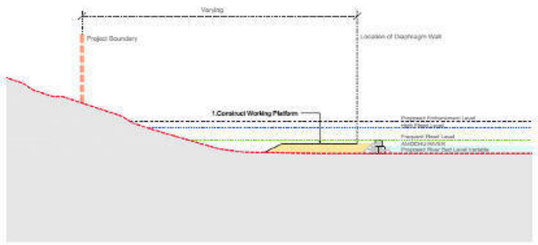
Appendix 4:
Construction Sequence for Embankment Works

Figure 9-2: Construction sequence for embankment work

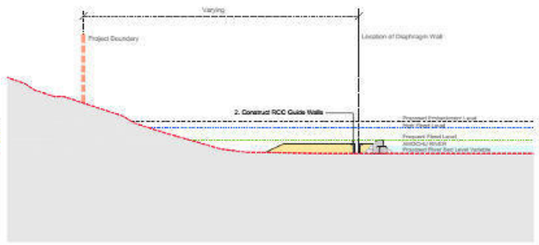
STAGE 1 - Existing Condition



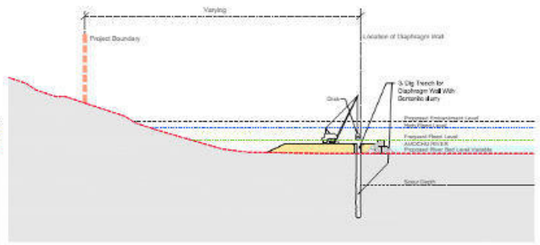
STAGE 2 - Construction of Working Platform



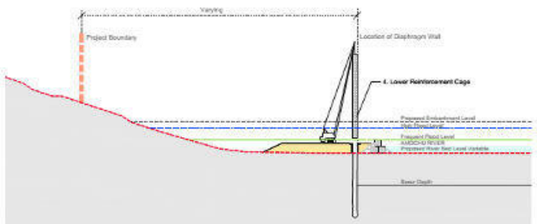
STAGE 3 - Construction of RCC Guide Wall



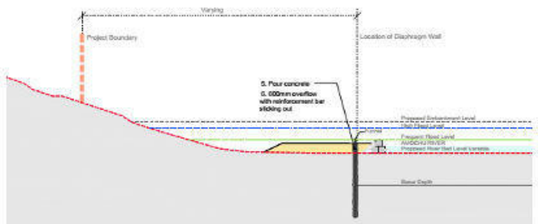
STAGE 4 - Digging Trench & Pouring Bentonite Slurry



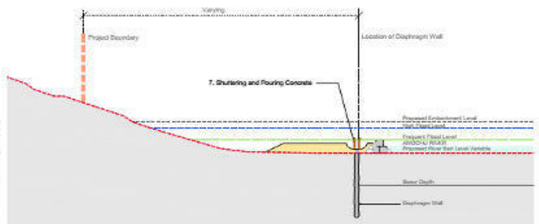
STAGE 5 - Lowering the Reinforcement Cage



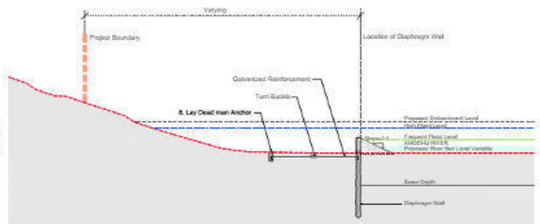
STAGE 6 - Pouring Concrete



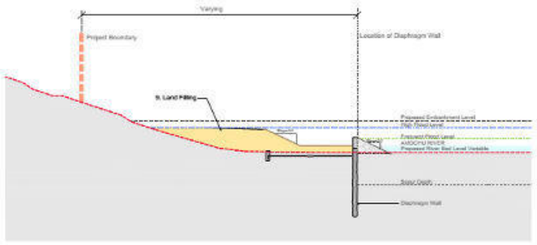
STAGE 7 - RCC Wall



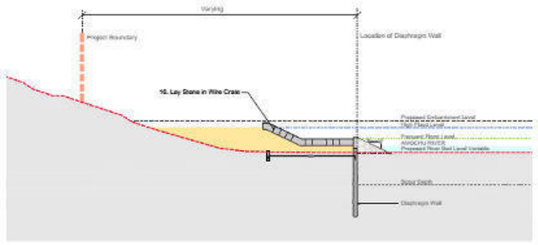
STAGE 8 - Laying Deadman Anchor



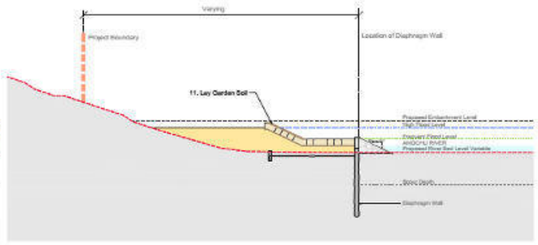
STAGE 9 - Land Filling



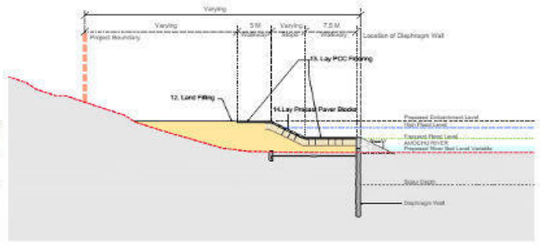
STAGE 10 - Stone in Wire Crates



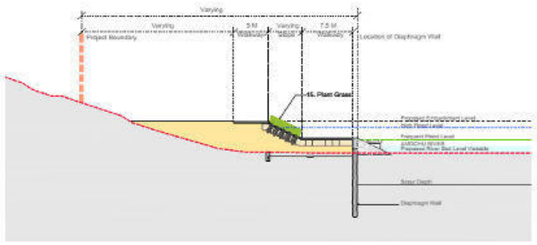
STAGE 11 - Garden Soil



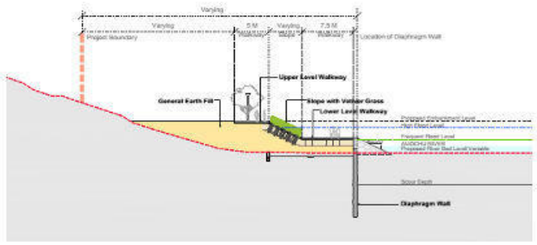
STAGE 12 - Flooring Finishes



STAGE 13 - Plantation



STAGE 14 - Proposed Slope Embankment - Stone in Wire Crates



Appendix 5:
Water Drawl and Supply

For construction activity

During construction stage huge amount of water is required. The main activity involves preparation of mixture of concrete mortar, curing, flooring, surface cleaning before and after painting, water sprinkling for dust suppression and other. The water requirement is mainly dependent on the technological advancement, habit of the users, season in which development is taking place, type of construction (RCC / Load bearing) etc.

The construction water requirement varies based on the season, habit of the construction labor, methods of construction, stage of the construction. However as a role of thumb, it is expected that construction works required water @ the rate of ~40 liters to ~60 liters per m2 of built up area per day throughout the development. In order to work out the tentative demand during construction stage, it is assumed that the development is proposed in 4 phases.

The domestic water requirement for the construction labor will be fulfilled from the tube well. 1 no of tube well is proposed for the labor camp & the construction office. The water quality is goo hence only minimum treatment is proposed (in the form of online chlorination system). The water from the tube well will be pumped to the overhead tank. The distribution will take place from the overhead tank.

For Domestic Use

The construction labour demand will vary based on the construction progress. In the initial phase (river training work) and it is estimated as 800 labors and as the development progresses the construction labour requirement will be about 1300 persons. The domestic water requirement is in the tune of 50 KLD at initial phase and 100 KLD at ultimate stage. This is inclusive of the construction labour, site offices, staff, engineers and other professionals working on the project.

Domestic water peak demand during construction stage will vary from a maximum of 100 KL/D to minimum of 50 KL/D. The labour deployed will vary but it is expected that a maximum work-force of 1300 persons will be deployed at site during the construction stage. The water supply will be initially through groundwater sources, and with the establishment of water intake and purification works, will be sourced from the River (on commencement of the other phases). It will be used after necessary primary treatment in the form of disinfectant and sand filter.

Water Balance for ALDTP

Table 9-15: Water balance for construction

Description of Item	Domestic Demand in KLD	Construction Water Demand (Peak) in KLD	Total water Demand (KLD)
Fresh water demand	100.00	7200.00	7300.00

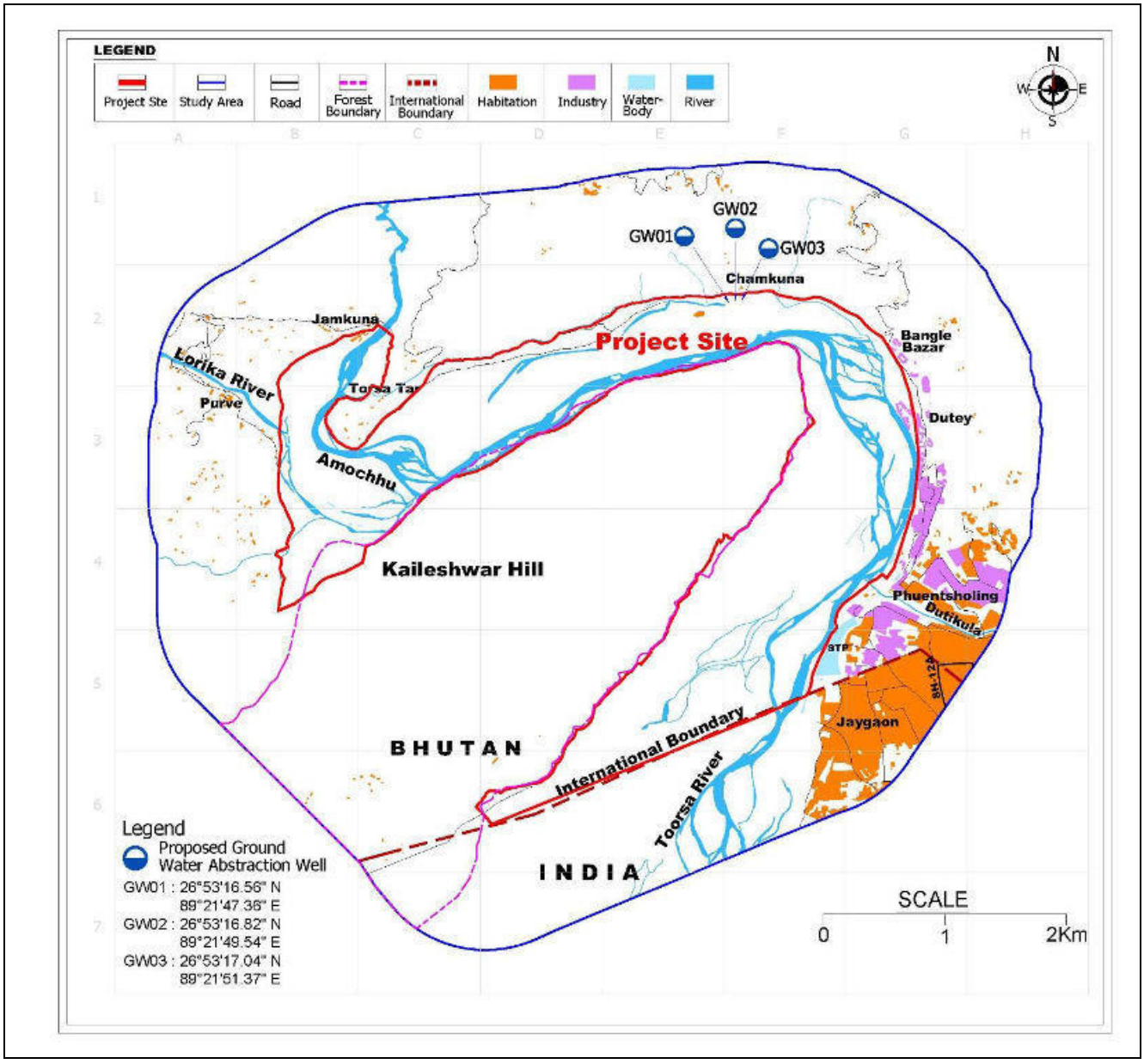
Water Distribution system

During the construction water demand, the domestic requirement will be fulfilled from the ground water sources. The primary treatment in the form of disinfectant dosing will be installed within the labour camp. The water shall be pumped from the tube well, & after filtration to the overhead tank (dedicated for the respective labour zone.) The distribution will be carried out from overhead tank by gravity in the respective zone at common point only.

For operation activity

The proposed water supply system shall be designed based on the projected population of the Master Plan. For the full Master Plan development, the estimated water requirement is ~19.10 Million Liters per Day (MLD), with freshwater requirements of ~11.00 (~60% of total water demand) and recycled water of ~11.45 (~40% of total water demand). In the first phase, for construction requirements, quick project start up and initial cost efficiencies, ground water will be used for the project, whilst the water intake structures are developed. Thereafter as the project develops, it is proposed that water for the project shall be sourced from the Amochhu River. Necessary permissions will be taken for ground water extraction. For the 1st phase, 3 no. of tube wells will be set up and located as shown in Figure 9-3

Figure 9-3: Proposed ground water abstraction well location



The water source (Amochhu River using head works) is feasible once the entire project is developed as the river is perennial and water is available throughout the year. The requirement of water for the proposed township is around 0.30% (one percent) of the minimum discharge of the river in a year.

Based on the above, it is considered that the above water consumption is sustainable over the long term. Table 9-16: ALDTP water and waste water balance – non-monsoon / dry season illustrates the water requirements of the ALDTP along with wastewater generated, treated and recycled.

Table 9-16: ALDTP water and waste water balance – non-monsoon / dry season

S. No.	Topic	Quantity (MLD)
1	Domestic Water Demand (Assuming 30% Demand)	11.00
2	Recycle water Demand (Assuming 30% Flushing Demand for commercial area)	1.87
3	Landscape Water Demand- (100% of the Total Landscape Demand)	8.10
4	Recycled Water available- i.e. 85% of the Demand (i.e. 85%of Sr. No.1)	9.35
5	Recycle Water Demand (i.e. 2+3)	11.33
6	Short of Recycle (i.e. 5-2)	1.99
7	Fresh Water Demand (i.e. 1-2+6)	11.12

During the non-monsoon / non rainfall times, the water will not be discharged into the River. The water balance for the project during monsoon months is presented in the table 4 that follows:

Table 9-17: ALDTP water and waste water balance – non-monsoon / wet season

S. No.	Topic	Quantity (MLD)
1	Domestic Water Demand (Assuming 30% Demand)	11.00
2	Recycle water Demand (Assuming 30% Flushing Demand for commercial area)	1.87
3	Landscape Water Demand- (50% of the Total Landscape Demand)	4.05
4	Recycled Water available- i.e. 85% of the Demand (i.e. 85%of Sr. No.1)	9.34
5	Recycle Water Demand (i.e. 2+3)	5.92
6	Excess Recycle (i.e. 5-2)	3.42
7	Fresh Water Demand (i.e. 1-2+6)	9.13

The excess recycle water will be disposed into the natural drainage after necessary treatment.

Water Balance for ALDTP

The water balance for the dry (non-monsoon) and wet (monsoon) seasons are attached as Figure 9-4: Water balance diagram for dry season and Figure 9-5: Water balance diagram for wet season respectively. The balance diagrammatically displays the information already provided in the water balance tables and shows the flow of different water, wastewater and recycled water streams.

