Project No:H-3837

ENVIRONMENTAL IMPACT ASSESSMENT STUDY FOR INTEGRATED URBAN REGENERATION AND WATER TRANSPORT SYSTEM (IURWTS) PROJECT IN KOCHI

Draft EIA Report

Study Period :
September, October & November, 2020
Name of NABL Laboratory :
Standards Environmental & Analytical Laboratories
NABL Acc. # : TC-5402

Project Proponent
KOCHI METRO RAIL LIMITED (KMRL)
JLN Metro Station, 4th floor,
Kaloor- Ernakulam-682017

DPR General Consultant
Antea Nederland B. V. &
Antea INDIA Private Limited (JV)
Magnum Towers, Main Golf Course Extension Road,
Sector - 58, Gurgaon

Studies and Documentation by
WAPCOS Limited (A Government of India Undertaking)
76 C, Sector 18, Gurgaon – 122015, Haryana.
Tel. +91-124-2397396, Email: environment@wapcos.co.in
NABET Certificate: QCI/NABET/ENV/ACO/20/1500 Dt.20.10.2020

December 2021

CONTENTS

LIST OF ANNEXURES

LIST OF APPENDIX

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

1. INTRODUCTION

Government of Kerala (GoK) considering the need to rejuvenate the canal networks and for urban regeneration of the canal commands in Kochi corporation conceived the project 'Integrated urban regeneration and inland navigation studies" (IURWTS). The project command involves 5 canals running through the heart of the urban fabric of Kochi corporation and occupying nearly one-third of the corporation area. As per the GO (Rt) No. 2010/2019/RD dated 23rdJuly 2019, KMRL was entrusted the job of Special Purpose Vehicle (SPV) for implementation of the project. Antea Group, Netherlands'swas appointed by KMRL as the General Consultant for assisting SPV in preparation of the DPR.

The overall objective was to improve inland Transport in the canal systems and have an intermodal connectivity with an integration of the Rail Metro and Water Metro. The Urban Regeneration and Canal Oriented Development (COD) is not considered as a simple form of renovation or rehabilitation of the obsolete and dilapidated canal infrastructure. The restoration of canals and urban regeneration is aimed at restructuring the urban fabric and renewal of the urban economy and thereby overall improvement of city's image.

2. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

As per EIA Notification issued by MoEF&CC on 14thSeptember 2006, application for prior Environmental Clearance was submitted to MoEF&CC vide letter dated 20.02.2020. The Draft Terms of Reference was discussed in the EAC (Infra-2) meeting held on 22-24 April 2020 and approval of Terms Reference (TOR) for the EIA study was issued by MoEF&CC vide letter No.10-23/2020-IA-III dated 13.05.2020.

3. PROJECT DESCRIPTION

The IURWTS project is focused on five main drainage canals namely Edappally Canal (11.23 Km), Chilavanoor Canal (11.15 Km), Thevara-Perandoor canal (9.88Km), Thevara canal (1.41km) and Market canal (0.66Km),

The IURWTS project covers a total area of 41.49 sq.km. Out of this, 33.08 Sq.km forms part of Kochi Corporation with an area of 8.41 sq.km on the eastern side falling in 3 municipalities (Kalamassery, Thrikkakkara and Thripunithura Municipalities). Out of the 74 wards of Kochi Corporation, 54 wards fall within the IURTWS project area including 19 wards each in Kalamassery and Thrikkakkara municipality and 2 wards in Thripunithura municipality. The physiographic setting of IURWTS Catchment is given inFigure 1.

Various activities proposed under the project are grouped into following major components:

- Canal and canal bank development and Urban Regeneration.
- Infrastructure / property development by way of Value Capture Financing and Transit Oriented Development to generate revenue.

The restoration process also focuses on enhancement of water storage capacity of canals, thus mitigating floods and improving canal navigation for enhancing last mile connectivity. In the urban regeneration front, a catchment approach will be adopted to assess the sewer loads from the canal catchment rather than confining to the sewer loads to the main canal areas only.