Figure 9-4: Water balance diagram for dry season

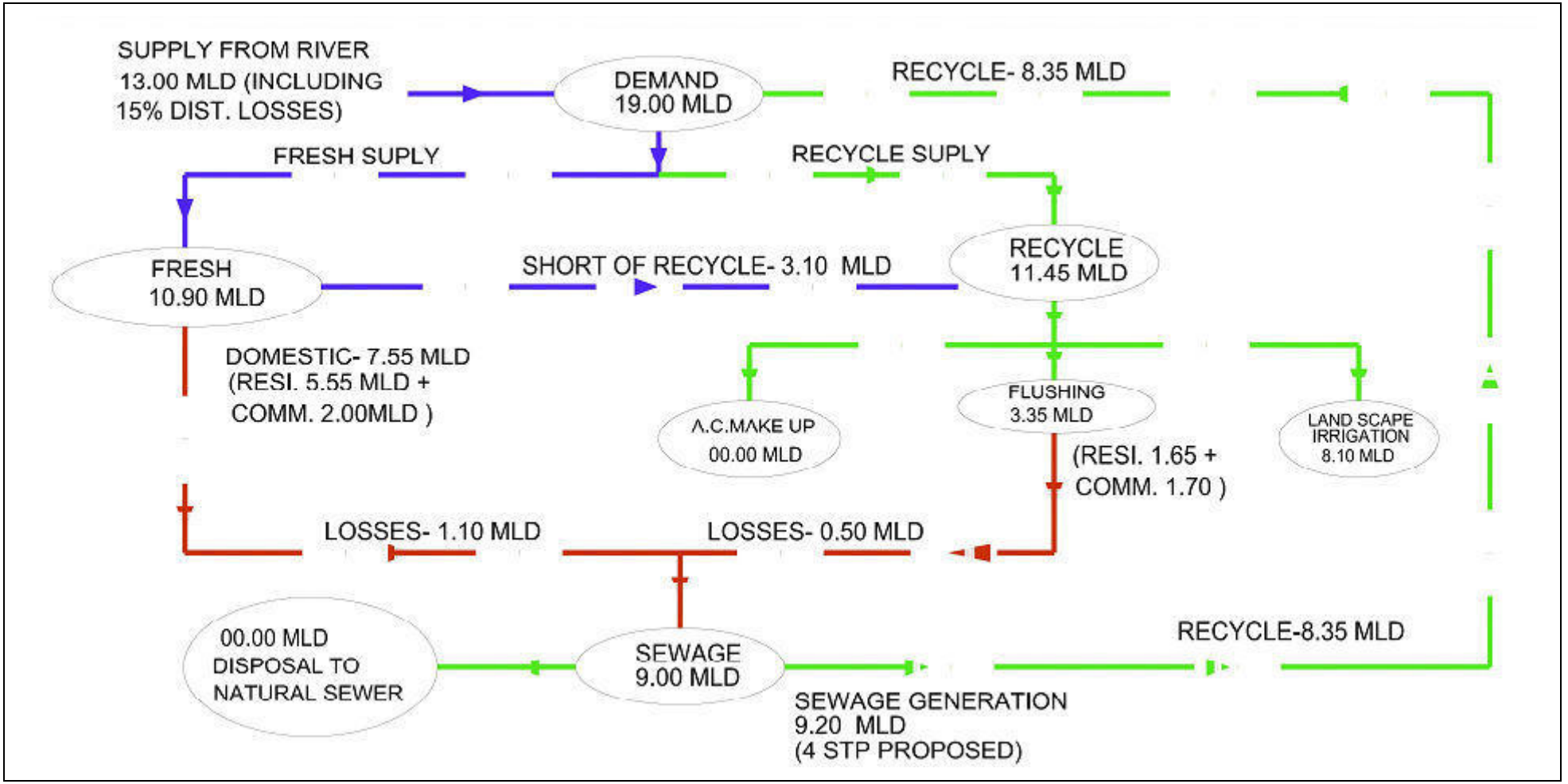
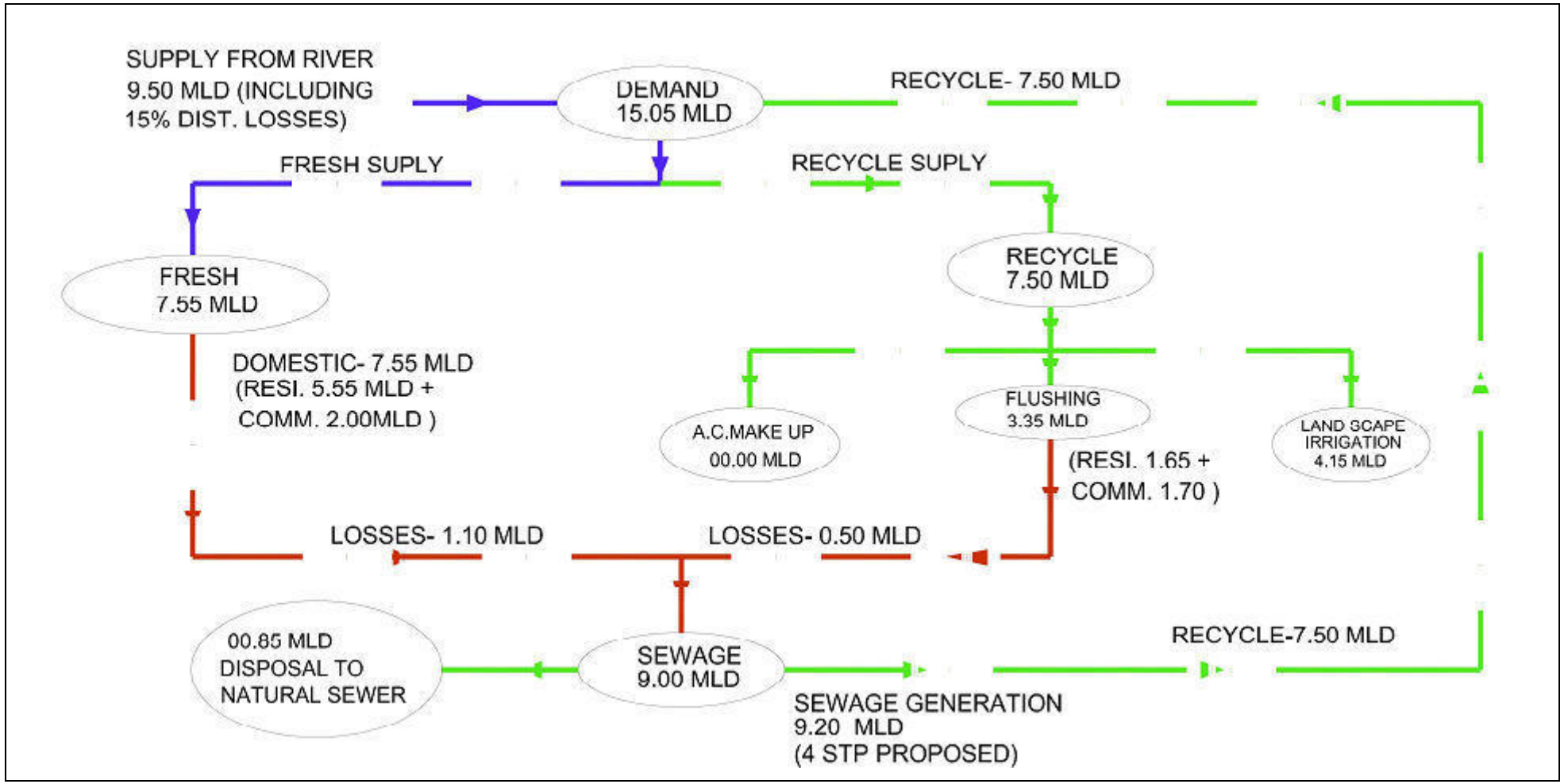


Figure 9-5: Water balance diagram for wet season



Water Source

Water Source for Zone-A

The domestic water de and for zone-a will be fulfill from the tube well. There are 3 tube wells are proposed. These tube wells will be drilled up to the depth of 30M, with a recharge facility. The perforated pipe network is proposed on the upper part so that the saturated ground water will also get collected.

Water Distribution System

The various components for the supply of water for the ALDTP area are provided in subsequent sub-sections of this section.

Head Works System

These consist of:

Intake well and connecting pipe – Intake well having 6.00 m ø up to the required depth with rose pieces of 550mm ø with length of 1.00 m at different level. The top slab will be provided at 1 m above the highest flood level. The intake well will be constructed with infiltration pipe network below river bed, so that during dry season/ change of river flow pattern, water will be collected from the saturated soil (percolation). The connecting pipe from intake well to jack well is proposed with 900mm ø RCC NP-III pipe having app. Length of 100m in two lanes. The water collected in the intake well will be transferred to jack well by gravity. The required gradient will be provided considering the lean weather flow.

Jack well and pump house - The jack well of 9.00 m ø in RCC M-30 grade concrete shall be constructed up to highest flood level. The bottom level of the jack well is 197.46 m pump floor level is 209.90m. The pump house constructed in brick masonry having 9.00 m ø & clear height of 6.00 m shall be constructed above the jack well. The cantilever inspection gallery shall be extended at pump floor level. Three vertical turbine pumps (two working and one stand by pumping arrangement) are proposed for lifting water from the jack well and transferring to the water treatment facility within the respective zone

Raw water transmission line: carries water from the Jack well to the treatment facility pumping main / transmission main. The raw water transmission main is proposed with Ductile Iron Pipe having Dia. 400MM ø K-9 grade for zone-c & 350mm ø DI K-9 grade as per the demand.

Water Treatment Facility

The water treatment facility is proposed in phases as the development is divided due to the river. This will also helpful reducing the cost of the operation & maintenance. Facility will purify the raw water and make it potable for supply and consumption. The WTPs are proposed for the ALDTP area. The method will be conventional treatment method, consisting of:

- Aeration – mixing of oxygen to remove the foul odor
- Coagulation – rapid mixing after addition of coagulants to remove impurities, metals
- Flocculation – remove turbidity and flocs formed of impurities
- Filtration – to remove suspended solid and turbidity. Rapid sand filters is proposed
- Disinfection – killing of microbes and pathogens in water by chlorination.

Conventional water treatment plant for Zone C shall comprise of aeration, flocculation and filtration with disinfectant dosing. The capacity of the WTP is 8.00 ML.

Conventional water treatment plant for Zone B shall Comprises of Aeration, Flocculation, Filtration with disinfectant dosing is proposed. The capacity of the WTP is 4.00 ML. The treatment facility shall be combined for Zone B.

Compact water treatment facility for Zone A- the treatment facility comprises of the compact rapid sand filter and disinfectant dosing.

Water Storage

Ground Service Reservoir (GSR) is proposed for Zone A and C. The GSR at Zone A will also serve Zone B. The material of construction for GSR is RCC. Elevated Service Reservoir (ESR) is proposed to supply water by gravity to the entire premises and up to 5th Floor from the finished ground level. Some of the areas in Zone-E & Zone-B will served by combined (Hydro Boosting + gravity) as they are located on higher elevation.

Distribution

Looking towards the topography, for the project area two distribution systems are feasible – gravity and hybrid (combination of gravity and pressurized) type. Being located in an undulating topography the hybrid type of water distribution is more reliable and workable in order to have an equitable pressure distribution.

For improved efficiency of water supply in the ALDTP area, the following advanced systems will be implemented:

Uninterrupted 24 x 7 water distribution.

Metered water supply – accountability, identification of losses, avoid wastages, reduce overall cost, recovery based on the usages of the water.

SCADA system – The Supervisory Control and Data Acquisition (SCADA) is a system operating with coded signals over communication channels to provide control of remote equipment. In ALDTP, a SCADA system will be monitoring the entire flow of water from the intake point to final distribution and thus identify theft, losses and leakages in the system. The Inlet and output to the water treatment facility will also be monitored as per the provided standards and accordingly the treatment will be automatically controlled to maintain the desired outlet parameters as per the WHO standards.

The metered supply shall be integrated with the SCADA system in order to monitor the UFW. The billing and recovery system shall be in place with telescopic tariff structures.

Concept Drawings

The concept drawing for jack well and intake well is attached below as figure 3

Figure 9-6: Water Supply System

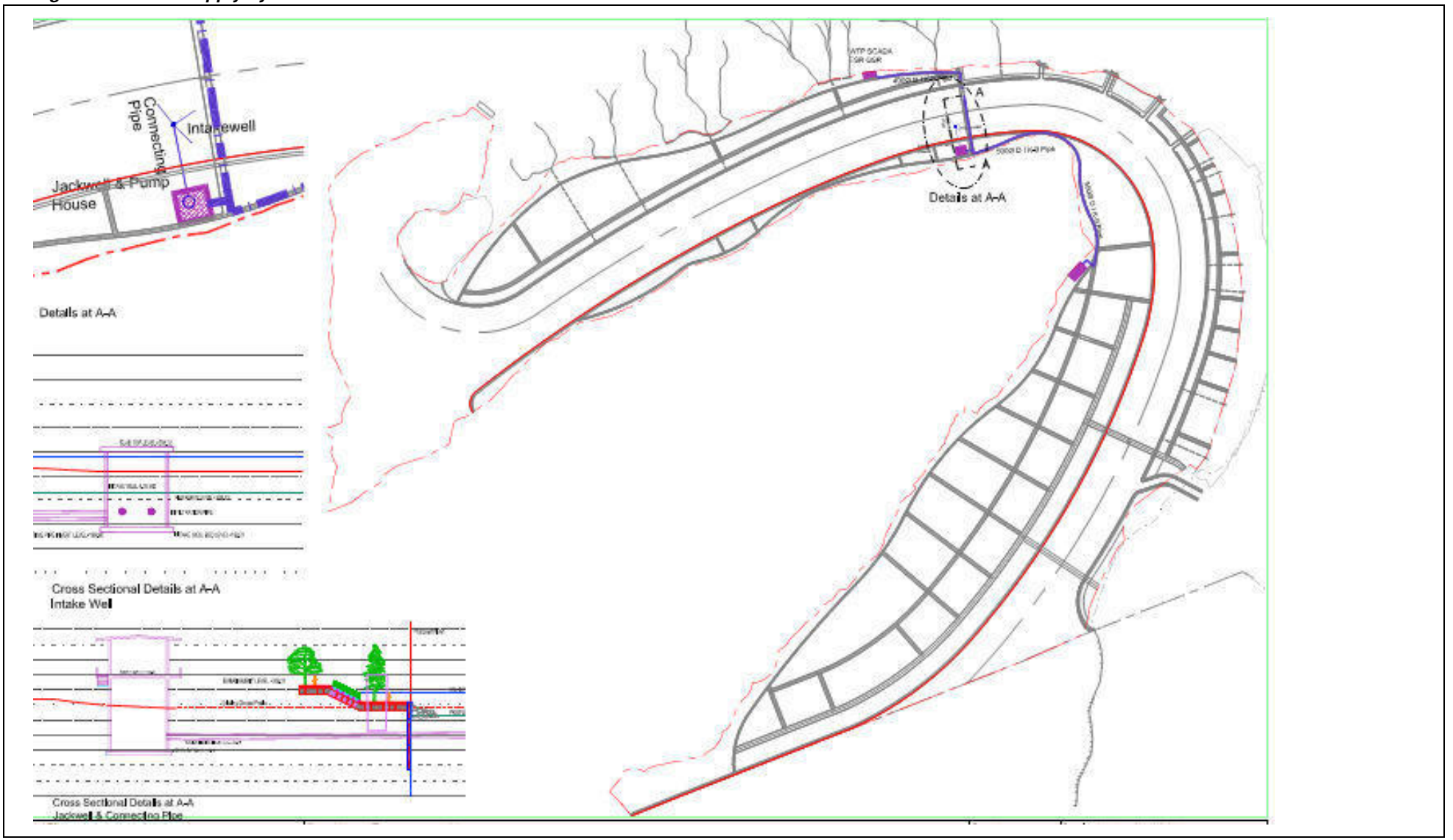
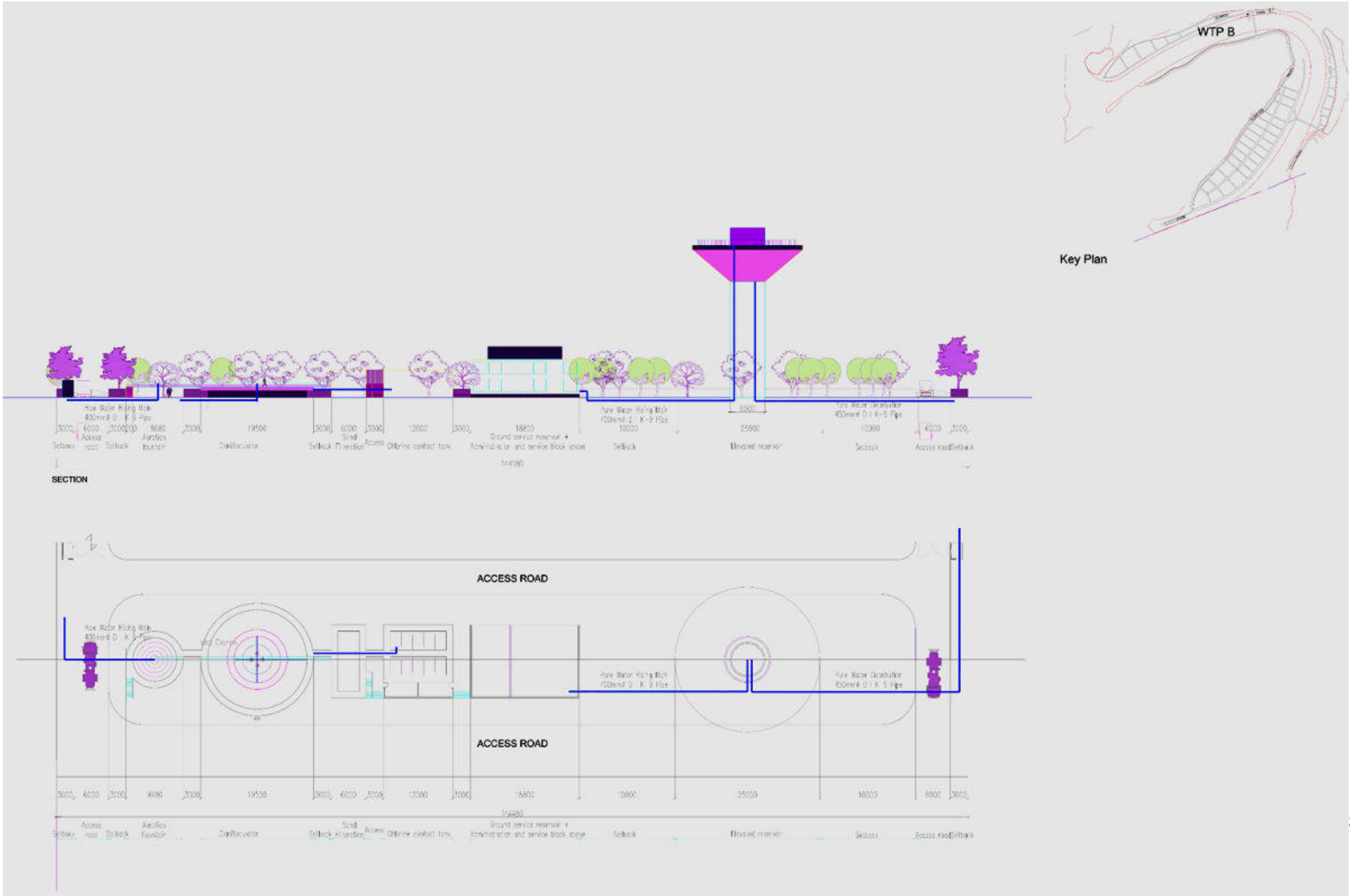


Figure 9-7: Water Treatment Plant Layout



Appendix 6:
Sewerage System

The ALDTP project shall cover the entire area as per final master plan in all the zones. Since the proposed master plan is for a new township, there is no existing sewerage system in place as on today. The details of systems to be followed are given in this sub-section.

Service Delivery Norms

The entire area (100%) shall be covered under the proposed sewerage system. Individual plots shall be provided with common sewerage network connectivity, supported with collection and conveyance of wastewater leading to sewage treatment plant.

Identification of Deficiency Areas

Since the master plan shall be prepared for the new area, there is no existing system within the project area neither are there any deficient areas. The experience of Phuentsholing City shall be considered for the proposed system so as to incorporate learnings from the existing City's sewerage operations.

Estimation of Demand

The estimation of wastewater flow is based upon contributory population and the per capita flow of sewage. Both these factors can be guided by the design period. The estimation of the design flow is based on:

- Design period
- Population forecast
- Tributary area
- Per capita sewage flow
- Flow assumption
- Ground water infiltration

These are further discussed.

Design Period

The Design period of ALDTP is considered as 30 years with base year as 2021. The development of the sewage facility is anticipated as 5 years sewerage network and treatment starting from the year is 2016.

Population Forecast

The overall population forecasted is a residential population of 49,393 persons and a commercial population (floating and others) of 47,695. Thus a total population of 97,088 persons is proposed to be served by the township.

Per Capita Sewage Flow

Conventional sewers shall be designed for a minimum sewage flow of 100 liters per capita per day allowing for higher flows as explained in the water balance shown earlier. The wastewater generation for the premises is to be adopted as 85% of the per capita supply and the peak factor to be adopted as 2.5.

Flow Assumptions and Sewerage Zoning

The development has been proposed in three phases and the sewage treatment facility has also been planned phase-wise. The proposed area has been further divided in 4 sewerage districts for the domestic effluent collection conveyance and treatment. This will result in the lesser operation and maintenance issues.

Two sewage treatment plants are proposed for Zone-C and 1 STP for Zone-A and B respectively. The STP for Zone-A will also collect and treat sewage from the Local Area Plan (LAP) prepared for Phuentsholing.

Components of the Sewerage System

These include: collection and conveyance, sewage pumping stations, sewage treatment plants, recycling and reuse of treated sewage and disposal of excess, unusable sewage (during wet periods) into the nearby natural outfall after necessary treatment as per NEC/ Bhutan standards. These are now discussed.

Collection and Conveyance System

This will consist of:

- System network to carry wastewater from generation premises to treatment and/or final disposal point
- Main sewer line to be laid 1.20m below surface and inspection chambers at intervals of 30m or at connection.

The collection system material double corrugated pipe (DWC) for diameters up to 300 mm and RCC pipes for 300mm diameter

The collection and conveyance system would be by gravity.

Manholes to be located along the network for access to the sewer for inspection, testing, cleaning and removal of the obstruction from the sewer line.

The sewage network is proposed all along the streets with proper earmarked service trenches.

Sewage Pumping Stations

The sewage will be conveyance till the STP and sewage pumping station is proposed near the sewage treatment facility.

Sewage Treatment Plants (STPs)

As explained in the water balance, the domestic water demand for the proposed development is estimated as ~11.00 MLD. A system for intake will be designed and developed for a final capacity of 13.0 MLD considering normal transmission and distribution losses and some headspace in design.

It is expected that 85% of the water supplied (net of supply losses) yields a realistic figure for sewage generation. Thus a ~11.00 MLD water supply will likely yield a sewage generation of ~9.4 MLD. Since this generation will develop over time, in a phase-wise manner, it makes sense to design a de-centralized system of sewage collection and treatment catering to each phase of growth of the proposed township. Another factor in the design of the sewerage system is the commitment of the ALDTP authorities to treat the sewage from the LAP as well as the Torsa Tar area. These two locations need a treatment capacity of ~1.55 MLD (1.75 MLD for LAP and 0.28 MLD for Torsa Tar). This brings the total sewage to be treated in the various STPs to 10.78 MLD. The overload factor of 10% is considered while deciding the capacity of the STP, the total STP capacity for the ALDTP and the additional STP service areas of the LAP and Torsa Tar area has been kept at 10.78 MLD. Installation of these STP capacities (in a phase wise manner) will comfortably take care of the sewage treatment requirements of ALDTP Township and LAP/Torsa Tar areas well into the future.

STPs to be installed within the ALDTP are listed in Table 9-18.

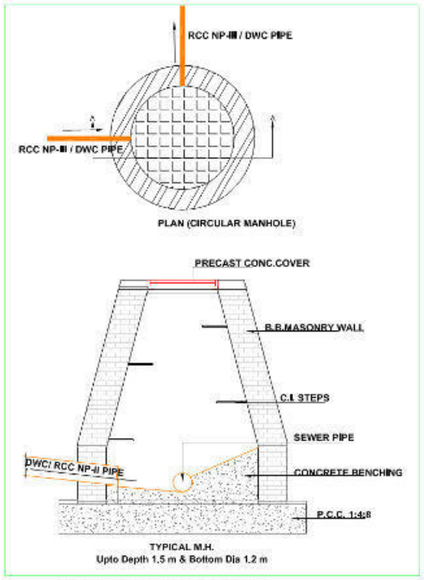
Table 9-18: STP Location, Capacity and Numbers

SN	Zone / Area Served	STP Capacity Proposed
1	**Zone-A and LAP Area**	3.00 MLD x 1 No. = 3.0 MLD
2	**Zone-C**	3.00 MLD x 2 Nos. = 6.0 MLD
3	**Zone-B**	1.50 MLD x 1 No. = 1.50 MLD
4	**Torsa TAR**	0.28 MLD x 1 No.= 0.28 MLD
5	**Total STP Design Capacity**	10.78 MLD

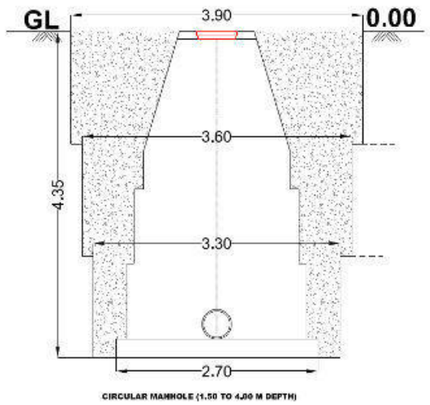
Schematics and Diagrams

Schematic of sewerage system for collection, pumping and treatment facility is given in Figure 9-8. STP Process Flow diagram is shown in Figure 9-9. A diagram showing principle of SBR waste water treatment system given in Figure 9-10.

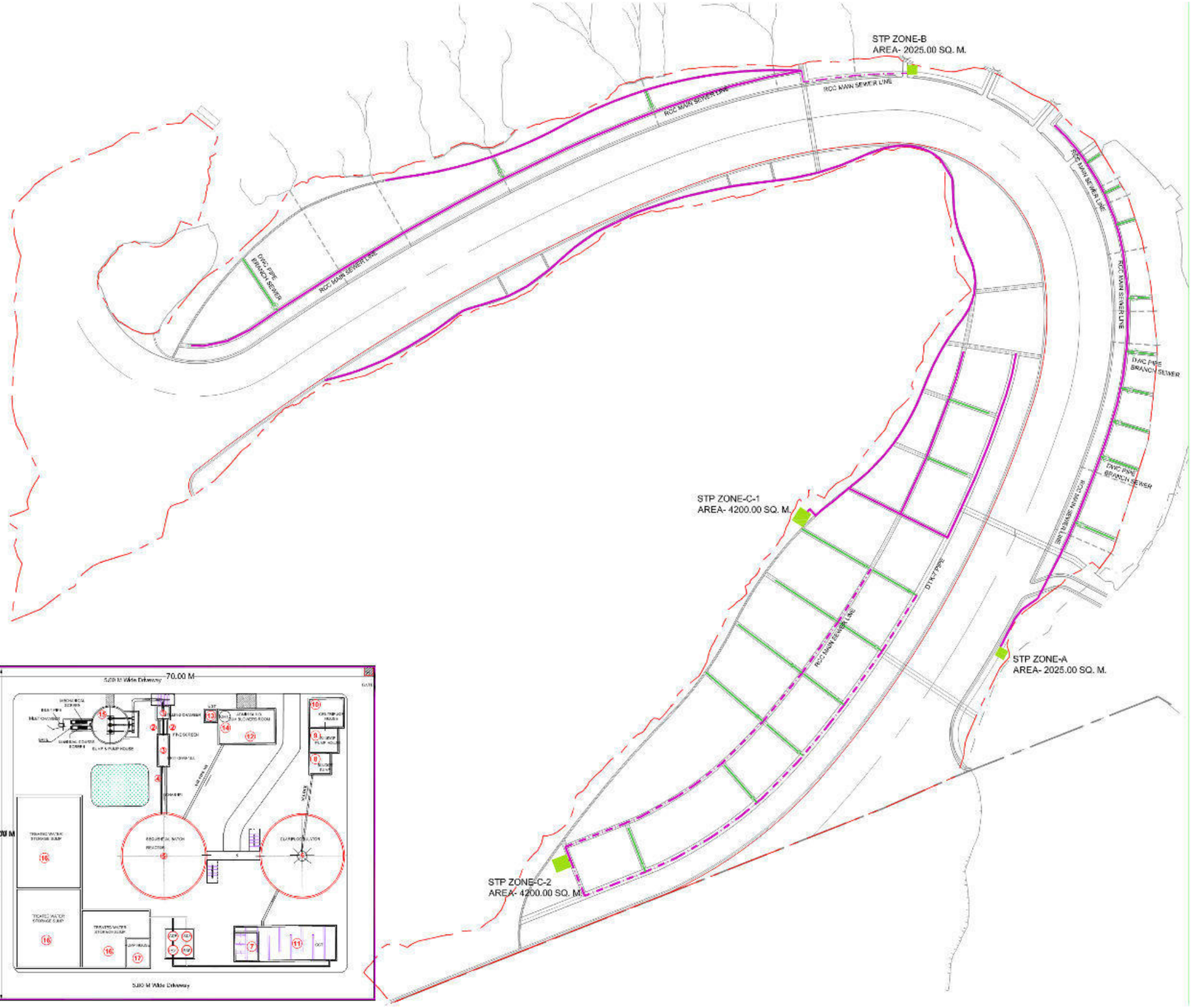
Figure 9-8: sewerage system for collection, pumping and treatment facility.



CIRCULAR MANHOLE DETAILS



CIRCULAR MANHOLE (1.50 TO 4.00 M DEPTH)



SEWAGE TREATMENT PLANT				
SR.NO.	PROCESS UNITS	SIZE OF THE PLOT	QTY.	CAPACITY
1.	STP-ZONE B	45.00X45.00	1	1.50 ML
2.	STP-ZONE- A	45.00X45.00	1	1.50 ML
3.	STP-ZONE C 1	60.00X70.00	1	3.00 ML
4.	STP-ZONE C 2	60.00X70.00	1	3.00 ML
5.	MAIN SEVER LINE	RCC NP-III PIPE		
6.	BRANCH SEVER LINE	DWC PIPE		

Figure 9-9: Process Flow Diagram of STP

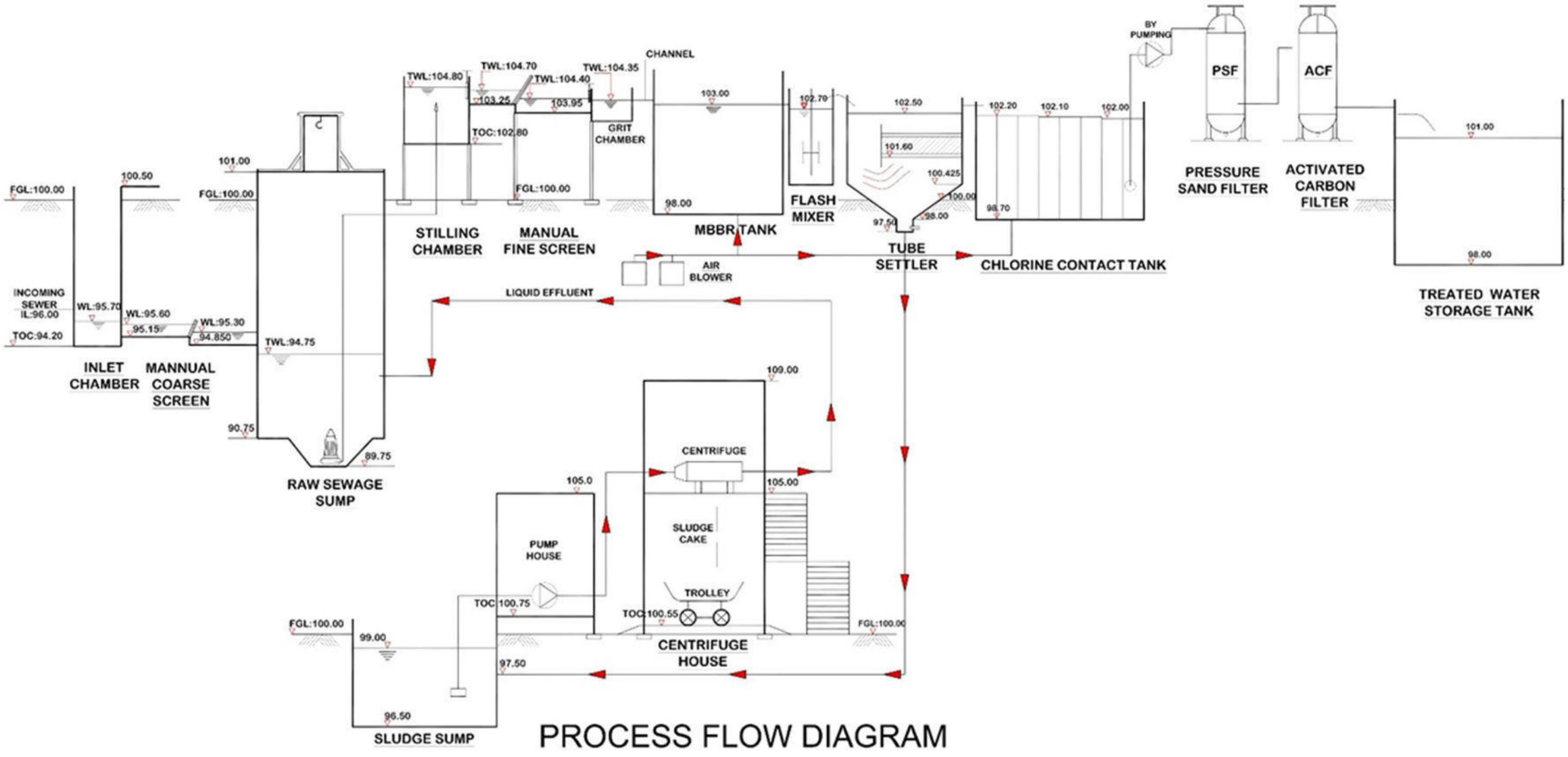
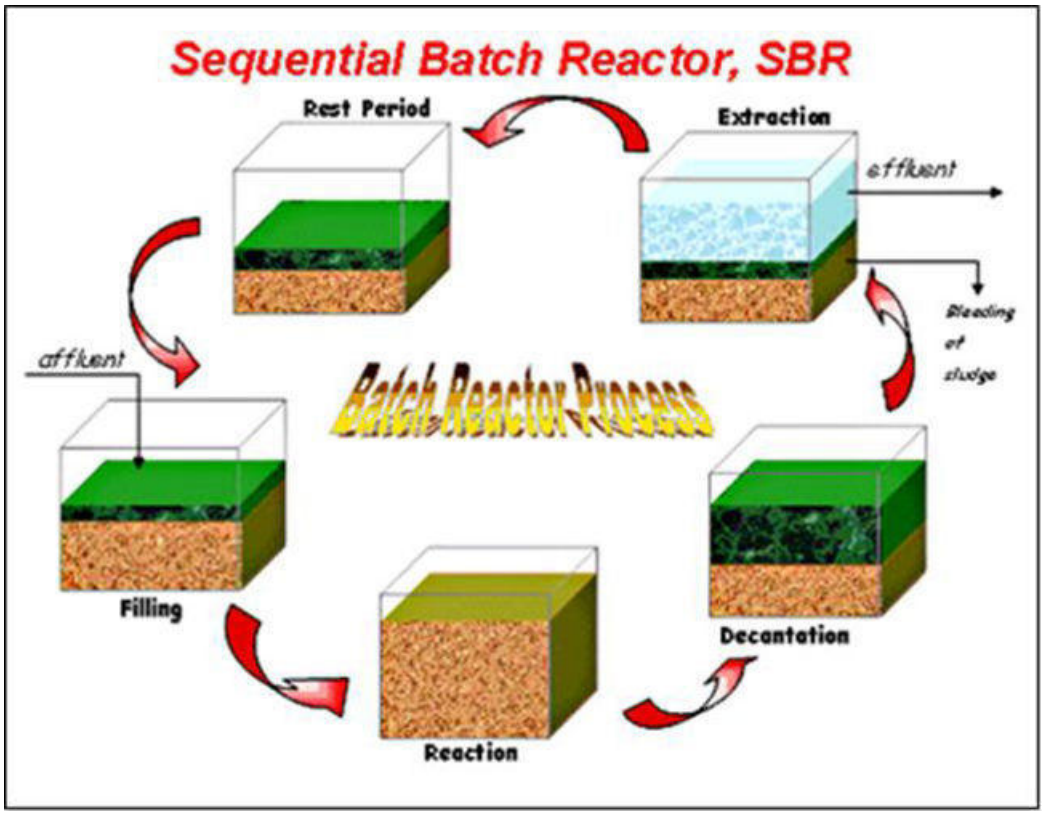


Figure 9-10: A diagram showing principle of SBR waste water treatment system



Expected Inlet and Outlet Characteristics of the Sewage

The expected inlet characteristics of the sewage, the design considerations as well as the norms for different disposals are given in Table 9-19. Norms with respect to NEC, Bhutan (the regulator) will be met. In addition norms set by the Ministry of Environment, Forests and Climate Change (MoEF CC) Government of India (GoI) as part of the Environment Protection Act (1986) / Rules (as amended till date) will be met since the wastewater is proposed to be discharged in the Amochhu River, close to the Indian border with Bhutan.

Table 9-19: Sewage Parameters

S. N	Parameters	Unit	Observed Characteristics of Influent to STP	Design Consideration	Observed Characteristics of treated sewage from STP	Acceptable Norms for treated sewage from STP		
						NEC, Bhutan	EPA, India (Discharge To Inland Water Bodies)	EPA, India (Onland for Irrigation)
1	pH	-	5.5-8.5	7.2-8.0	6.5	-	5.5 to 9.0	5.5 to 9.0
2	BOD	mg/l	200-250	250.0	25	30.0	30.0	100.0
3	COD	mg/l	350-600	400.0	400	-	250.0	250.0
4	TSS	mg/l	250-300	300.0	100	100.0	100.0	200.0
5	VSS	mg/l	200-300	260.0	-	-	-	-
6	Nitrogen	mg/l	40-80	50.0	40	-	50.0	-
7	Oil & Grease	mg/l	5-10	7.5	9	-	10.0	-
8	Phosphorus				1	-	1.0	-
9	Faecal Coliforms	MPN / 100 ml			1000	1000.0	1000.0	1000.0

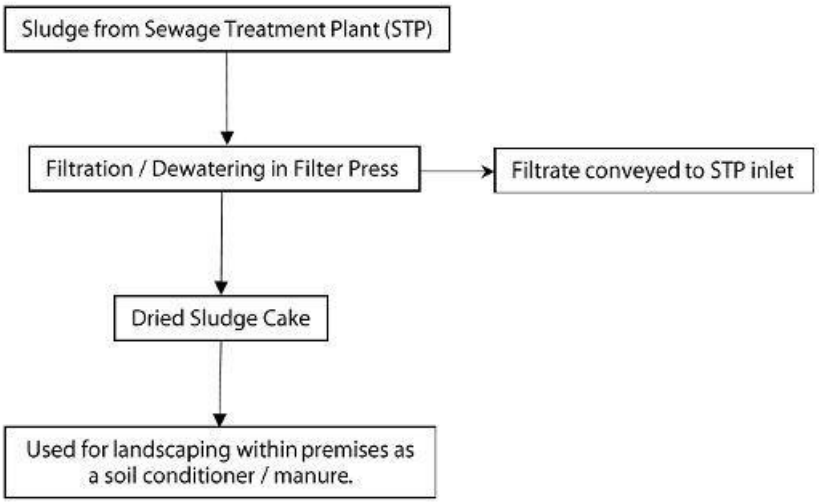
STP Design

For this project, the aerobic treatment method is proposed due to its robust and proven nature, ease of use and maintenance. Within aeration technologies available, an appropriate choice has to be made based on various parameters such: as land availability, desired outlet parameters requirement as per regulatory standards, energy requirement, ease of construction, ease of operation and maintenance (O&M), capex (capital cost) and opex (recurring O & M costs).