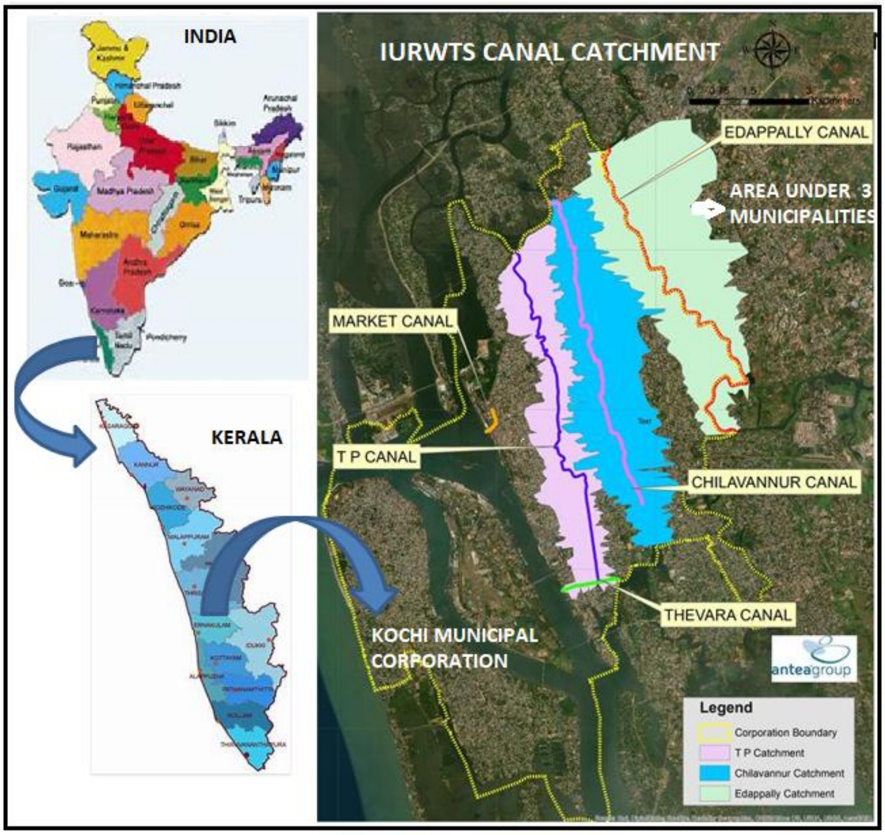


Figure 1: Physiographic setting of IURWTS Catchment

3.1 Canal Oriented Development

The canal-oriented development will meet the requirements and demands of various stakeholders as well as it will add value to the overall canal improvement and development.

Canal Cleaning

It is proposed to clean water hyacinth and other floating materials including plastic waste deposited in the canal. Provision has been included for cleaning the canal during the start and completion phase of the project i.e. during the preconstruction phase, and on completion of the project.

Desilting and Widening of Canals

The width of five canals is restored to the original width of canal as per village record and ensuring that the requirement for flood mitigation and navigation of vessels are met. The dredged level has been fixed taking into consideration the hydro-geological aspects by not disturbing the hard strata of the canals. and the minimum navigation depth to be maintained during low tide water level in the canal. Proposal to desilt the sub canals at essential locations is also proposed for smooth drainage of the flood waters in the catchments. The 30 percent of the earth obtained is required for grading of the canal banks as part of the restoration activities.

Shore protection: Based upon the different types of shore protection measures, detailed design and estimate proposed based on site-specific type requirement. Bioengineering embankments are also included in site suitable locations.

Reconstruction of roads along canal: The reconstruction of damaged roads along the canal affected due to the widening of canals will be carried out.

Reconstruction of road bridges: Based on the parametric analysis for different types of road structures chosen, site specific road bridges having a uniform and aesthetically pleasing appearance and in line with the canal-oriented development activities will be reconstructed in the detailed design and estimation stage. The reconstruction included is for 56 nos. bridges.

Reconstruction of footover bridges: Steel structure which are environmentally acceptable, aesthetically pleasing, and easy to assemble are proposed for the reconstruction of footbridges. Total 31-foot bridges for reconstruction and 15 nos. new for crossover of the utilities are included.

Construction of access road to road bridges: As the bridge heights are increased to provide a clearance height of 4 meters, it is proposed to carry out gradient correction to the access roads, reconstruction of damaged portion and demolishing charges.

Canal bank beautification with landscaping & promenade: Considering the availability of free space, limited encroachment and the location advantage, it is proposed to beautify a stretch of 4 km on either side of Edappally canal. The canal bank beautification benefits to the well-being of people and encourages lifelong tranquility that is in harmony with nature. It also adds value to the tourist infrastructure of the city and to increase the open area and parks inside the catchment. As per site availability, it is also proposed to provide walkways, fencing, and landscaping in limited stretches along other canal banks where space is available after implementation of the development activities.

Construction of Jetties and Jetties Terminal Buildings: The choice of location of the jetties are determined by the intermodal connectivity with the rail metro, water metro, and road modes, i.e. the first and last mile connectivity. The navigational width of 16.5 m was estimated for 2-way movement in the project canals. Jetties and jetty terminal are designed for an average plinth area of 70 sq.m considering minimum CAPEX and O&M cost. A total of 30 jetties are proposed to meet the navigation requirement

Construction of office building for Special Purpose Vehicle with testing laboratory: An institutional mechanism to monitor the post implementation stage activities has been proposed. To house the SPV office a plinth area 1200 m^2 is added to a jetty terminal near Lulu mall along Edappally canal. The other facilities provided in this building are a water quality testing laboratory, a tidal fluctuation measurement unit, and a control office connected to all the CCTV units along the 5 canals..

Construction of access roads to jetties and jetty terminals: Access roads to the jetty terminals will be improved.

Purchase of vessels / boats for navigation of passengers and tourism: Based on the traffic survey results, number of boats with various characteristics have been estimated to cater to the demand of the public.

Navigational aids, Signages, Markers and Way finding signages: Based on design considerations, the required navigation aids and related accessories have been estimated.

Miscellaneous items such as solar installations, EV chargers, electrical systems, non-motorized transport like electric buses, etc. for last mile connectivity are included to support the project operations.

3.2 Urban Regeneration

The urban regeneration works include the provision of household sewer network connectivity and with primary sewer lines aligned along both sides of the canals. Provision for sewage interceptors to collect the sewage load from the sub canals, and pumping systems to pump the sewer load from interceptors into the main sewer line.

Sewage Treatment plant

The sewer load of the entire project command to be treated over and above the existing and ongoing scheme has been estimated as 31 MLD. A total of 4 STPs is proposed to treat the sewer load generated in the project catchment are proposed at the canal ends without impacting the urban fabric and also with no inhabitants in a radius of 50m from the STP boundaries.

Sanitation Facilities: The transitional sanitation facilities for population not covered by the proposed sewage network has been included to prevent sewage being discharged into the canal.

Solid waste management: Kochi Municipal Corporation has already envisaged a proposal for converting the solid waste into energy at Brahmapuram, Kochi. The requirement of daily waste is 250 tons. IURWTS catchment falls within corporation municipality and occupies a major portion of Kochi municipal corporation area. Hence rather than having a separate plant, it is proposed to have a coordinated effort with KMC for solid waste management for the initial 3-year period. Provision for innovative collection methods are only proposed**.**

4. ENVIRONMENTAL BASELINE STATUS

The Study Area for the EIA Report encompasses the entire area within a radius of 10 km of the project area. The Baseline Status of various environmental parameters in the Study Area is described in the following paragraphs.