Based on the above parameters, the Sequential Batch Reactor (SBR) technology with tertiary treatment and ozonation only for recycled water has been proposed. The process is operated in periodic cycles comprising of filling, mixing, settling, decanting and idling. The sewage enters into the filling tanks in which microorganisms are in contact with the air supplied. The extent of aeration is decided on the basis of the BOD requirements. The aeration reduces the BOD and makes the water fit for reuse after necessary polishing (in the form of tertiary treatment stage).

Once the aeration is completed, clear water is transferred to settling tanks and the biomass transferred to the inlet tank. This process is also known as cyclic Activated Sludge Process (ASP). The sludge which will be generated will be transported to filter presses and the finally dried sludge will come out in the cake form. This cake can be used for the landscaping within the premises as a soil conditioner / manure and due to this sludge drying beds have currently not been provisioned, which is shown in Figure 9-11.

Figure 9-11: Flow chart of STP sludge reused



Sequential Batch Reactor (SBR)

SBR is a type of suspended growth activated sludge system. Specific bacteria are cultured in the SBR to digest the dissolved organic matter. SBR system does not operate on a continuous cycle whereby a tank is required for each process. SBR is fill-and–draw activated sludge system in which aeration, sedimentation and separation processes are carried out in the same tank but sequentially in alternate batches tanks. SBR system consists of 5 process phases –Fill (Aerate), React, Settle, Decant and Idle. The system will be integrated in the automated SCADA mechanism to higher efficiency and reduce the aeration based on the MLSS / BOD requirement

Disposal of Treated Water

The treated wastewater will be re-used to the extent possible and during the dry / non-monsoon months all the recycled water will be reused, much of the same for landscaping. During the wet / monsoon months, however the quantum (app. In the tune of 3.30 MLD) the treated wastewater required for landscaping will drop. At such times, the recycled water will be sent for flushing. However, during such times, ~3.30 MLD will be discharged into the natural drainage without affecting the environment. Additionally on rare occasions, i.e. during times of very high rainfall and floods, it is possible that landscaping requirements will be close to nil and in that case recycled water will be used to the maximum possible extent for flushing, and thereafter the remainder (~7.50 MLD) will be discharged into the Amochhu River.

Appendix 7:
Storm Water Management

Overview

This chapter will cover the storm water management design strategy adopted for ALDTP. The system components involved for planning the infrastructure shall be studied considering the existing scenario in the vicinity and the Phuentsholing city. The over flooding and the landslide measures shall be considered on high priority as it seems to be the area of frequent occurrences. The cross drainage works and the runoff diversions of the streams entering the premises and philosophy for effective disposal / diversions of the streams shall be considered.

Runoff Assessment

In this sub chapter, the estimation of the runoff quantity is essential and the same shall be adopted for designing the storm water collection and conveyance system for the proposed ALDTP. This also includes the runoff from the Kaileshwar hills and other part of the development.

Design period

The design period for the system design shall be considered in between 15 to 30 years. The project development phase is to be considered for minimum 5 to 7 years. The design period for the proposed ALDTP is considered as 30 years and the base year is considered as 2021. The development of the storm water facility is anticipated as 5 years storm water network and treatment starting from the year is 2016. The overall system is designed for the year 2021-2051.

Estimation of the Storm water runoff

The sanitary sewers are not expected to receive storm water. Strict inspection, vigilance, and proper design and construction of sewers and manholes should eliminate this flow or bring it down to a very insignificant quantity. However in small habitations where rainfall is almost a continuous affair, it may be necessary to include storm water in the design of sewers.

The storm runoff is that portion of the precipitation, which drains over the ground. Estimation of such runoff reaching the storm sewers therefore is dependent on the intensity, duration of precipitation, characteristics of the tributary area, and the time required for such flow to reach the sewer (time of concentration).

The design of storm water sewers begins with an estimate of the rate and volume of surface runoff. When rain falls on a given catchment, a portion of the precipitation is intercepted by the vegetation cover that mostly evaporates, a portion hits the soil and some of it percolates down below and the rest flows over the ground. The higher the intensity of rain, the higher will be the peak runoff.

The time-period after which the entire area begins contributing to the total runoff, at a given monitoring point, is known as the time of concentration. It is also defined as the time it takes for a drop of water to flow from the most distant point to the outlet of the basin. The duration of rainfall that is equal to the time of concentration is known as the critical rainfall duration. The rational formula for the relationship between peak runoff and the rainfall.

$Q = 10\ C\ I\ A$

Where,

Q: Runoff in m3/hr.

C: Dimensionless runoff coefficient

I: Intensity of rainfall in mm/hr.

A: Area of drainage district in hectares

Estimation of the runoff from the Kaileshwar hill

There are major streams entering into the project area starting at the Kaileshwar hills and leading towards the river Amochhu from the left bank and the right bank. There are 9 major streams passing through the project area. The runoff from each stream is calculated based on the various parameters. The parameters considered for adopting the design philosophy are as mentioned

The runoff is calculated on the basis of the rational formula i.e. $Q= 10\ C\ I\ A$

The coefficient of runoff is considered as 0.65 as the soil pervious and hence the same is adopted for design consideration.

The intensity of the rainfall is considered based on the various rainfall data and the rain frequency curve. For adopting the rain intensity the rain fall pattern as per the IMD for the areas in close vicinity of the area.

The rainfall intensity considered for design purpose is 30mm /hour, 50mm/hour and 75mm/hour. This is considered as the data receives, indicates the daily rainfall data. Hence the same shall be adopted.

The runoff from the premises shall be collected into the recharging basin. These recharging basins are proposed will form the recharging and velocity reducing mechanism for the development as well as the soil erosion measures will get considered.

The table below mentions the runoff from the premises and the recharging pond area.

Table 9-20: Runoff from the Hills

Stream	Catchment Area in Ha.	Runoff from the premises on rainfall intensity			Proposed Area of the Retention Pond in Sq. M.
		30mm / hr.	50mm/hr.	75 mm/hr.	
C 1	59.00	5752.96	9588.27	14382.40	3844.00
C 2	34.00	3315.27	5525.44	8288.16	2304.00
C 3	28.00	2730.22	4550.36	6825.55	1936.00
C 4	21.00	2047.66	3412.77	5119.16	1444.00
C 5	12.00	1170.09	1950.16	2925.23	802.78
C 6	15.00	1462.62	2437.70	3656.54	1024.00
C 7	26.00	2535.20	2535.20	6338.01	1764.00
C 8	35.00	3412.77	5687.96	8531.93	2304.00
C 9	24.00	2340.19	3900.31	5850.47	1600.00

Figure 9-12: Streams and outfalls from the Kaileshwar Hill in the ALDTP area

Drains & Culvert System

The drains and culverts are the major parts of the storm water collection and conveyance system. The drains are designed for the peak rain intensity (recorded in the area 75mm / hr.) and the flow shall be checked for normal intensity recorded in the area. The recommendations of the component for implementation shall be adopted on the basis of the merits and demerits of the component and feasibility of the same.

System Components

In this, the various components involved in the runoff collection conveyance system and rain water harvesting measures adopted for the proposed ALDTP are discussed.

Collection from the zones

The provisions of the connectivity shall be made based on the master plan. The connecting manhole will be provided for every plotted development and the additional provisions for maintenance and grit removal shall be made.

The runoff collected from the plot will get discharged into the network laid along the road surfaces in utility corridors will then further lead to the nearby disposal point / natural drain / streams or will get discharged into the river.

The cross drainage works are provided for the streams passing through the project area the runoff from the project area will be discharged to the same network. Irrespective of the same cross drainage work in the form of box drainage / open outfall will be provided all along the road network at an interval of 30m. The storm water network proposed is close pipe network with minimum 600mmø. The material of Pipe shall be RCC NP-IV.

Collection from the Road surfaces

The road surface runoff will be collected into the catch basin on the side of the driveway and the runoff collected will be disposed to the drainage network in the utility corridor. The road side open channels are also proposed on the curves, steep slope and probable locations on the over flooding / stagnation of the runoff. Even in case of over flooding the vehicular movement shall not get on hold. The surface runoff from the other part of the road network like cycle tracks, jogging tracks and pathways shall be collected and transferred into the road side storm drainage network.

The cross drainage network shall be proposed on the natural streams and the probable locations at intervals of minimum 300M so that the runoff from the outside the project area will be disposed to the river. The back flow prevention measures shall be taken in order to avoid the inflow from the River during monsoon.

It is observed that the most of the drainage network are clogged due to the silt stagnation in to the drainage network. All the inspection chambers proposed for road network shall be constructed with the provisions of oil, grease & silt separation so that the silt shall not enter into the drainage network.

Collection from the common landscape, amenity, road side areas

The premises are proposed with the large open green spaces along the Riverfront and Kaileshwar hills. The subsurface drainage network will be proposed for the green spaces and lawns. This is proposed as the ground water table is high and possibility of the saturation in the root zone of the lawn is more. In order to avoid the damages to the root it is recommended to adopt subsurface drainage for the landscape green spaces.

The runoff from the hard pavement like pathway jogging track and other area (hard and semi hard) shall be collected with the drainage gully and the opening. These drainage gully are connected by the pipe network. The pipe used for this system shall be U PVC or DWC pipe.

Collection & conveyance from outside the premises

The hillock is located on the upstream side of the premises in all the zones. At the same major streams are leading towards the river are passing through the development. The higher values and concentration shall be given to this area as it may cause the major reason for flooding in the area.

Runoff Design for ALDTP-

The runoff from the premises is calculated on the basis of the CPHEEO manual guidelines and rational method. There are two separate network proposed for surface runoff collection from the driveways and runoff from the premises after development.

Runoff from the Driveways: for 40M wide Road

The Width of the driveway:	7.00M
Interval of Collection Basis:	15.00M
Rainfall Intensity:	100MM/hr.
Runoff coefficient:	0.90
Runoff from the premises:	Q= 10 CIA
Runoff:	Q= 10 x (10.50 x 15.00) x 0.90 x 0.10
	Q= 0.01418 m3 / sec.

Cross Sectional Area proposed: Velocity is considered as 0.80 and the cross sectional area of the section is proposed is 0.16 which is higher than the required area of 0.075m. The runoff from the driveways will be collected through the cross drain at an interval of 15M.

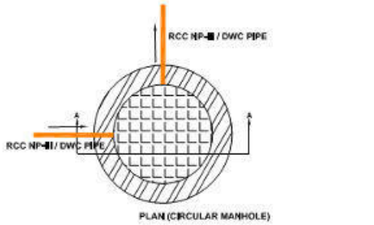
Runoff from the Plotted development:

Area of the plot:	0.60 Ha
Area under hard pavement;	0.30 Ha
Area under soft pavement;	0.30
Runoff coefficient:	0.90 / 0.40
Runoff from the premises:	Q= 10 CIA
	Q= 10 (0.30 x 0.90 x 0.10) + 10 (0.30 x 0.40 x 0.10)
	Q= 390.00 m3 / hr. i.e. 0.11 m3 /Sec.
Cross Sectional Area required:	Q= AV
	V- 1/n 3.968 x 10^-3 x D2/3 x S 1/2
	Pipe Die required is 0.30M
	Pipe diameter proposed is 450mm RCC NP-II Pipe.

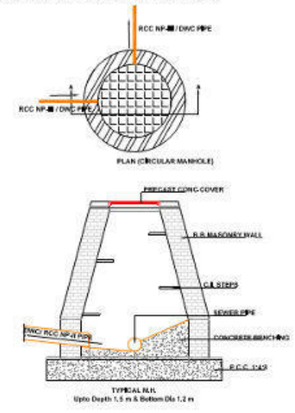
Recommended System Components for ALDTP-

The system components will be defined based on the class of the runoff. The runoff from the upstream side Kaileshwar hills will be collected in to the catch basins proposed on the downstream side of the respective stream. The overflow provisions are proposed for the catch basins and open channel is proposed for collection. This open channel is discharged into the River outside the boundary. The runoff from the landscape area will be collected into the subsurface drainage network and then disposed the network along the roads

Figure 9-13: Map showing the Storm water system in ALDTP



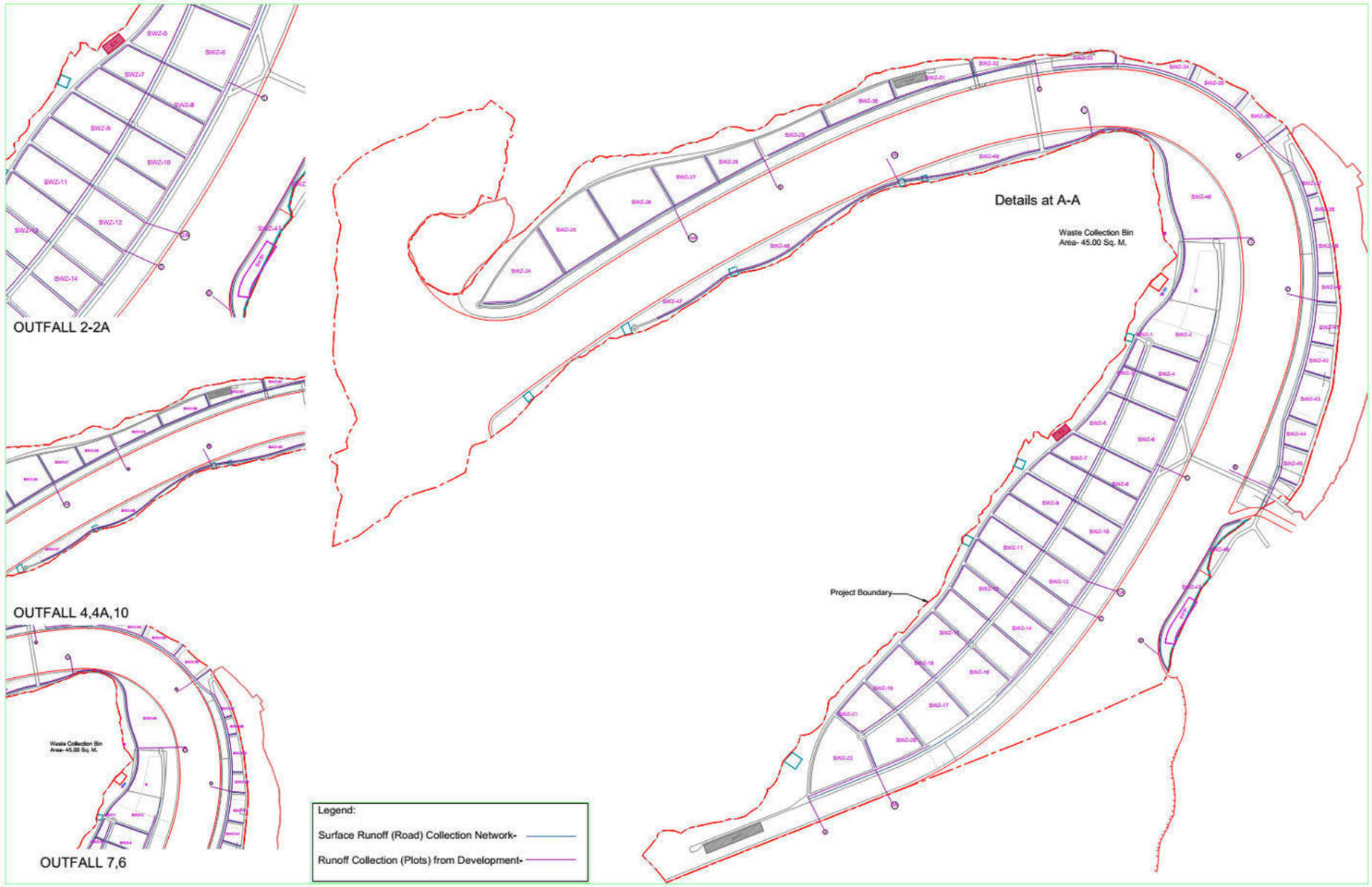
CIRCULAR MANHOLE DETAILS



01	STREAM C-01	AREA-59.00 ha	0.4	0.05	1546.66	
02	STREAM C-02	AREA-34.00ha	0.4	0.05	1888.88	
03	STREAM C-03	AREA-28.00ha	0.4	0.05	1555.55	
04	STREAM C-04	AREA-21.00 ha	0.4	0.05	1166.66	
05	STREAM C-05	AREA-12.00 ha	0.4	0.05	1162.22	
06	STREAM C-06	AREA-15.00 ha	0.4	0.05	666.66	
07	STREAM C-07	AREA-26.00 ha	0.4	0.05	1444.44	
08	STREAM C-08	AREA-35.00 ha	0.4	0.05	1944.44	
09	STREAM C-09	AREA-24.00 ha	0.4	0.05	1333.33	

Kalleshwar Hills Flow Details

Figure 9-14: Storm water collection and conveyance system



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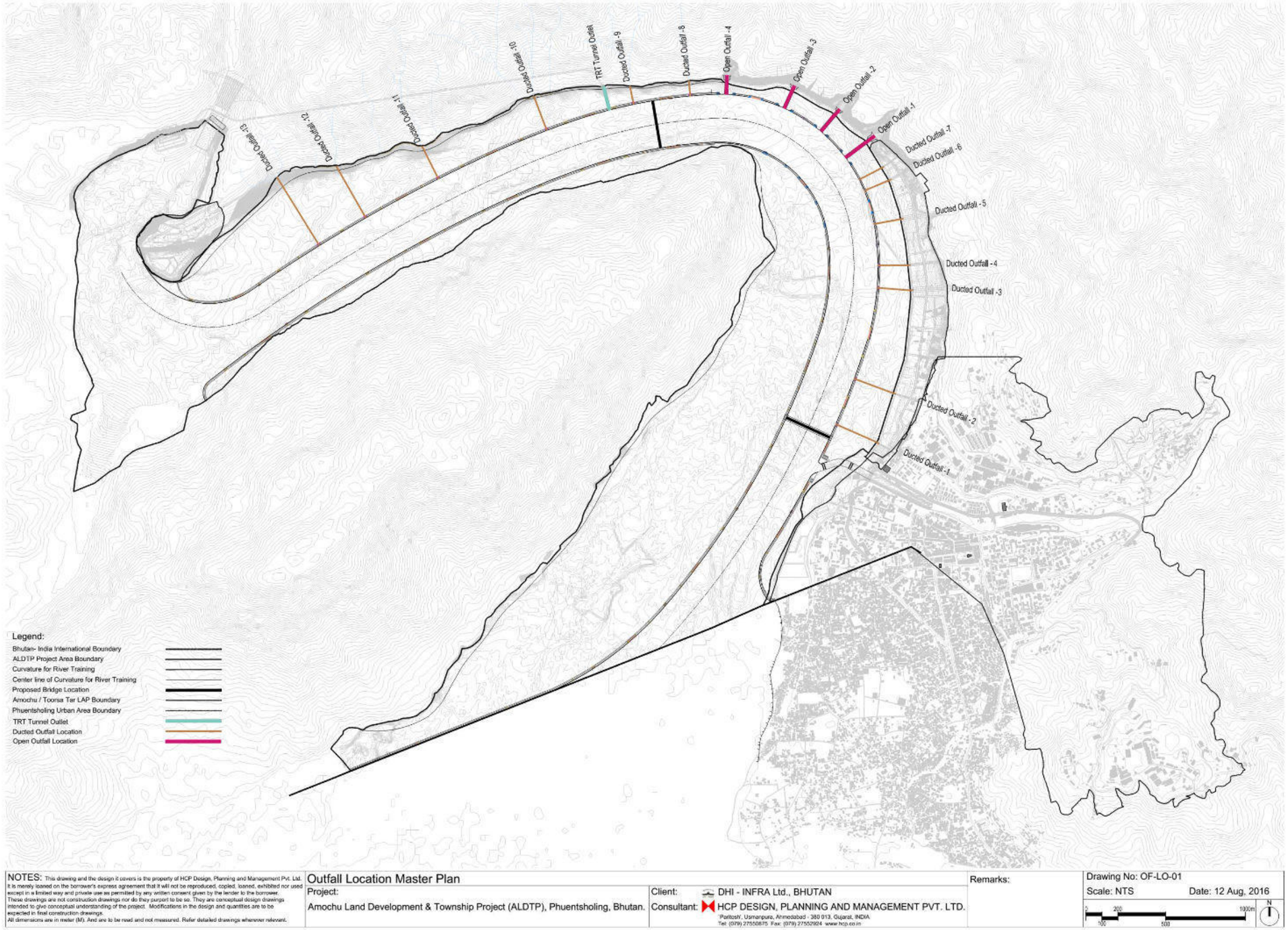
	Project: Amochu Land Development & Township Project (ALDTP), Phuentsholing, Bhutan.	Client: DHI - INFRA Ltd., BHUTAN Consultant: HCP DESIGN, PLANNING AND MANAGEMENT PVT. LTD. UNITY CONSULTANTS PVT. LTD.		Scale: NTS Date: 12 August, 2016 N 0 10 5 20

Figure 9-15: Storm Water Layout map



Appendix 8:
Solid Waste Management

Like the water and wastewater management systems, the solid waste treatment facility is proposed in phases. In the first phase, the wet / biodegradable treatment facility is proposed within the ALDTP and the dry / inert (non-biodegradable wastes) will be transferred to Phuentsholing Treatment unit.

Solid waste quantities will be evaluated every five years or whenever a significant new development is approved (within the overall master plan context) and the solid waste master plan accordingly re-worked.

Sludge from STPs

Due to SBR technology selection, the sludge generation will be minimum. The sludge which will be generated will be transported to filter presses and the finally dried sludge will come out in the cake form. This cake can be used for the landscaping within the premises as a soil conditioner / manure and due to this sludge drying beds have currently not been provisioned.

E-wastes

- E-Wastes for ALDTP: 500 kg/day
- For Zone A: 120 kg/day
- Bio-medical wastes
- Bio-medical Wastes: provisionally, up-to 1.0 TPD are expected to be generated from clinics, hospitals and other treatment facilities within the Township.

Waste Collection and Transport

Collection Bins

As per National Integrated Solid Waste Management Strategy, the following types of colored bins would be used depending on the type of waste.

Green Bins – For Organic waste

Blue Bins – For inorganic Waste

Red Bins – For all kinds of Healthcare Waste

Yellow Bins – E waste

Separate collection of inert waste like road sweep, drain silt, etc. will be done. Construction and demolition waste will be stored separately.

Collection from Residential Areas

Wastes will be transported and stored in segregated format until further processing and disposal. Segregated waste from each household will be collected in similar colored bins provided to waste pickers on vehicle, which will be transferred in segregated form only in the collection vehicle. For this purpose, small collection vehicles with dedicated dry and wet waste containers (capacity of 2 Tonnes) of green and white color would traverse all relevant arterial and feeder roads every day at predetermined times for waste collection.

Market Place and Community Centers

Bin systems will be introduced, in public places, like market place, community centers, commercial malls, Entertainment Park, gardens, public parks etc. The size of the bins will depend on the quantity of waste to be generated at the respective site.

It is currently proposed to have a 3.5 m3 bin each for food waste of bio-degradable in nature comprising of fish chicken and mutton waste, vegetable waste etc. For various kinds of non-biodegradable and recyclable wastes bins shall be kept at strategic locations. Apart from these, there would be a 2-bin waste of 120 liters located at every 500 meter distance along the lanes within the shopping centers /shopping plaza.

Sorting of Waste

Currently, it is assumed that sorting of wastes will either not be required owing to the fact that in the ALDTP it will be possible to collect segregated wastes from various sources. In case mixed (i.e. unsegregated waste is generated, arrangements will be made for a sorting in the centralized processing plant.

Treatment and Disposal of Wastes

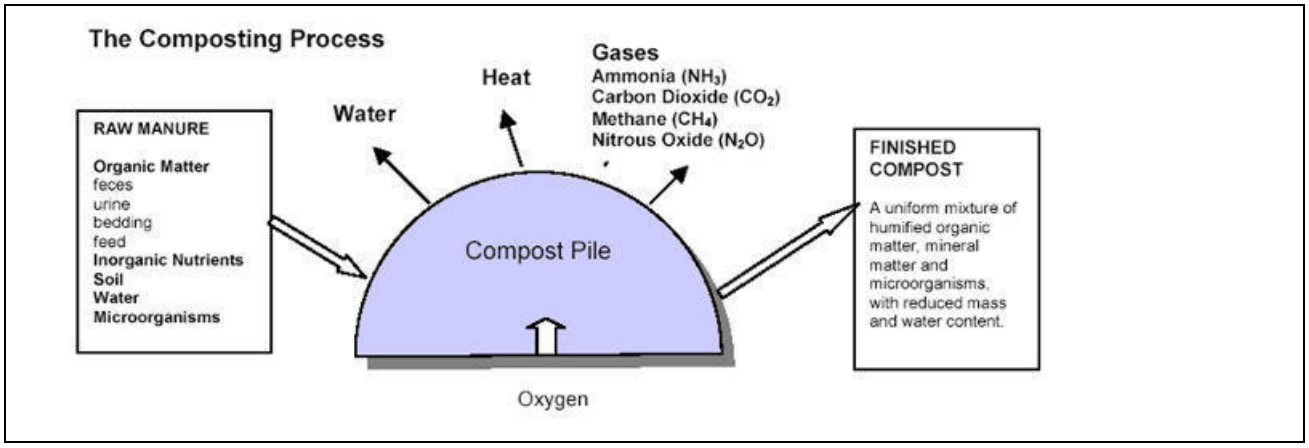
Wet Waste (Bio-Degradable Wastes): Composting

Windrow composting is the production of compost by piling organic matter or biodegradable waste in long rows ('windrows'). This method is suited for producing large volumes of compost. These rows are generally turned to improve porosity and oxygen content, mix in or remove moisture, and redistribute cooler and hotter portions of the pile. Composting process control parameters include the initial ratios of carbon and nitrogen rich materials, the amount of bulking agent added to assure air porosity, the pile size, moisture content, and turning frequency. Windrow composting has distinctive advantage over the other process i.e.

- Can handle large quantity of solid waste
- Low cost intensive
- Easier operation as lesser controlling parameters required to be handled
- Acceptance worldwide

The flow chart of the Windrow Composting Process is shown in Figure 9-16.

Figure 9-16: Flow chart of Windrow Composting process



The comparison between windrow composting, mechanical composting and Vermi composting processes are presented is shown in Table 9-21.

Table 9-21: Comparison of composting processes

Sl. No	Windrow Composting	Vermi Composting	Mechanical Composting
1	Large quantity of solid waste can be handled	Effective for low quantity of solid waste	Effective for low quantity of solid waste
2	Quick start up time	The primary disadvantage of vermiculture, is that it can take many months, to build up a large working population of earthworms capable of vermicomposting	Quick start up time
3	Easy in operation as lesser controlling parameters are required	Operation is difficult as worms are very susceptible of toxic material present in MSW and high chances that worms die due to presence of some heavy metals or toxic elements in MSW. Vermicomposting is carried out at relatively low temperatures (under 25 °C). It is vitally important to keep the temperature below 35 °C,	Easy in operation if nature of waste is 100 % biodegradable.

Sl. No	Windrow Composting	Vermi Composting	Mechanical Composting
		otherwise the earthworms will be killed	
4	As in this process, temperature exceed more than 70°C, all the pathogens get destroyed, problem of rodents and insect pests is avoided	As vermicomposting works at relatively low temperatures, so complete elimination of pathogens is not possible during the vermicomposting process	The process, takes place at high temperature therefore pathogens get destroyed.
5	The quality of compost will have less % of NPK as compared to vermi compost, but will comply with the organic manure norms	One big advantage of using earthworms to compost waste is that the resulting compost often contains much more nitrogen and plant available nutrients than windrow compost.	The quality of compost is good and have high % of NPK
6	Area requirement for the processing is less	Area Requirement is more.	Area requirement is very less
7	It is effective for Mixed MSW.	Require segregated waste only i.e. pure Organic waste	Only 100% segregated bio-degradable waste can be treated in composting machine
8	Windrow composting is well established and successful technology for MSW and acceptable worldwide	Vermi composting has very good result on Press mud waste and other waste which are fully organic in nature and doesn't contain toxic material, but not so successful on MSW.	This technology is better for homogeneous kind of bio degradable waste. Not good for mixed MSW,
9	Cost effective process	Costlier process than wind row composting but less that mechanical composting	Capital cost very high; maintenance cost also high

Based on the comparison as stated above the process of windrow composting has been selected in this project because of the following reasons:

As it is very difficult to provide only organic matter to the compost plant daily, there is always a possibility that the incoming waste contain some contaminants which are not suitable for the growth of the worms and results in the deaths of the worms. But in case of windrow composting, there won't be any such constraint as windrow composting can also be effective for mixed MSW.

Since 100% (or Very High) bio-degradable waste is practically very difficult to segregate from a mixed waste of ALDTP, mechanical composter may not be very effective

Windrow Composting is well established and successful technology for MSW and is acceptable worldwide.

Hence a windrow composting Plant is proposed for processing the bio-degradable portion of the waste for ALDTP. The resulting manure / soil conditioner resulting from the composting process will be used for greenbelt development within the Township. The final compost parameters will be monitored and maintained. The acceptable outlet parameters are shown in Table 9-22.

Table 9-22: Recommended Outlet Parameters

S. No.	Parameters	Unit	Recommended Values
1	pH	-	7.0
2	Moisture	%	18.00
3	Color	--	Blackish Brown
4	Odour	--	Absence of foul smell
5	Bulk density	gm. /cm^3	0.36
6	Total Organic Carbon	%	24.00
7	Total Nitrogen as N	%	1.80
8	Total Phosphate P2 O5	%	0.075
9	Potash as K2O	%	1.116
10	C : N Ratio	--	1:18 to 1:20
11	Particle Sizes	%	88% passes through 4mm sieve

Dry Waste (Recyclables): Recycling Facility in Central Processing Plant

The storage & segregation facility is proposed for the dry waste and the segregated waste will be handed over to the Scrap dealers periodically. A separate dedicated area of minimum 6400 sq. m. has been left for setting up of a processing plant in ALDTP.

The centralized processing plant would receive segregated waste in wet and dry form. The centralized processing plant would receive segregated waste in wet, dry and mixed form. The dry waste processing would utilize manual labour or equipment that separate material into various streams e.g. fiber, paper, plastic, containers etc. into the storage yards. The wet waste collected in the segregated form from collection points would be pre-processed before sending for composting. The processing facility would be complete with pre-sorting material handling equipment, various size reduction facilities for metal cans, plastic bottles etc. The processing facility would also comprise of pollution control equipment and other equipment.

Inert Waste: Sanitary Landfill

Inert wastes could be from street sweeping as well from reprocessing facilities, amongst others. Waste inert will be sent to the sanitary landfill.

The sanitary landfill will be carried out by Phuentsholing Thromde (PCC).The Project Proponent has requested for provision of an area of 4000 Sq. M. and following up for the same is being done as agreed by Phuentsholing Thromde.

A sanitary landfill will be designed (as per guidelines of Waste Prevention and Management Regulation (2012) by NEC, Bhutan) for scientific dumping of rejects and non-recyclable materials will be provided within the township. Liner system for the landfill will consist of HDPE geo-membrane and geo textile layers to be laid over compacted clay layer of 900 mm thickness. The clay layer would be of bentonite clay to be laid over native compacted soil to 95% Procter density. Suitable leachate collection and conveyance system will be put in place with leachate treatment facilities for the same.

Collection and Treatment of Leachate from Sanitary Landfill

Leachate collection system including leachate pond and leachate treatment system would be set up in combination with STP to manage leachates arising from the sanitary landfill.

The leachate collection system would be designed to take care of water generated from a storm resulting in maximum rainfall in 24 hours continuously for 72 hours based on a 50 years historical storm data. Leachate pond would be essentially a 2-chamber pond with liner system in the bottom and side walls to hold the leachate without percolating into the soil underneath for treatment of same.

Biomedical Waste

The biomedical waste generation is estimated from the project area. The quantity estimated is in the tune of 1.00 tones/ day. The biomedical waste facility will be developed with the medical facility in the respective zone. The responsibility of developing the facility will lies with the Hospital management. The medical waste treatment facility will be developed in line with the NEC/ WHO guidelines. The medical waste treatment facility will be developed operated by the owner / Hospital only.

Treatment of bio-medical wastes will follow the general procedures given in Table 9-23.

Table 9-23: General procedure for handling and disposal of bio-medical wastes

Category	Type of Waste (with examples)	Type of Bag or Container to be Used	Treatment and Disposal Options
	Soiled Waste: Items contaminated with blood, body fluids like dressings, plaster casts, cotton swabs and Bags containing residual or discarded blood and blood components		Autoclaving or micro-waving / hydroclaving followed by shredding or mutilation or combination of sterilization and shredding. Treated waste to be sent for energy recovery
	Expired or Discarded Medicines: Pharmaceutical waste like cytotoxics including contaminated cytotoxic drugs along with glass or plastic ampoules, vials etc. antibiotics, drugs etc.		Expired `cytotoxic drugs and items contaminated with cytotoxic drugs to be returned back to the supplier with proper documentation. Common bio-medical waste treatment facility or hazardous waste treatment, storage. Encapsulation or Plasma Pyrolysis at >1200° C. All other discarded medicines shall be either sent back to manufacturer
	Chemical Waste: Chemicals used in production of biological and used or discarded disinfectants.		Disposed by Plasma Pyrolysis or Encapsulation in hazardous waste treatment, storage and disposal facility.
Yellow	Chemical Liquid Waste: Liquid waste generated due to use of chemicals in production of biological and used or discarded disinfectants Silver X-ray film developing liquid Discarded formalin Infected secretions, aspirated body fluids Liquid from laboratories and floor washings, cleaning, house-keeping and disinfecting activities	Separate collection system leading to effluent treatment system	After resource recovery, the chemical liquid waste shall be pre-treated before mixing with other wastewater. The combined discharge shall conform to the discharge norms given by the NEC.

	Discarded linen, mattresses, beddings contaminated blood or body fluid	Non-chlorinated yellow plastic bags or suitable packing material	Non- chlorinated chemical disinfection followed by Plazma Pyrolysis or for energy recovery. In absence of above facilities, shredding or mutilation or combination of sterilization and shredding. Treated waste to be sent for energy recovery or Plazma Pyrolysis.
	Microbiology, Biotechnology and other clinical laboratory waste: Blood bags, Laboratory cultures, stocks or specimens of micro-organisms, live or attenuated vaccines, human and animal cell cultures used in research, industrial laboratories, production of biological, residual toxins, dishes and devices used for cultures.	Autoclave safe plastic bags or containers	Pre-treat to sterilize with non- chlorinated chemicals on-site as per World Health Organization guidelines thereafter for Incineration (if required)
Red	Contaminated Waste (Recyclable): Wastes generated from disposable items such as tubing, bottles, intravenous tubes and sets, catheters, urine bags, syringes (without needles and fixed needle syringes) and vaccutainers with their needles cut) and gloves.	Red colored non-chlorinated plastic bags or containers	Autoclaving or micro-waving/ hydroclaving followed by shredding or mutilation or combination of sterilization and shredding. Treated waste to be sent to registered or authorized recyclers or for energy recovery or plastics to diesel or fuel oil or for road making, whichever is possible. Plastic waste should not be sent to landfill sites.
White (Translucent)	Waste sharps including Metals: Needles, syringes with fixed needles, needles from needle tip cutter or burner, scalpels, blades, or any other contaminated sharp object that may cause puncture and cuts. This includes both used, discarded and contaminated metal sharps	Puncture proof, Leak proof, tamper proof containers	Autoclaving or Dry Heat Sterilization followed by shredding or mutilation or encapsulation in metal container or cement concrete, or Combination of shredding cum autoclaving along with final disposal to iron foundries (having valid NEC permits), or Sanitary landfill or designated concrete waste sharp pit
Blue	Glassware: Broken or discarded and contaminated glass including medicine vials and ampoules except	Cardboard boxes with blue colored marking	Disinfection (by soaking the washed glass waste after cleaning with detergent and Sodium Hypochlorite treatment) or

	those contaminated with cytotoxic wastes.		Through autoclaving or microwaving, or Hydroclaving and then sent for recycling.
	Metallic Body Implants		Similar to glassware

*Disposal by deep burial is permitted only in rural or remote areas where there is no access to common bio-medical waste treatment facility. This will be carried out with prior approval from the relevant authority and as per the specified. The deep burial facility shall be located as per the provisions and guidelines issued by relevant authority

E-wastes

For dumping of E-waste in landfill, it will be necessary to establish collection and recycling process for waste from residential, commercial, institutional and industrial zones of ALDTP. Separate arrangement for E-waste collection, storage of collected E-waste until further transport shall be arranged in central processing facility.