4.1 Meteorology

Primary and secondaryMeteorological data with respect to wind speed, wind direction, temperature, rainfall, relative humidity, visibility, etc., was collected to represent the Kochi area.The average annual rainfall is reported as 3014.8 mm, and most of which is received in the period from May to October under the influence of south-west monsoons. The mean monthly maximum temperature ranged from 29.5°C in August to 33.0°C in April and the mean monthly minimum temperature ranged from 23.0°C in January to 25.9°C in April.

4.2 Land-use Pattern

The land use pattern of the Study Area has been studied using satellite data dated 14.01.2019. The major landuse category in the study area of IURWTS project is vegetation, as it accounts for about 40.85% of the study area followed by Built up area (27.70%) and Waterbody (27.42%). The area under Aquaculture and Mangroove is 1.68% and 1.77% of the study area respectively. The area under Agricultural land is negligible and it account for for about 0.57%.

4.3 Ambient Air Quality

The average concentration of PM_{10} at various stations ranged from 68.2to 27.9$\mu g/m^3$at various locations. The average concentration of $PM_{2.5}$ at various stations monitored ranged from 34.6 to 14.5 $\mu g/m^3$.

4.4 Ambient Noise Levels

Ambient Noise Levels were monitored at various locations in the Study Area. The day time equivalent noise level ranged from a minimum of 45.4dB(A) to a maximum of 56.2dB(A).

4.5 Aquatic Ecology

Biodiversity Assessment was conducted by Department of Marine Biology, Microbiology & Biochemistry, School of Marine Sciences, Cochin University of Science & Technology (CUSAT) during September 2020 to November 2020.Findings of the study are summarised as below:

- The water and sediment quality were generally poor in most of the canals. All the canals recorded low dissolved oxygen (DO) level whereas BOD level was higher. Low DO and high BOD value revealed the extremely polluted condition in the canals.

Large scale release of sewages from domestic, industrial and spread of invasive water opportunistic organisms and water plants play a crucial role in the hypoxic to anoxic DO and increasing BOD trend in most of the canals.

- Thus the present investigation indicates that, all the canals are facing serious heavy metal pollution. Dumping of wastes, use of agro-chemicals such as fertilizers and pesticides, sewage-sludge, municipal runoff and other developmental activities are the main contestant in anthropogenic enrichment of heavy metals in canal systems.
- The primary production was totally collapsed mainly arising from the unhealthy water quality condition prevailing in the canals.
- The fishery and aquatic macrophytes from the canals were generally poor for the study.
- Environmental quality and biodiversity of Chilavannoor, Market, Edappally, Thevara-Perandoor and Thevara canals are seriously affected by contamination and pollution from various anthropogenic activities.
- The reduced macrobenthic biomass, abundance and diversity in the canals, just limiting to 4 to 5 species (Clams, Mussels, Barnacles and Gastropods) could be related to the alarming environmental quality status of the selected canals.

5. ASSESSMENT OF IMPACTS& MITIGATION MEASURES

Based on the project details and the baseline environmental status, potential impacts that are expected to occur as a result of the execution and operation of the proposed project have been identified.

5.1 Impact on Land Environment

Construction phase

- Pre-construction activities include the clearing, stripping and leveling of sites, construction of approach roads, earth filling and excavation for foundations etc. and may lead to some impacts on land environment.
- The proposed jetties are proposed on the bank of canals, and envisages the construction of passenger Boat Jetty and the STPs as major construction work.
- The solid waste generated from the Labour camps solid wastes generated will contain mainly vegetable matter followed by paper, cardboard, packaging materials, wood boards, polythene.

Mitigation measures:

- The levelling and reclamation is proposed to be undertaken using the earth obtained from deepening and widening of the proposed canals..
- On completion of construction activities, surplus materials, debris, discarded boxes, containers, drums etc; will be removed from the site and disposed in designated disposal site.
- Solid waste management at labour camps shall be based on the principle of reduce, reuse and recycle and adequate facilities for collection and conveyance of the solid waste.

Operation Phase

- The operation of the proposed project infrastructure facilities will provide an impetus to the mushrooming of secondary and tertiary activities in the area.
- The solid waste generation is envisaged during operation phase could be the disposal of garbage or solid waste generated from various sources.

Mitigation measures:

- Adequate facilities for collection, conveyance and disposal of solid waste will be developed. Provisions shall be made to separately store the degradable and non-degradable solid waste
- The solid waste generated in the catchment of the 5 canals has been estimated and the cost involved in collection of the solid waste through innovative methods.

5.2 Impact on Water Environment

Construction phase

- About 625 persons would be staying in labour camps. The sewage generated would be of the order of 132.2m^3/day from the labour camp. The disposal of sewage without treatment could lead to significant problems related to water pollution and public health. The disposal of sewage without treatment can cause problems of odour and water pollution.
- During construction phase, the domestic wastes generated will contain mainly vegetable matter followed by paper, cardboard, packaging materials, wood boards, polythene, sewage and other liquid wastes etc. may find their way into water bodies.
- The deepening and other construction activities normally increase the turbidity levels in the water column. The change in water-column turbidity during deepening is a short-term impact. The increase in turbidity lasts as long as the material is being dredged.
- The quantity of debrisestimated from deepening is 4,54,013 m^3 and from widening is 241401 m^3, Thus total quantity to be dredged is 6,95,414m^3. Out of the total quantity estimated 20% is proposed to be used for canal embankment, landscape works and remaining conveyed to land filling sites.

Mitigation measures:

- Proper sanitation facilities including the community toilets withbiodigester. Facilities for potable drinking water shall be developed for the work force involve during construction phase.
- Solid waste management shall be based on the principle of reduce, reuse and recycle and adequate facilities for collection and conveyance of municipal wastes generated at each post shall be developed. Garbage bins will be kept for collection of solid waste at appropriate locations at each construction site.
- Solid waste will be disposed off at designated landfill sites to be identified in consultation with local administration.
- The innovative dredger Dino 6 available in international markets will be used for widening canals with lesser width. The end of the pipe is connected to geo-synthetic tubes placed in the shore and the same used for low lying area filling. Hence, the whole process has no adverse impact on the ecosystem within the canal and canal banks.
- The disposal of dredged soil from the canals, shall be disposed of to M/s Kerala Enviro Infrastructure Ltd (KEIL), is operating “Common Treatment, Storage and Disposal Facilities (TSDF), approved landfill site. An agreement has already been executed with KEIL in this regard.

Operation phase

- The total water required for passengers and staff expected as 225.0 KLD. The sewage that would be generated from these terminals would be about 80% of the water demand. Sewage generated is expected to be 180 KLD.

- During the operational phase there will be activities of boat movement in the region. The boat will be electric and no toilet shall be in the same. All these activities may have little impacts on aquatic life.
- As part of the project all the waste water mixing in the canal is diverted through sewage network and treated in 4 different STPs. The structured collection of household sewage and treatment indiscriminate mixing of sewage in many water bodies are eliminated as part of the project and make it the canals clean.

Mitigation measures

- Suitable waste water treatment measures will be provided for the treatment of domestic sewerage from the jetty premises.
- The treated sewage from the STP is proposed to be sent to existing canal after meeting the discharge criteria set by CPCB for discharging to the surface waste water.

5.3 Impacts on Ambient Air Quality

Construction phase

- The potential source of air quality impact arising from the establishment/ construction of the proposed project is fugitive dust generation.
- The combustion of diesel various construction equipment could be one of the possible sources of incremental air pollution during the construction phase.

Mitigation measures:

- All the vehicles must have valid PUC certificates at all the time during construction phase of the project, Water sprinkling shall be done to suppress the dust emissions from the site.
- All the DG sets used for construction shall have valid consents from Kerala Pollution Control Board and shall have built-in stacks to reduce the air emission impacts.
- All the roads in the vicinity of the project site and the roads connecting the quarry sites to the construction site should be paved or black topped to minimize the entrainment of fugitive emissions. If any of the road stretches cannot be blacktopped or paved, then adequate arrangements shall be made to spray water on such stretches of the road.
- Suitable barriers shall be provided around construction sites to mitigate air pollution.

Operation Phase

- During project operation phase, major activity would be passenger service and operation of STPs. The propulsion of the boats will be electric. The operation of STPs will create foul smells in the surrounding area.

Mitigation measures:

- Vehicles will be turned off when not used for extended periods of time.
- Effective traffic management to be undertaken to avoid significant delays in and around the project area.
- Proper Greenbelt plan around the periphery of the STPs.

5.4 Impacts on Noise Environment

Construction phase

- Noise during construction phase are due to operation of various construction equipment.

- There will be significant increase in vehicular movement for transportation of construction material.

Mitigation measures:

- Vehicles to be equipped with mufflers recommended by the vehicle manufacturer.
- Staging of construction equipment and unnecessary idling of equipment within noise sensitive areas to be avoided whenever possible.
- Monitoring of noise levels will be conducted during construction phase of the project. In case of exceeding of pre-determined acceptable noise levels by the machinery will require the contractor(s) to stop work and remedy the situation prior to continuing construction.
- The construction acitivities shall be limited to day time.Suitable barriers shall be provided around construction sites.

Operation phase:

- No adverse impacts on noise environment are anticipated during operation phase of proposed project as only passenger boat movement is involved.

5.5 Impacts on Socio-Economic Environment

Construction phase

- Generation of temporary employment opportunities and would temporarily increase the income levels of the local population.
- Local businessmen will get opportunity to supply construction materials. The demand generated from the employees working at site for basic facilities will increase the local business opportunities in the area. Any development, either temporary or permanent will support the family of many villagers.
- The project partly affected several commercial structures and residence cum commercial structures. But access to canal transport may marginally increase the commercial value of the buildings and it will mitigate the impact.

Operation phase:

- The proposed project is one of the long due development initiatives of the government. The water logging happened during the last two years (2018 and 2019) flood made an attitudinal change in people's mind regarding the canal development.
- Developing a system for regular communication and addressing the grievance may mitigate the impact an ensure community participation.

6. ENVIRONMENTAL MANAGEMENT PLAN

The Environmental Management Plan (EMP) was delineated to ensure that the adverse impacts likely to accrue are altogether removed or minimized to the extent possible. The Environmental Management Plan (EMP) for the proposed project is classified into the following categories:

- Land Environment
- Water Environment
- Air Environment
- Control of Noise
- Greenbelt Development
- Socio-Economic Environment

The key measures suggested as a part of the Environmental Management Plan are area listed as below:

- ✓ Provision for drinking water
- ✓ Provision of community toilets and septic tank

- ✓ Temporary colonies of the construction workers should be established sufficiently away from the HTL and adequate sanitation facilities shall be provided to prevent degrading the environmental quality of the area.
- ✓ Construction activities will be carried out in the confined manner to reduce the impacts on marine environment.
- ✓ Construction waste including debris shall be disposed safely in the designated areas and in no case shall be disposed in the marine environment.