Figures and Diagrams

Figures and Diagrams depicting Solid Waste Management concepts are shown in Figure 9-17, and Figure 9-18

Figure 9-17: Solid Waste Treatment Plant – Zone A- GAD

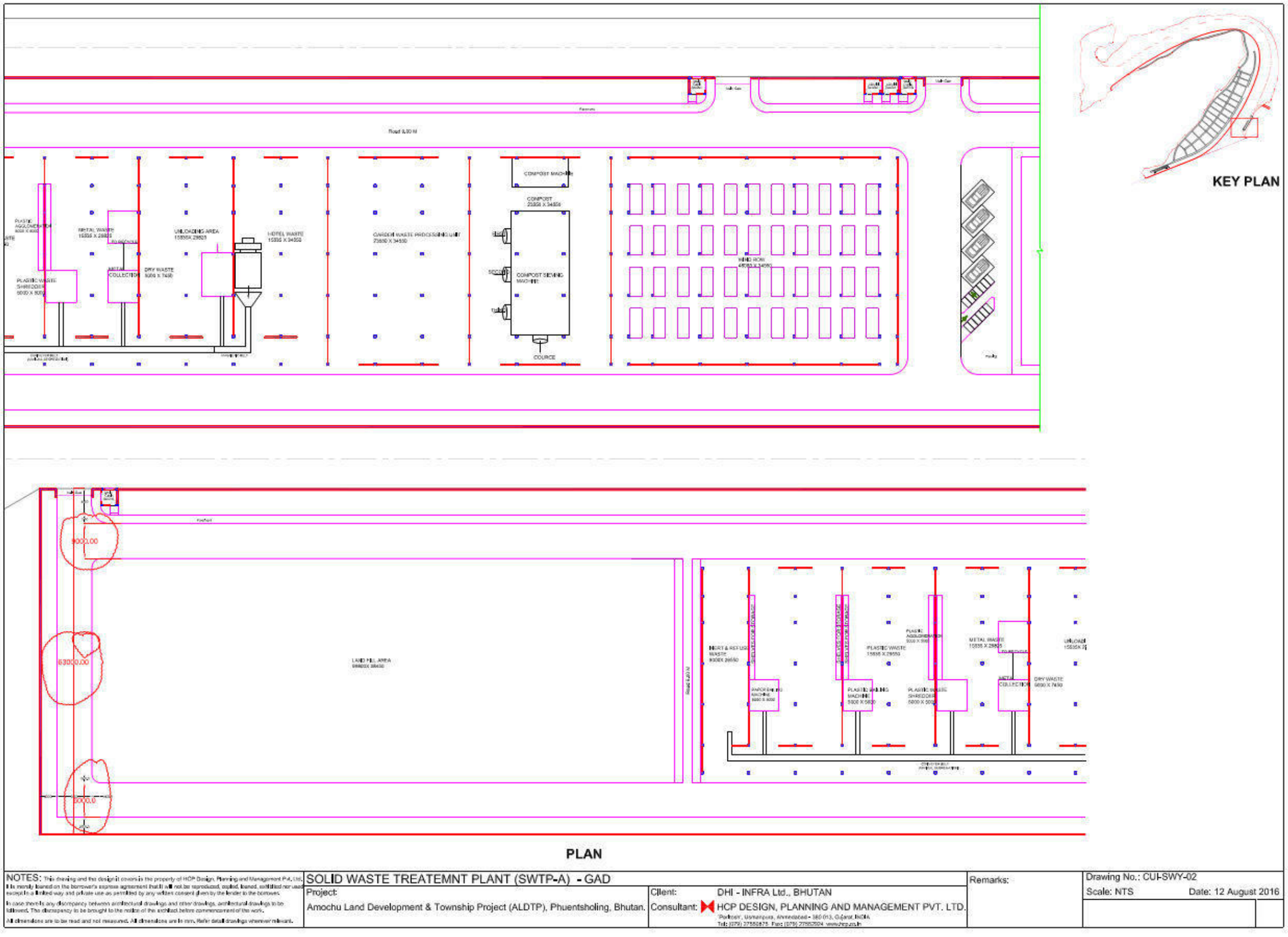
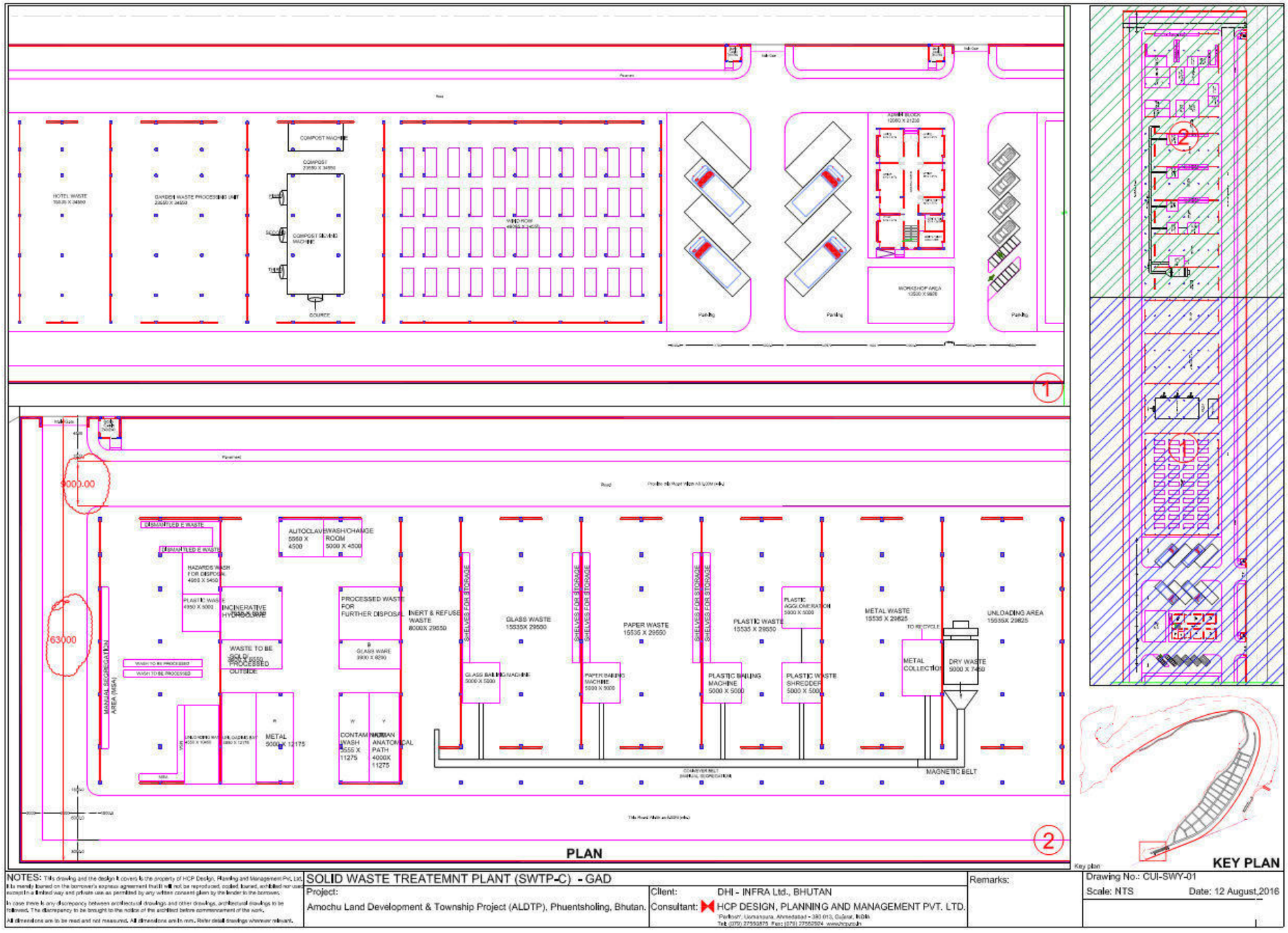


Figure 9-18: Solid Waste Treatment Plant – Zone C- GAD



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In case there is any discrepancy between architectural drawings and other drawings, architectural drawings to be followed. The discrepancy to be brought to the notice of the architect before commencement of the work.
All dimensions are to be read and not measured. All dimensions are in mm. Refer detail drawings wherever relevant.

SOLID WASTE TREATEMNT PLANT (SWTP-C) - GAD

Project: Amochu Land Development & Township Project (ALDTP), Phuentsholing, Bhutan.

Client: DHI - INFRA Ltd., BHUTAN

Consultant: HCP DESIGN, PLANNING AND MANAGEMENT PVT. LTD.
Parikrati, Usmanpura, Ahmedabad - 380 013, Gujarat, INDIA
Tel: (079) 27559875, Fax: (079) 27550924, www.hcpsurat.in

Remarks:

Drawing No.: CUI-SWY-01
Scale: NTS Date: 12 August,2016

Appendix 9:
Power supply and Distribution system and substation

Based on the total power requirement it is proposed to have substations having transformers as per demand requirements of the premises. The switching station / RMU will be proposed in the area and the sufficient land shall be made available to the concern authority. All the substations with transformers shall be located near the load centers as close as possible to reduce the distribution losses to minimum possible. All these switching stations will be connected to the grid and the entire substation will be interconnected with ring system as per the guidelines to avail reliability.

The planned components are:

- The power requirement is estimated in the tune of 90 MvA.
- The power source is available in the vicinity. The power will be tapped on the overhead lines running close to the project area.
- The 66 kV overhead line will bring to the project area.
- A 220/ 66 x 11kV substation is proposed as power block for ALDTP.
- 66 / 33 or 11kV switching station shall be proposed as 1 no. for Zone-A. The power received from the source will be lowered down to the desired level at the switching station.
- A 33 / 11 kV underground H T line is proposed to supply the power to the zonal substations.
- An 11/0.4kV substation in respective premises as per demand load.

The power supply components will include:

- Overhead lines and underground HT cables for transmission
- Switching stations
- Sub-stations
- HT Breaker for RMU
- Transformer
- LT feeder pillars

The HT line will run in grid system in the premises along the main road. The LT supply for street lighting and the area lighting will be carried out from the substation and feeder pillars will be placed at an interval of 500m along the roads.

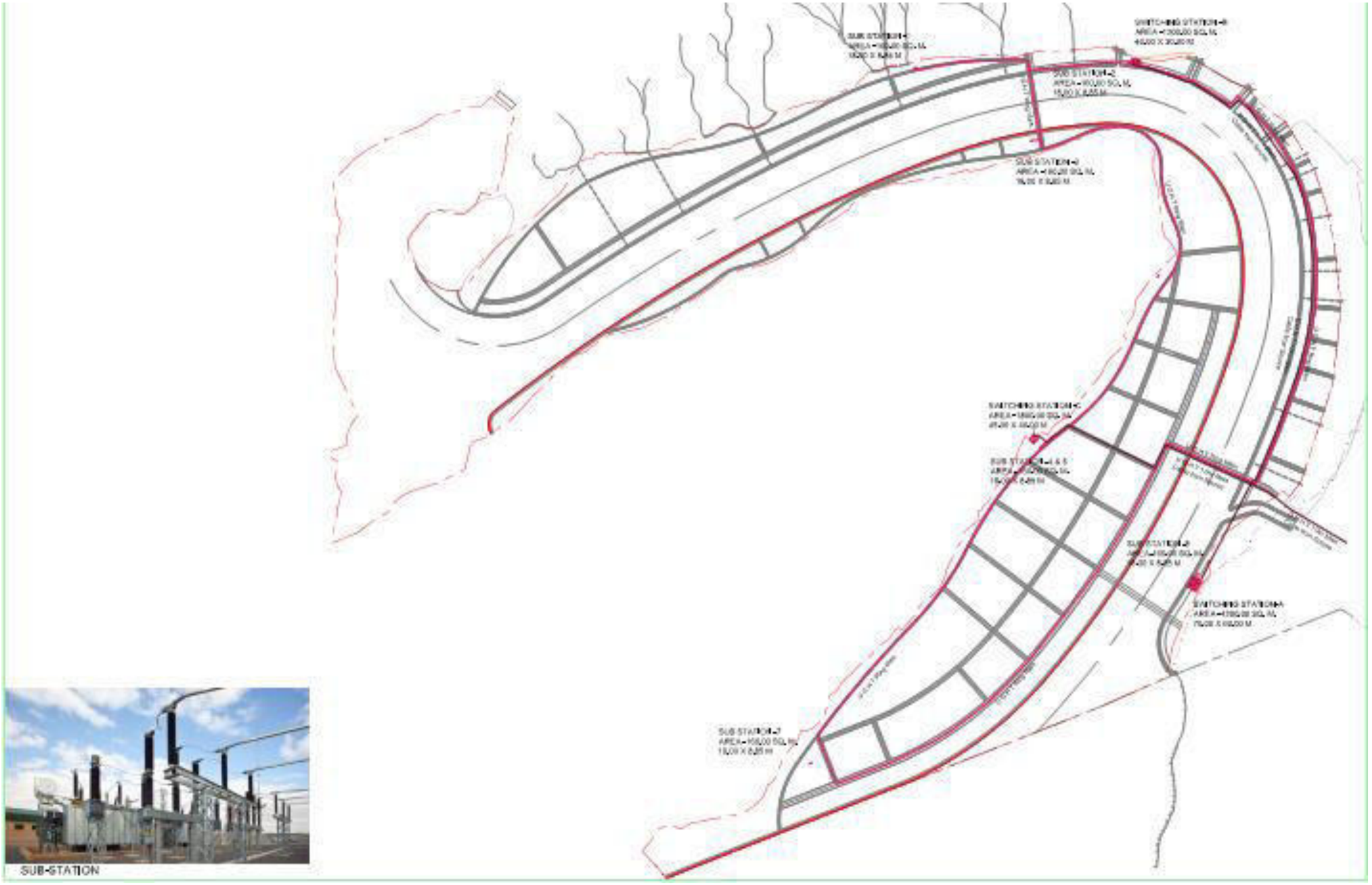
Automated street lighting system for the street and area lighting.

Power consumption control in the form of LED lights for common area and the residential area is proposed within the project site.

Figures and Diagrams

Power supply system for ALDTP is shown in ***Figure 9-19*** and the Substation location and HT layout is shown in ***Figure 9-20***.

Figure 9-19: Power supply system for ALDTP



SUB-STATION

Figure 9-20: Substation location and HT layout

Feeder Pillar Installation

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	Project: Amochu Land Development & Township Project (ALDTP), Phuentsholing, Bhutan.	Client: DHI - INFRA Ltd., BHUTAN Consultant: HCP DESIGN, PLANNING AND MANAGEMENT PVT. LTD. UNITY CONSULTANTS PVT. LTD.		Scale: NTS Date: 12 August, 2016 N 0 10 5 20

Appendix 10:
Land Use
&
Landover classification

Classification of Land use and Landover

The National Remote Sensing Agency (NRSA), Government of India, conducted a land use survey using Remote Sensing Techniques in the year 1988-89 at the behest of the Planning Commission for classifying land by visual interpretation techniques and digital techniques. NRSA's output resulted in a two-level system of classification, comprising seven primary land use / land cover categories. Some of these primary categories required further delineation, leading to a second level of classification that resulted in further sub-categories.

This system of classification has been the basis for Kadam's land use / land cover studies. Whilst these categories are generally found relevant with respect to describing land use and land cover classes in the Indian context, sometimes modifications are required, and made, to include additional sub-categories, which are more relevant in describing the land use and land cover for a particular study. Such sub-categories are defined, in any case.

The definitions for the primary and secondary categories are provided in the following sections.

Built up Land or Habitation

It is defined as an area of human habitation developed due to non-agricultural use and that, which has a cover of buildings, transport, communication utilities in association with water vegetation and vacant lands.

The primary land use category has been further categorized as residential and industrial.

Residential / Commercial

Structures used by humans for living and working, but not including structures used exclusively for manufacturing.

Industrial

Structures used for manufacturing products.

Agricultural Land

It is defined as the land primarily used for farming and for production of food, fiber, and other commercial and horticultural crops. It includes land under crops (irrigated and un-irrigated), fallow land and plantations. These are further defined.

Crop Land

It includes those lands with standing crop (per se) as on the date of the satellite imagery. The crops may be of either Khari (June-September) or Rabi (October – March) or Khari Rabi seasons.

Fallow Land

It is described as agricultural land which is taken up for cultivation but is temporarily allowed to rest un-cropped for one or more seasons, but not less than one year. These lands are particularly those which are seen devoid of crops at the time when the imagery is taken during Rabi and Khari.

Plantations

Plantations are described as an area under agricultural tree crops (for e.g. mango plantations) planted adopting certain agricultural management techniques. It includes tea, coffee, rubber, coconut, arecanut, citrus, orchards and other horticultural nurseries.

Forests

It is an area (within the notified forest boundary) bearing an association predominantly of trees and other vegetation types capable of producing timber and other forest produce. Forests can be further divided into sub-categories mentioned as follows.

Evergreen / Semi-Evergreen Forests

These are forests which comprise thick and dense canopy of tall trees, which predominantly remain green throughout the year. Such forests include both coniferous and tropical broad-leaved evergreen trees. Semi-evergreen forests are often a mixture of both deciduous and evergreen trees but the latter predominate.

Deciduous Forests

These are described as forests which predominantly comprise of deciduous species and where the trees shed their leaves once in a year.

Degraded Forest or Scrub

It is described as a forest where the vegetative (crown) density is less than 20% of the canopy cover. It is the result of both biotic and abiotic influences. Scrub is a stunted tree or bush/shrub.

Scrub (Forest)

All lands with poor tree growth mainly of small or stunted trees having canopy density less than 10 per cent. Scrub is a stunted tree or bush/shrub.

Open forest

All lands with tree cover of canopy density between 10 to 40 percent.

Dense Forest

All lands with tree cover of canopy density of 10 percent and above.

Forest Blank

A forest blank is an opening amidst forests without any tree cover. It includes openings of assorted size and shapes as seen on the imagery.

Forest Plantations

It is described as an area of trees of species of forestry importance and raised on notified forest lands. It includes eucalyptus, casuarinas, bamboo, etc.

Land with / without Scrub

They occupy (relatively) higher topography like uplands or high grounds with or without scrub. These lands are generally prone to degradation or erosion. These exclude hilly and mountainous terrain.

Sandy Area (Coastal and Deserted)

These are the areas, which have stabilized accumulations of sand in-site or transported in coastal riverine or inland (desert) areas. These occur either in the form of sand dunes, beaches, channel (river/stream) islands, etc.

Barren Rocky / Stony Waste / Sheet Rock Area

It is defined as the rock exposures of varying lithology often barren and devoid of soil cover and vegetation and not suitable for cultivation. They occur amidst hill forests as openings or scattered as isolated exposures or loose fragments of boulders or as sheet rocks on plateau and plains. It includes quarry or gravel pit or brick kilns.

Water Bodies

It is an area of impounded water, areal in extent and often with a regulated flow of water. It includes man-made reservoirs/lakes/tank/canals, besides natural lakes, rivers/streams and creeks.

River / Stream

It is a course of flowing water on the land along definite channels. It includes from a small stream to a big river and its branches. It may be perennial or non-perennial.

Reservoir / Lakes / Ponds / Tanks/Canal

It is a natural or man-made enclosed water body with a regulated flow of water. Reservoirs are larger than tanks/lakes and are used for generating electricity, irrigation and for flood control. Tanks are smaller in areal extent with limited use than the former. Canals are inland waterways used for irrigation and sometimes for navigation.

Vegetation Cover

It is a land area predominantly covered with vegetation and is not part of Protected / Reserved Forests.

Scrub

It is described as a vegetative cover having density less than 10% of the canopy cover. Scrub is area covered by grasses or herbs and scattered tree or shrubs.

Open Vegetation

This is categorized based on the vegetation cover having density ranging between 10% - 40% of the canopy cover.

Dense Vegetation

This is categorized based on the vegetation cover having density greater than 40% of the canopy cover.

Others

It includes all those land use and land cover classes which can be treated as miscellaneous because of their nature of occurrence, physical appearance and other characteristics.

Appendix 11:
Ground Water Analysis

Appendix 11: Ground water analysis

1st Season – winter season

Table 9-24: Ground water analysis results (1st Season – winter season)

Sr. No.	Parameters	Unit	IS 10500 Standard Limits for Drinking Water		Groundwater Quality, Date of Sampling & Source	
			Desirable Limit	Permissible Limit	GW1	GW2
1	pH	pH Scale	6.5 – 8.5	6.5 – 8.5	7.03	7.25
2	Temperature	˚C	NS	NS	19.2	19.2
3	Turbidity	NTU	5	10	<0.1	<0.1
4	TDS	mg/lit	500	2000	68	120
5	Electrical Conductivity	µmho/cm	NS	NS	171	256
6	COD	mg/lit	NS	NS	<5	<5
7	BOD	mg/lit	NS	NS	<3	<3
8	Phenol	mg/lit	0.001	0.002	<0.001	<0.001
9	Chlorides	mg/lit	250	1000	21	26
10	Sulphates	mg/lit	200	400	7	15
11	Total Hardness	mg/lit	300	600	40	70
12	Ca++ Hardness	mg/lit	NS	NS	24	52
13	Mg++ Hardness	mg/lit	NS	NS	16	18
14	Total Alkalinity	mg/lit	200	600	40	90
15	Nitrate	mg/lit	45	100	4.4	5.0
16	Fluoride	mg/lit	1.0	1.5	0.51	0.11
17	Sodium	mg/lit	NS	NS	2.1	18.3
18	Potassium	mg/lit	NS	NS	0.9	0.3
19	Calcium	mg/lit	75	200	9.6	20.8
20	Magnesium	mg/lit	30	100	3.9	4.4
21	Salinity	mg/lit	NS	NS	39	46
22	Total Nitrogen	mg/lit	NS	NS	1.40	1.51
23	Total Phosphorus	mg/lit	NS	NS	<1	<1
24	Dissolved Oxygen	mg/lit	NS	NS	2.8	2.9
25	Ammonical Nitrogen	mg/lit	NS	NS	0.24	0.18
26	SAR (Sodium Absorption Ratio)	-	NS	NS	0.14	0.95
27	Heavy Metals	mg/lit				
a	Arsenic (as As)	mg/lit	0.05	NR	<0.002	<0.002
b	Cadmium (as Cd)	mg/lit	0.01	NR	0.03	0.021
c	Chromium (as Cr)	mg/lit	0.05	NR	<0.003	<0.003

Sr. No.	Parameters	Unit	IS 10500 Standard Limits for Drinking Water		Groundwater Quality, Date of Sampling & Source	
			Desirable Limit	Permissible Limit	GW1	GW2
d	Copper (as Cu)	mg/lit	0.05	1.5	0.05	0.11
e	Cyanide (as CN)	mg/lit	0.05	NR	<0.003	<0.003
f	Iron (as Fe)	mg/lit	0.3	1	<0.3	<0.3
g	Lead (as Pb)	mg/lit	0.05	NR	<0.01	<0.01
h	Mercury (as Hg)	mg/lit	0.001	NR	<0.001	<0.001
i	Manganese (as Mn)	mg/lit	0.1	0.3	<0.04	<0.04
j	Nickel (as Ni)	mg/lit	-	-	<0.02	<0.02
k	Zinc (as Zn)	mg/lit	5	15	<0.08	<0.08
28	Total Coliform	MPN	10/100 ml	10/100 ml	Absent	Absent
29	Faecal Coliform	MPN	10/100 ml	10/100 ml	Absent	Absent

2nd Season – Summer Season

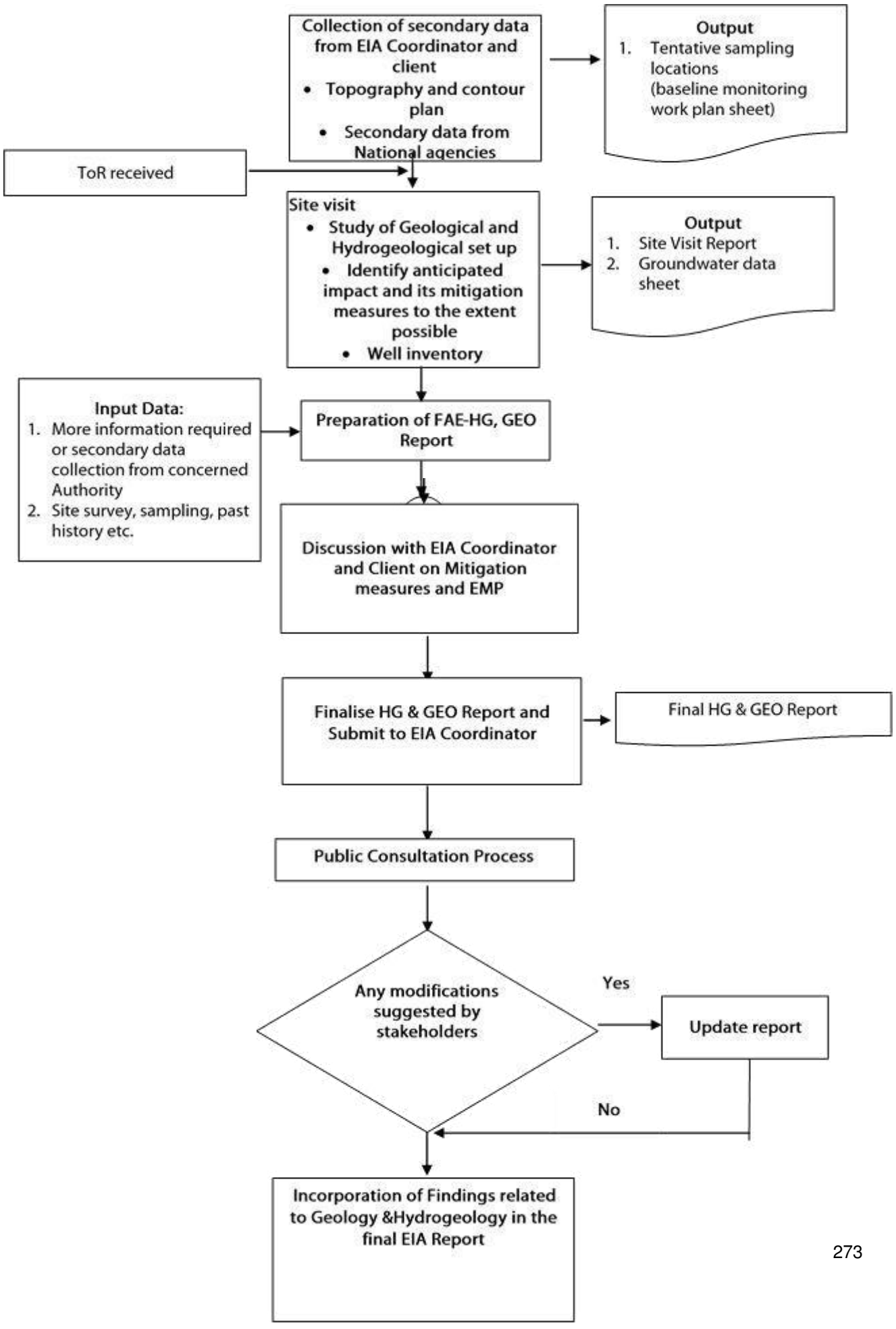
Table 9-25: Ground water analysis results (2nd Season – Summer Season)

Sr. No	Parameters	Unit	IS 10500 Standard Limits for Drinking Water		Groundwater Quality, Date of Sampling & Source	
			Desirable Limit	Permissible Limit	GW1	GW2
1	pH	pH scale	6.5-8.5	No Relaxation	7.40	7.14
2	Temperature	o C	NS	NS	23	23
3	Turbidity	NTU	1	5	<0.1	<0.1
4	TDS	mg/lit	500	2000	152	248
5	Electrical conductivity	µmhos/cm	NS	NS	194	358
6	COD	mg/lit	NS	NS	<5	<5
7	BOD	mg/lit	NS	NS	<3	<3
8	Phenol	mg/lit	0.001	0.002	<0.001	<0.001
9	Chlorides	mg/lit	250	1000	21	17
10	Sulphates	mg/lit	200	400	18	53
11	Total Hardness	mg/lit	200	600	130	220
12	Ca++ Hardness	mg/lit	NS	NS	72	120
13	Mg++ Hardness	mg/lit	NS	NS	58	100
14	Total Alkalinity	mg/lit	200	600	120	70
15	Nitrate	mg/lit	45	NR	1.1	5.9
16	Fluoride	mg/lit	1	1.5	0.11	0.68

17	Sodium	mg/lit	NS	NS	10	10
18	Potassium	mg/lit	NS	NS	2.3	2.3
19	Calcium	mg/lit	75	200	28.9	48.1
20	Magnesium	mg/lit	30	100	14.1	24.3
21	Salinity	mg/lit	NS	NS	38	30
22	Total Nitrogen	mg/lit	NS	NS	0.35	1.63
23	Total Phosphorous	mg/lit	NS	NS	<1	<1
24	Dissolved Oxygen	mg/lit	NS	NS	3.1	2.7
25	Ammonical Nitrogen	mg/lit	0.5	NR	<0.01	<0.01
26	SAR	-	NS	NS	0.38	0.29
27	Heavy Metals					
a	Arsenic (as As)	mg/l	0.01	0.05	<0.002	<0.002
b	Cadmium (as Cd)	mg/l	0.003	NR	<0.003	0.009
c	Chromium (as Cr)	mg/l	0.05	NR	<0.003	<0.003
d	Copper (as Cu)	mg/l	0.05	1.5	0.06	0.09
e	Cyanide (as CN)	mg/l	0.05	NR	<0.003	<0.003
f	Iron (as Fe)	mg/l	0.3	NR	<0.3	<0.3
g	Lead (as Pb)	mg/l	0.01	NR	<0.01	<0.01
h	Mercury (as Hg)	mg/l	0.001	NR	<0.001	<0.001
i	Manganese (as Mn)	mg/l	0.1	0.3	<0.04	<0.04
j	Nickel (as Ni)	mg/l	0.02	NR	<0.02	<0.02
k	Zinc (as Zn)	mg/l	5	15	<0.08	<0.08
28	Total Coliform	MPN	Shall not be detectable in any 100ml sample	Shall not be detectable in any 100ml sample	Absent	Absent
29	Faecal Coliforms	MPN	Shall not be detectable in any 100ml sample	Shall not be detectable in any 100ml sample	Absent	Absent

Appendix 12:
Methodology followed in undertaking the Geology and Hydrogeology study

Appendix 12: Methodology followed in undertaking the Geology and Hydrogeology study



Appendix 13:
Photographs of surface water sampling locations

Appendix 13: Photographs of Surface water Sampling Locations

Photograph 9-1: Photographs of Surface Water Sampling Locations (1st season – winter)

Nr. Doyagang Village (Nr. Bridge) – Amochhu River

Nr. Torsatar (Nr Kailashgiri west) - Amochhu River

Nr. Chamkuna Village - Amochhu River

Nr. Dutay - Amochhu River

Nr. Mobile Tower - Amochhu River

Nr. Jaigaon Village - Amochhu River

Nr. Purve Village – Lorika River

Nr. Chamkuna Village - Stream

Nr. India Bhutan Border - Amochhu River

Phuentsholing Nr. Bridge - River Omchhu

Photograph 9-2: Photographs of Surface Water Sampling Locations (2nd Season - summer)

Amochhu River - Nr. Bridge

Amochhu River - Nr. Torsatar

Amochhu River-Nr. Chamkuna Village

Amochhu River - Nr. Mobile Tower

Amochhu River - Nr. STP (India Side, Jaigaon Village)

Stream Near STP (India Bhutan border)

Appendix 14:
Surface water analysis results

Appendix 14: Surface water analysis results

1st Season – Winter Season

Table 9-26: Surface water analysis results (1st Season – Winter Season)

S.N.	Parameters	Unit	Ambient Water Quality Criteria as per NEC Environmental Standards			Surface water Quality									
			A (Very Good)	B (Good)	C (Moderate)	SW1 Nr. Doyagang Village (Nr. Bridge)	SW2 Nr. Torsatar (Nr Kailashgiri west)	SW3 Nr. Chamkuna Village	SW4 Nr. Dutay	SW5 Nr. Mobile Tower	SW6 Nr. Jaigaon	SW7 Nr. Purve Village	SW8 Nr. Chamkuna Village	SW9 Nr. India Bhutan Border	SW10 Phuentsholing Nr. Bridge
1	pH	pH scale	6.5-8.5	6.0-9.0	6.0-9.0	6.68	6.75	7.15	6.95	6.90	7.13	7.78	7.72	7.25	7.42
2	Electrical conductivity	µmhos/cm	800	1000	2000	206	158	152	166	130	141	391	648	394	301
3	Color	Pt-co	5	50	-	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
4	Odour	-	Unobjectionable	Unobjectionable	-	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
5	Mineral Oil	-	No Film	No Film	-	No Film	No Film	No Film	No Film	No Film	No Film	No Film	No Film	No Film	No Film
6	TDS	mg/lit	-	-	-	112	72	68	76	64	64	160	332	184	152
7	Turbidity	NTU	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
8	Ca Hardness	mg/lit	-	-	-	28	26	26	22	22	20	88	110	58	26

9	Mg Hardness	mg/lit	-	-	-	22	14	4	18	18	20	42	70	82	34
10	Calcium	mg/lit	-	-	-	11.2	10.4	10.4	8.8	8.8	8.0	35.3	44.1	23.3	10.4
11	Magnesium	mg/lit	-	-	-	5.35	3.4	0.97	4.37	4.4	4.86	10.2	17.0	19.9	8.26
12	Sodium	mg/lit	-	-	-	15.5	9.8	23.8	25.7	23.8	30.0	26.6	28.1	24.8	28.1
13	Potassium	mg/lit	-	-	-	0.2	1.9	0.4	0.1	0.4	0.2	1.6	0.6	1.2	0.6
14	Salinity	-	-	-	-	46	39	31	39	31	31	39	38.7	62	70
15	COD	mg/lit	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5	90	120
16	BOD	mg/lit	2	5	50	<3	<3	<3	<3	<3	<3	<3	<3	21	30
17	Phenol	mg/lit	0.001	0.002	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
18	Chlorides	mg/lit	50	200	-	26	21	17	21	17	17	21	21	34	39
19	Sulphates	mg/lit	25	100	-	19	6	12	9	5	5	36	123	15	13
20	Nitrate	mg/lit	10	50	-	1.21	0.29	2.78	4.28	0.50	1.07	4.64	2.1	<0.1	<0.1
21	Fluoride	mg/lit	1	2	-	0.11	0.13	<0.1	0.22	<0.1	0.29	<0.1	0.49	<0.1	<0.1
22	Total Nitrogen	mg/lit	0.5	2	-	1.05	0.35	1.04	1.40	0.47	0.58	1.40	0.81	5.82	3.49
23	Total Phosphorou	mg/lit	0.5	<1	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

	s														
24	Dissolved Oxygen	mg/lit	6	4	-	5.1	4.9	5.1	5.2	5.3	5.1	4.9	5.1	5.5	5.2
25	Ammonical Nitrogen	mg/lit	0.05	0.5	-	0.56	0.17	0.25	0.21	0.18	0.18	0.14	0.18	4.87	3.21
26	SAR	-	-	-	26	0.95	0.67	1.89	1.76	1.63	2.05	1.01	0.91	0.91	1.57
27	TSS	mg/lit	25	100	-	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
28	Surfactants	mg/lit	0.1	0.2	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
29	Boron	mg/lit	-	-	1	0.42	<0.1	2.02	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
30	Heavy Metals														
a	Arsenic (as As)	mg/l	0.01	0.05	-	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
b	Cadmium (as Cd)	mg/l	0.003	0.003	-	<0.003	0.004	<0.003	0.005	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
c	Chromium (as Cr)	mg/l	0.003	0.003	-	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
d	Copper (as Cu)	mg/l	0.05	0.1	-	<0.05	0.10	<0.05	<0.05	<0.05	<0.05	0.05	0.05	<0.05	<0.05

e	Cyanide (as CN)	mg/l	0.05	0.05	-	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
f	Iron (as Fe)	mg/l	0.2	0.5	-	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
g	Lead (as Pb)	mg/l	0.02	0.02	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
h	Mercury (as Hg)	mg/l	0.0005	0.0005	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
i	Zinc (as Zn)	mg/l	0.2	0.5	-	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
32	Total Coliform	MPN	50	5000	10000	<1.8	<1.8	<1.8	<1.8	<1.8	2	<1.8	<1.8	140	170
33	Faecal Coliforms	MPN	20	2000	5000	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	25	32