After selection of suitable and feasible environmental mitigation measures, the cost required for implementation of various environmental management measures has been estimated to have an idea of their cost-effectiveness. Summary of Environmental Management Plan is given in Table-1.

Table-1: Summary of Environmental Management Plan

S.No.	Potential Environmental Impacts	Mitigation Measures	Implementing Agency
Pre-construction Stage			
1	Clearances and Approvals	(i) Secure regulatory clearances such as CRZ Clearance of CRZ rules , GoI (ii) Obtain planning permissions from relevant local planning authority and the local administration	KMRL
2	Site clearance	Site clearance shall be carried out to in such a way that the clearance and grubbing waste is disposed immediately in the designated dumping site identified for the project. In no case the waste material shall not be disposed in the sea or any other sensitive environment components.	Contractor
Construction Stage			
1.	Establishment of Construction Camp and site office	• Proper cooking fuel should be provided to the labour residing in the camps. In any case, woods should not be used for cooking. • Proper sanitation facilities should be provided in the construction camps. • Potable drinking water should be provided to the workers. • Water logging conditions should not be allowed inside the camp.	Prospective Contractor
2.	Construction Sites	• It should be kept free of water logging • Protective guards should be provided across the areas where workers may fall or could face	Contractor

S.No.	Potential Environmental Impacts	Mitigation Measures	Implementing Agency
		an impalement hazard. • Keep form and scrap lumber away from work areas, passageways • No loose material should be allowed to leave unattended, and sites should be properly finished after completing the work • Good housekeeping should be maintained at construction sites	
3.	Public Safety	• Warning sign boards should be provided along the construction sites in English as well as local language • Trespassing of the construction sites should not be allowed	Contractor
4.	Occupational Health & Safety	• Safe access to the job sites should be provided to all workers • Passage ways, walkways, should be kept free of materials, scraps or obstructions • First Aid box should be readily available at construction sites • Contact with nearest nursing homes/clinics/primary health centre should be maintained by the Contractor to deal with any emergency at site • The contractor should comply with all the precautions as required for the safety of the workmen as per the International Labour Organization as far as those applicable to this project • Personal Protective Equipment such as helmets, hand gloves, safety shoes, nose masks, safety goggles should be provided to the workers.	Contractor
5.	Ambient Air quality	• Properly functioning construction equipment to minimize exhaust shall be maintained • Pollution Free certified vehicles to be allowed	Contractor

S.No.	Potential Environmental Impacts	Mitigation Measures	Implementing Agency
		• Avoid traffic in populated areas as much as possible • Cover stockpiled silt and trucks hauling silt, sand, and other loose materials or require trucks to maintain at least two feet of freeboard • Sprinkling of water on loose soil, especially during summers, shall be practiced as necessary	
6.	Noise	• Construction equipment, vehicles and machines shall be equipped with noise suppression devices and properly maintained mufflers • Staging of construction equipment and unnecessary idling of equipment within noise sensitive areas to be avoided whenever possible. • Notification, describing noise abatement measures that will be implemented, to be given to residents within 100 m of major noise generating activities. • Regular monitoring of noise levels to be undertaken. In case of exceedance of pre-determined acceptable noise levels, the contractor(s) to stop work and remedy the situation before continuing with works	Contractor
7.	Water	• Solid waste shall be disposed at authorized sites identified in disposal plan • Waste water shall be treated and discharged through soak pits. • SW and GW quality to be tested regularly for any fecal contamination (at least once a week)	Contractor
8.	Emergency Management	First aid kits and emergency treatment facilities shall be provided by the contractor at the work sites, camp sites and all other ancillary facilities.	Contractor
9.	Greenbelt development	Green belt will be developed around the four STP sites, 30 Jetties, Areas of Canal oriented Development in Edappally	Contractor and KMRL

S.No.	Potential Environmental Impacts	Mitigation Measures	Implementing Agency
		Canal and all available places on the banks of canals after widening and laying the sewer lines	
10.	Land Acquisition	• Follow Right to Fair Compensation and Transparency in Land Acquisition Rehabilitation and Resettlement Act 2013 and Kerala Rules, 2015. (LARR Rules)	KMRL
Operation Stage			
1	Monitoring Operational Performance	Monitoring the operational performance of the various mitigation measures implemented in the project.	KMRL
2	STP/Sewer line	• Monitor the treated sewage/effluent quality and ensure compliance with PCB standards for effluent disposal into surface water bodies, on land or for the agricultural use. • Provide buffer zones in the form of green belt around the STP; to be ensured during the design and construction phase itself. • Regular monitoring of sewer line and manholes for visible leakages/ overflows. • Immediate repair operation for the damaged portion of sewer line. • Ensure proper covering of manhole and avoid dumping of solid waste to prevent chocking of sewer line	KMRL
3.	Air Environment	All the DG sets shall be kept as per the CPCB norms to avoid the pollution due to that..	KMRL
4.	Noise	DG sets with acoustic enclosures shall be deployed.	KMRL
5.	Solid Waste	Solid waste from the site should be source segregated and collected into biodegradable & non-biodegradable waste. The biodegradable waste will be treated in organic waste converter (OWC) and used as manure, whereas the non biodegradable waste shall be sent to authorised	KMRL

S.No.	Potential Environmental Impacts	Mitigation Measures	Implementing Agency
		recyclers.	

7. DISASTER MANAGEMENT PLAN

The nature of the proposed project is such that these are minimal chances of accidents. The project operations do not entail any risk or hazard. DMP has been suggested for even remote possibility of emergency.