2nd Season – Summer Season

Table 9-27: Surface water analysis results (2nd Season – Summer Season)

SN	**Parameters**	**Unit**	**Ambient Water Quality Criteria as per NEC Environmental Standards**			**Surface water Quality**								
			A (Very Good)	B (Good)	C (Moderate)	**SW1 Amochhu River Nr. Jamkh**	**SW2 Amochhu River Nr. Torsat**	**SW3 Amochhu River Nr. Cham**	**SW4 Amochhu River Nr. Dutav**	**SW5 Amochhu River Nr.**	**SW6 Amochhu River Nr. Jaigoa**	**SW8 Stream Nr. Chamkuna**	**SW9 Amochhu River Nr. India**	**SW10 Amochhu River Pheuntsholin**

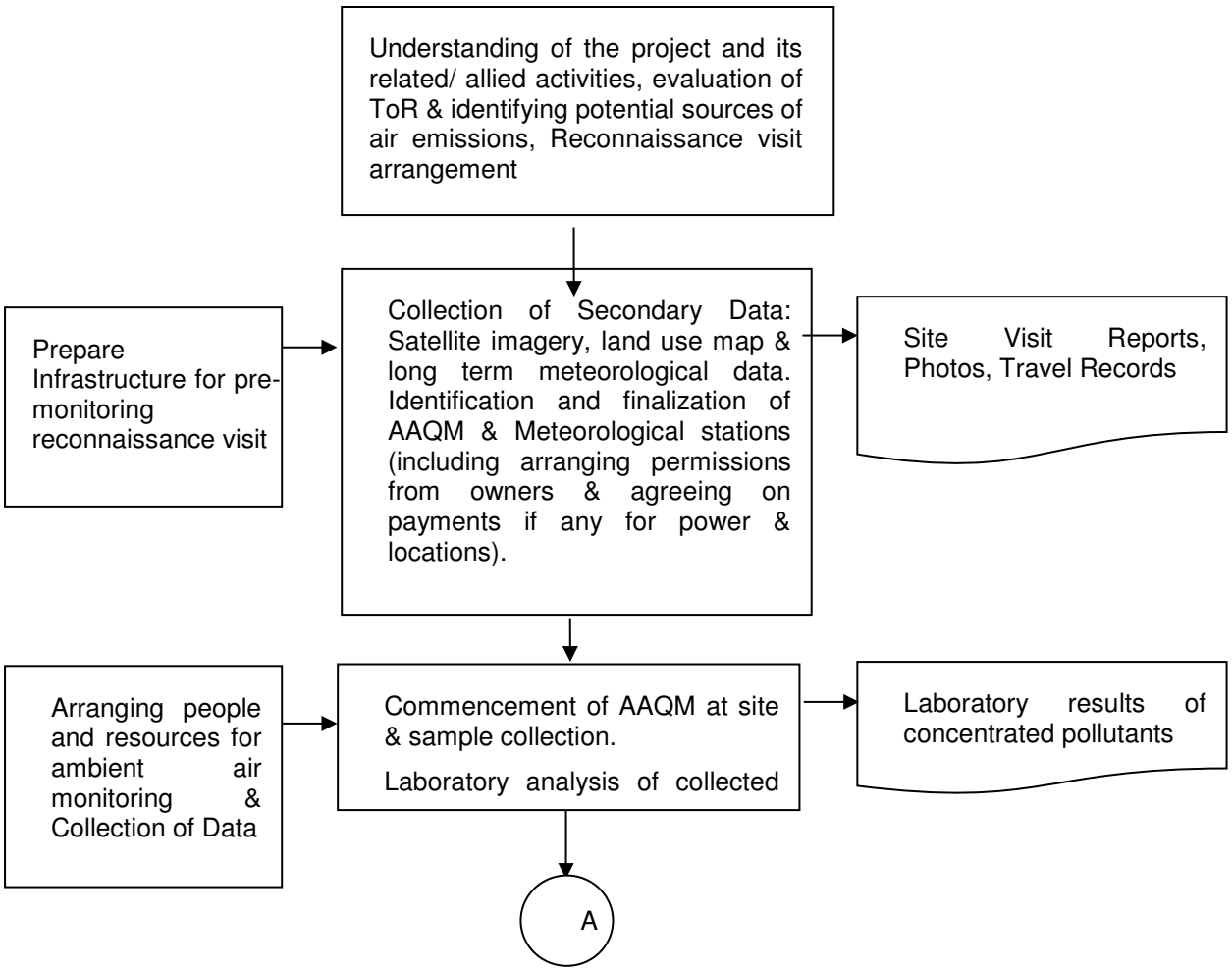
						una Village (Nr. Bridge)	**ar (Nr Kailashgiri west)**	**khuna Village**		**Mobile Tower**	**n Village**	**Village**	**Bhutan Border**	**g Nr. Bridge**
1	pH	pH scale	6.5-8.5	6.0-9.0	6.0-9.0	6.56	6.75	7.70	6.85	6.55	6.82	7.55	6.86	7.54
2	Electrical conductivity	µmhos/cm	800	1000	2000	166	123	1100	180	220	166	602	148	297
3	Color	Pt-co	5	50	-	<5	<5	<5	<5	<5	<5	<5	<5	<5
4	Odour	-	Unobjectionable	Unobjectionable	-	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
5	Mineral Oil	-	No Film	No Film	-	No Film	No Film	No Film	No Film	No Film	No Film	No Film	No Film	No Film
6	TDS	mg/lit	-	-	-	116	72	612	92	152	108	396	104	192
7	Turbidity	NTU	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
8	Ca Hardness	mg/lit	-	-	-	28	24	190	35	50	26	198	24	100
9	Mg Hardness	mg/lit	-	-	-	62	16	220	28	90	34	82	26	20
10	Calcium	mg/lit	-	-	-	11.2	9.6	76.2	13.2	20.0	10.4	79.4	9.6	40.1
11	Magnesium	mg/lit	-	-	-	15.1	3.9	53.5	7.6	21.9	8.3	19.9	6.3	4.9

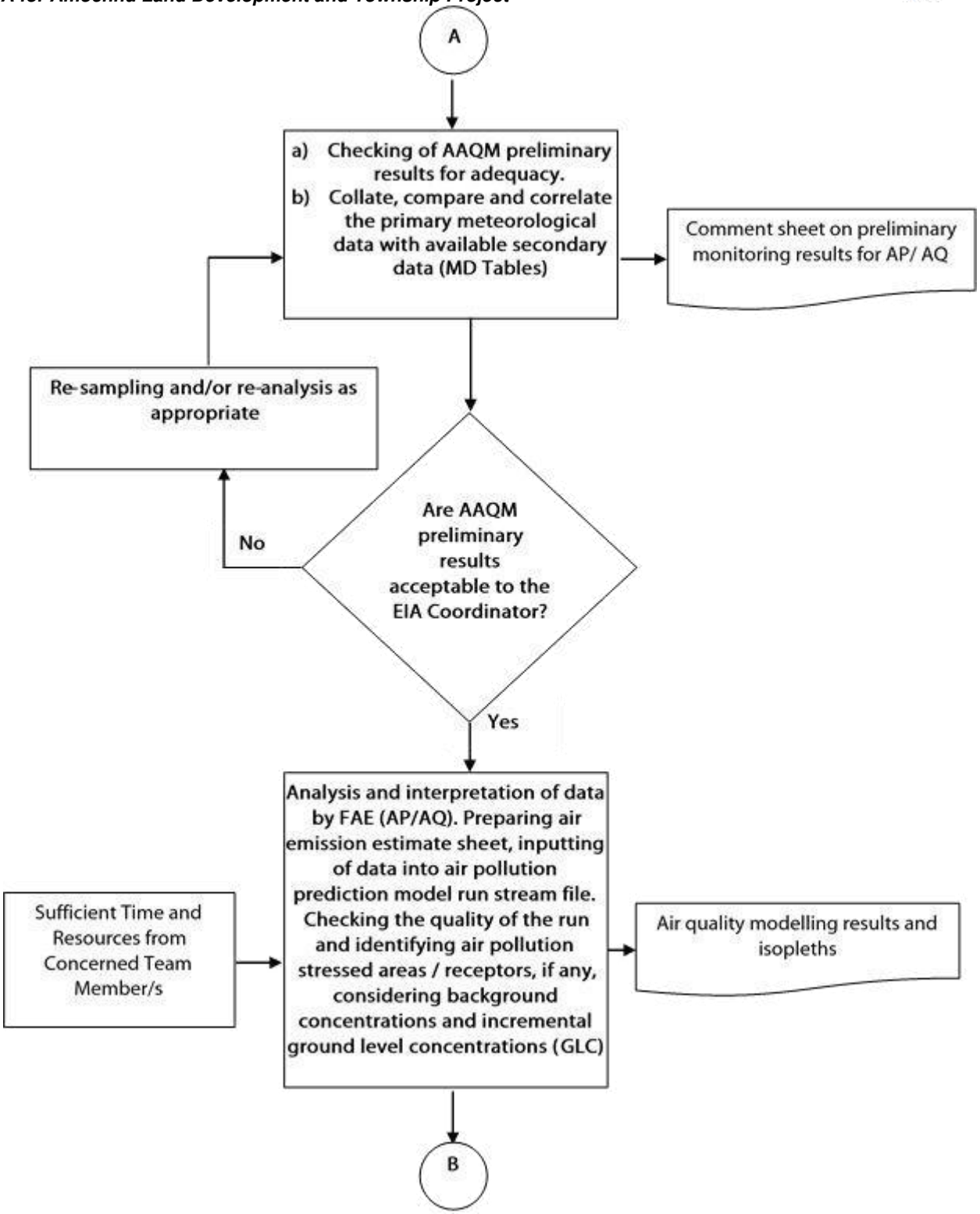
12	Sodium	mg/lit	-	-	-	10	10	10	20.5	10.5	10	10	10	10
13	Potassium	mg/lit	-	-	-	4.6	2.1	1.9	1.2	1.1	0.2	1.1	2.1	1.2
14	Salinity	-	-	-	-	38	23	106	32	30	45	23	37.7	38
15	COD	mg/lit	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5	<5
16	BOD	mg/lit	2	5	50	<3	<3	<3	<3	<3	<3	<3	<3	<3
17	Phenol	mg/lit	0.001	0.002	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
18	Chlorides	mg/lit	50	200	-	21	13	59	29	17	25	13	21	21
19	Sulphates	mg/lit	25	100	-	3	11	213	14	19	10	120	9	42
20	Nitrate	mg/lit	10	50	-	9.21	<0.1	9.35	4.31	5.71	<0.1	<0.1	<0.1	<0.1
21	Fluoride	mg/lit	1	2	-	0.26	<0.1	0.63	0.3	0.24	<0.1	0.12	0.10	<0.1
22	Total Nitrogen	mg/lit	0.5	2	-	5.35	<0.01	2.68	1.31	1.51	<0.01	<0.01	<0.01	<0.01
23	Total Phosphorous	mg/lit	0.5	<1	-	<1	<1	<1	<1	<1	<1	<1	<1	<1
24	Dissolved Oxygen	mg/lit	6	4	-	5.2	4.8	5.1	4.8	4.9	5.1	4.9	5.3	4.7
25	Ammonical	mg/lit	0.05	0.5	-	3.06	<0.01	0.14	0.18	<0.01	<0.01	<0.01	<0.01	<0.01

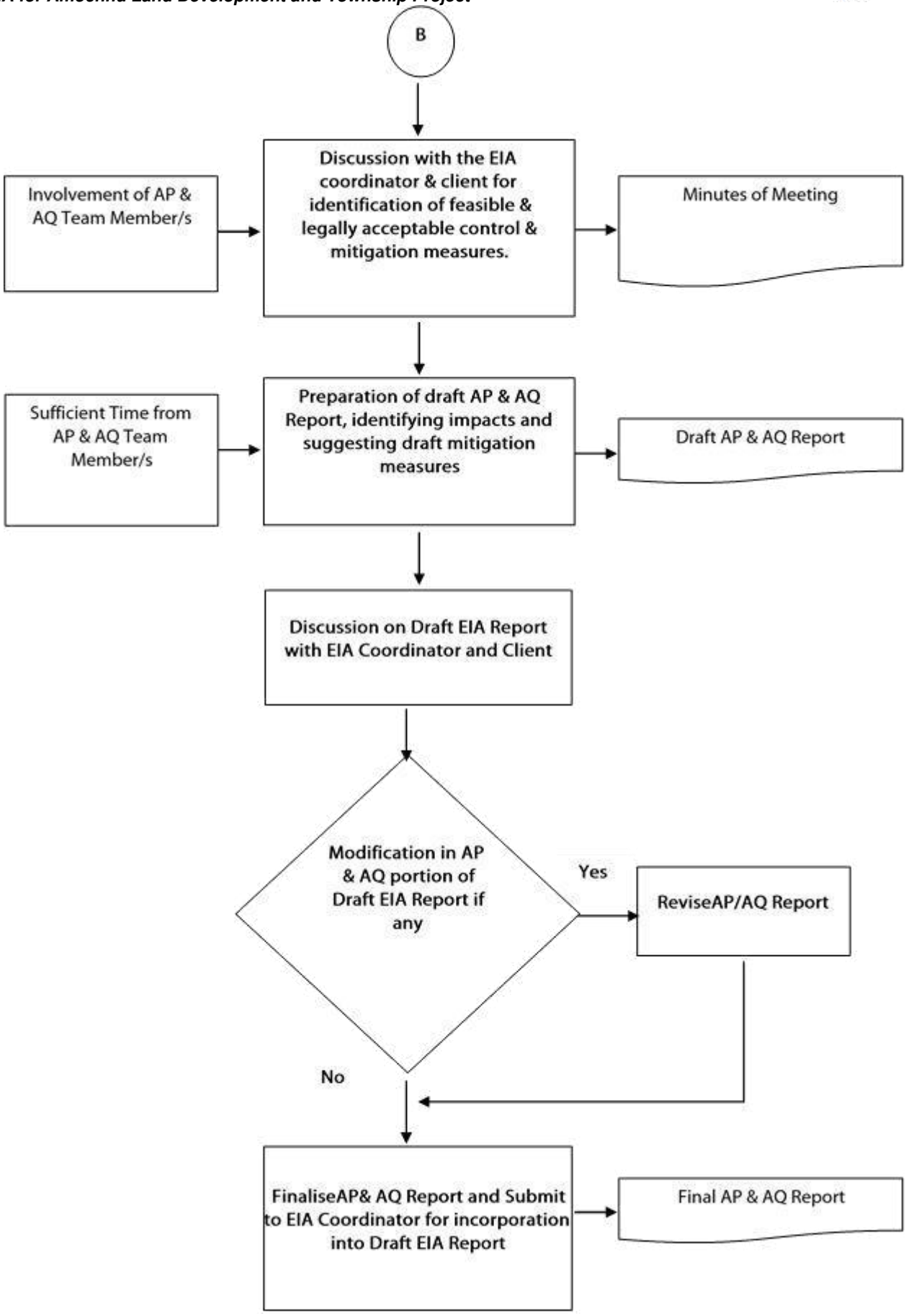
	Nitrogen													
26	SAR	-	-	-	26	0.46	0.69	0.21	1.02	3.12	0.56	0.26	0.61	0.40
27	TSS	mg/lit	25	100	-	<25	<25	<25	<25	<25	<25	<25	<25	<25
28	Surfactants	mg/lit	0.1	0.2	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
29	Boron	mg/lit	-	-	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
30	Heavy Metals													
a	Arsenic (as As)	mg/l	0.01	0.05	-	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
b	Cadmium (as Cd)	mg/l	0.003	0.003	-	<0.003	<0.003	0.008	0.005	<0.003	0.006	<0.003	<0.003	<0.003
c	Chromium (as Cr)	mg/l	0.003	0.003	-	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
d	Copper (as Cu)	mg/l	0.05	0.1	-	<0.05	0.11	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.12
e	Cyanide (as CN)	mg/l	0.05	0.05	-	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
f	Iron (as Fe)	mg/l	0.2	0.5	-	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
g	Lead	mg	0.02	0.02	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

	(as Pb)	/l												
h	Mercury (as Hg)	mg /l	0.0005	0.0005	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
i	Zinc (as Zn)	mg /l	0.2	0.5	-	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
32	Total Coliform	MPN	50	5000	10000	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8
33	Faecal Coliforms	MPN	20	2000	5000	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8

Appendix 15:
General Study Approach: Meteorology & Air Pollution Monitoring, Assessment and Management


Understanding of the project and its related/ allied activities, evaluation of ToR & identifying potential sources of air emissions, Reconnaissance visit arrangement
Prepare Infrastructure for pre-monitoring reconnaissance visit
Collection of Secondary Data: Satellite imagery, land use map & long term meteorological data. Identification and finalization of AAQM & Meteorological stations (including arranging permissions from owners & agreeing on payments if any for power & locations).
Site Visit Reports, Photos, Travel Records
Arranging people and resources for ambient air monitoring & Collection of Data
Commencement of AAQM at site & sample collection.
Laboratory analysis of collected
Laboratory results of concentrated pollutants
A


A
a) Checking of AAQM preliminary results for adequacy.
b) Collate, compare and correlate the primary meteorological data with available secondary data (MD Tables)
Comment sheet on preliminary monitoring results for AP/ AQ
Re-sampling and/or re-analysis as appropriate
No
Are AAQM preliminary results acceptable to the EIA Coordinator?
Yes
Sufficient Time and Resources from Concerned Team Member/s
Analysis and interpretation of data by FAE (AP/AQ). Preparing air emission estimate sheet, inputting of data into air pollution prediction model run stream file. Checking the quality of the run and identifying air pollution stressed areas / receptors, if any, considering background concentrations and incremental ground level concentrations (GLC)
Air quality modelling results and isopleths
B


B
Involvement of AP & AQ Team Member/s
Discussion with the EIA coordinator & client for identification of feasible & legally acceptable control & mitigation measures.
Minutes of Meeting
Sufficient Time from AP & AQ Team Member/s
Preparation of draft AP & AQ Report, identifying impacts and suggesting draft mitigation measures
Draft AP & AQ Report
Discussion on Draft EIA Report with EIA Coordinator and Client
Modification in AP & AQ portion of Draft EIA Report if any
Yes
ReviseAP/AQ Report
No
FinaliseAP& AQ Report and Submit to EIA Coordinator for incorporation into Draft EIA Report
Final AP & AQ Report