8. HTL/LTL DEMARCATION

The CRZ mapping for the proposed project has been done by Institute of Remote Sensing (IRS), Anna University, Chennai. The CRZ mapping report includes the HTL/LTL map covering an area of 7 km radius from the project components of 1:4000 scale.

9. SOCIAL IMPACT ASSESSMENT

SIA has been conducted in order to identify the PAPs and PAF. According to this, R&R shall be given by Right to Fair Compensation & Transparency in Land Acquisition, Rehabilitation & Resettlement Act, 2013 (RTFCTLARRA, 2013).The total budget for implementation of the Rehabilitation and Resettlement Plan is Rs.196.72 lakhs.

10. ENVIRONMENTAL MONITORING PROGRAMME

An Environmental Monitoring Programme for implementation during project construction and operation phases has been suggested to oversee the environmental safeguards, to ascertain the agreement between prediction and reality and to suggest the remedial measures not foreseen during the planning stage but during the operation phase and to generate data for further use. The equipment, manpower and cost required for the implementation of environmental monitoring programme were also suggested.

13. PROJECT BENEFITS

Proposed project the following are the immediate benefits:

- Improve intermodal connectivity with the Rail Metro and Water Metro by way of restoration of canals.
- Flood mitigation and flood plain management.
- Canal development will create beautifully landscaped canal spaces for leisure and tourism, cute shops, and eateries for creating an illusion of urban vitality along the canal banks and enhanced livelihood opportunities. This would further improve the city's image
- Sanitation facilities and sewage disposal system integrated to serve the inhabitants of the project command.
- Restrict dumping of waste, control encroachments, stop sewage mixing etc.
- Infrastructure / property development along the canals through Value Capture Financing & Transit Oriented Development for generating revenue.
- Improve monitoring of the canal systems, which will reduce to zero waste disposal, mosquito menace, and carbon reduction
- Enhanced utility of the canal waterfront as a natural attraction for social and economic activity for locals and tourists.

11. EMP IMPLEMNTATION COST

The cost estimates for implementing EMP shall be Rs. 4.5 crore. The details are given in Table-2.

Table-2: Summary of cost estimate for implementing Environmental Management Plan (EMP)

S. No.	Items	Budget (Rs. lakh)
1	Sanitation Facilities in Labour Camps	125.00
2	Air Pollution Control Measures	30.00
3	Provision of Free Fuel	49.0
4	Solid Waste Management	94.64
5	Training and awareness on firefighting	30.0
6	Public Health Facilities	30.0
7	Greenbelt Development	30.0
8	Aquatic Biodiversity Management Plan	60.0
	Total	**Say 448.64 lakhs** **Say 4.5 Crore**

The cost required for implementation of Environmental Monitoring Programme during operation phase is Rs.15 lakh/year.

INTRODUCTION

1.1 GENERAL

Kochi being one of the prominent port cities and as part of Ernakulam district, enjoys a strategic location among all the ports in India. Being a historical port city, it has an elaborate network of navigable water channels. Water transport by means of traditional boats was a prime mode of movement from one island to another and surrounding the Ernakulam mainland. However, with improved road infrastructure, canal transport in Kochi experienced a decline and the inland canals got neglected and became waste dumping ground due to intense urbanization and industrialization over past few decades.

Government of Kerala (GoK) considering the need to rejuvenate the canal networks and for urban regeneration of the canal commands in Kochi corporation conceived the project 'Intergrated urban rgeneration and inlad navigation studies" (IURWTS). Th project command involves 5 canals running through the heart of the urban fabric of Kochi corporation and occupying nearly one-thrid of the corporation area. As per the GO (Rt) No. 2010/2019/RD dated 23rd July 2019, KMRL was entrusted the job of Special Purpose Vehicle (SPV) for implementation of the project. Antea Group was appointed by KMRL as the General Consultant for assisting SPV in preparation of the DPR.

The overall objective was to improve inland Transport in the canal systems nd have an intermodal connectivity with an integration of the Rail Metro and Water Metro. The Urban Regeneration and Canal Oriented Development (COD) is not considered as a simple form of renovation or rehabilitation of the obsolete and dilapidated canal infrastructure. The restoration of canals and urban regeneration is aimed at restructuring the urban fabric and renewal of the urban economy and thereby overall improvement of city's image.

1.2 PROJECT COMPONENTS

Five canals are proposed to be taken up under the project: Edappally Canal (11.23 km), Thevara –Perandoor Canal (9.88 km), Chilavanoor Canal (11.15 km), Thevara Canal (1.41 km), and Market Canal (0.66 km). The project command of these canals falls in a rapidly urbanized coastal and estuarine region, which delimits within the Kochi corporation and three municipalities, viz., Kalamassery, Thrikkakkara, Thripunithura of Kochi city. Out of these, Edappally Canal, Thevara - Perandoor Canal and Chilavanoor Canal are three major canals in Kochi City aligned in the North - South direction, cutting across the heartland of Ernakulam mainland. Edappally , Chilavanoor and Thevara-Thevara- perandoor canals are connected to the water bodies (Kochi lagoon) at the extreme end of the canals fed by the upstream 5 rivers(Anchencoil,Pamaba, Manimalla,Meenachal and Muvattupuzha rivers) on the south and with a branch of Periyar river on the north side . The development of Thevara Canal will reduce the navigable distance between Kundannur and Venduruthy backwaters.

The location map and proposed canal navigation is shown Figure-1.1 and Figure-1.2 respectively.

The development of these canals will facilitate passenger movement through canal waterways "Canal Metro" and between Rail Metro stations and Water Metro. In addition, the proposed development wil augment tourism potential for Kochi city.

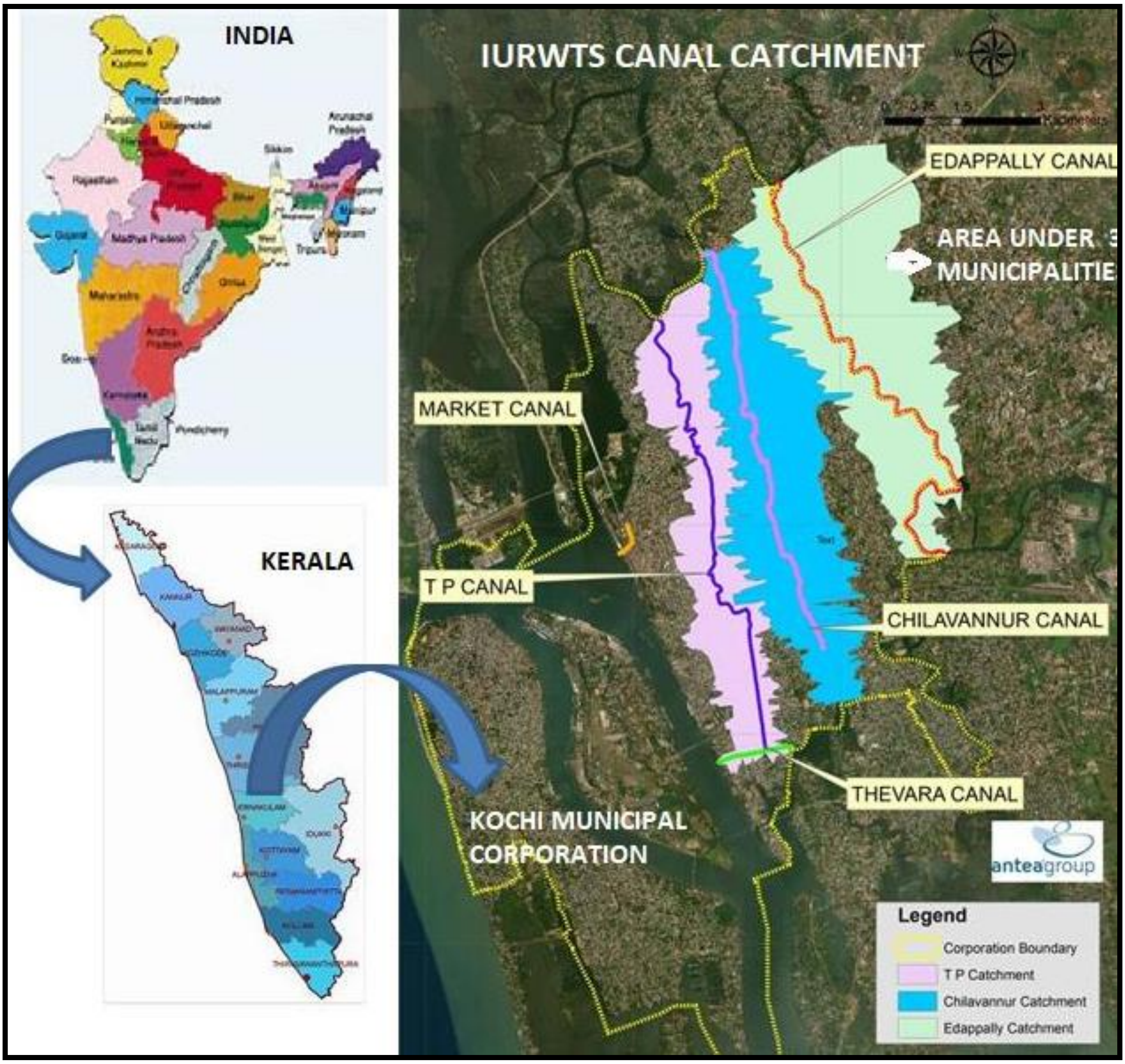


Figure-1.1: Location Map

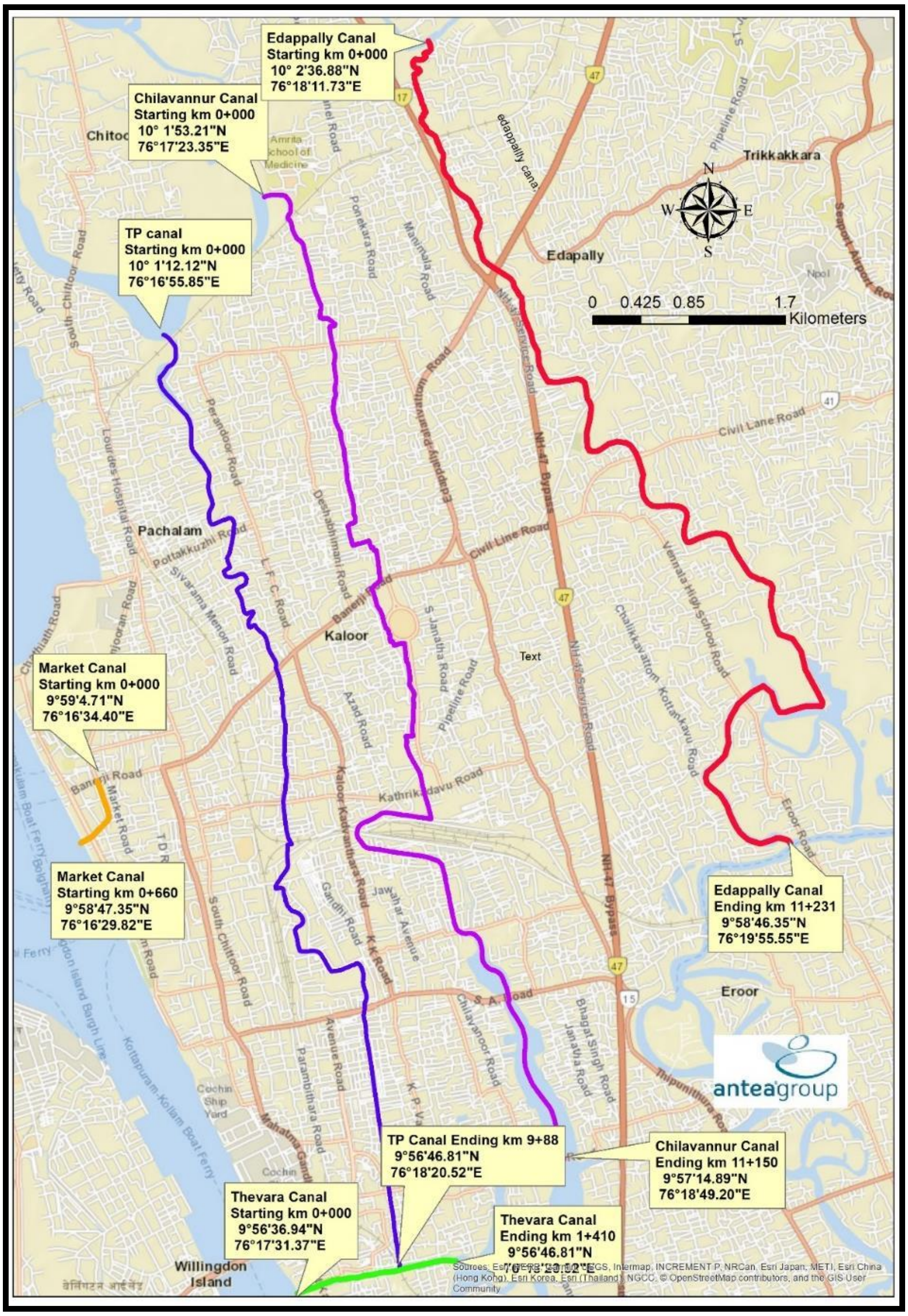


Figure-1.2: Locations of proposed Canals for Navigation

The major components of the projects are as follows:

- Improve intermodal connectivity with the Rail Metro and Water Metro by way of restoration of canals.
- Providing necessary infrastructure for navigation facilities and vessels.
- Flood mitigation and flood plain management.
- Canal bank development which includes beautifications, walkways, recreation, and tourism.

* Enhance sewerage network to the inhabitanats of the catchment , establish sewage treatment plants, and provide sanitation facilities to the inhabitants of the project not connected with sewer network and for public comfort in the catchment and measures to restrict dumping of waste, control encroachments, stop sewage mixing, etc.
* Infrastructure development for generating revenue through navigation, beautification spoys along edpally canal to attract both international,national and domestic tourist.

1.3 NEED FOR THE PROJECT

The major deficiencies at present observed, in utilization of the proposed canal system include:

* Vent way reduction in the canal width due to unauthorized settlement by squatters and enchroachers.
* Discharge of sewage due improper planning in the existing sanitation facilities and lack of sewer network connection
* solid waste dumping into the canals due to unecientific collection, conveyance and disposal facilities
* Unplanned infrastructure development both across the canals (Road and foot bridges) and in the catchment.
* Frequent flood inundation in adjoining areas of canal catchments due to inadequate drainage facilities..
* Neglect of canals water transport by the administration by improper maintenance and emphasis given more on other on alternative modes of transport.
* Haphazard and unscientific development surrounding the canals

Hence the need for Canal Oriented Development (COD) and Urban Regeneration is considered an urgent need to improve the deficiencies and meet the growing stake holders need for better connectivity. In this context the need for taking up this project was considered with following assumptions:

* Revival and rejuvenation of the 5 canal and subdrains reaching the canals
* Develop the canals into a complementary mass rapid water transit system for the city. This in turn will ease the road traffic density in the city.
* Modern water transport facilities available will improve the riding quality, comfort, travel time through the canal system.
* Cost of development of waterways is comparatively economical.
* Rejuvenating the canal to its original conditions maintaining the canal width as per village records will improve the storm water drainage, mitigate floods in the canal commands.

- Revitalizing and reinventing the forgotten waterways will enhance density along the canal.
- Improve monitoring of the canal systems, which will reduce to zero waste disposal, mosquito menace, and carbon reduction

1.4 NEED FOR THE EIA STUDY

As per the list of projects or activities requiring prior environmental clearance given in the EIA Notification issued by MoEF&CC on 14th September 2006, proposed project as listed on S. No. 7(e) and requires EC from MoEF&CC. Since, the project is proposed in the coastal domain area, CRZ Clearance would also be required as per the CRZ Notification of January 2011. Application for Pre Environmental Clearance was submitted to MoEF&CC vide letter dated 20.02.2020. The Draft Terms of Reference was discussed in the EAC (Infra-2) meeting held on 22-24 April 2020 and approval of Terms Reference (TOR) for the EIA study was issued by MoEF&CC vide letter No.10-23/2020-IA-III dated 13.05.2020 (Refer **Annexure-I).**

The affidavit of project proponenet is enclosed as **Appendix-1**. The NABET certificate of WAPCOS Limited is also enclosed as **Appendix-2**. The Analysis of water, soil and Ambient Air Quality is done through, NABL Accredited Standards Environmental & Analytical Laboratories, Ernakulam. The NABL Certificate of the lab is attached as **Appendix-3**. Consent to Establish from Pollution Control Board is attached as **Appendix-4.**

As suggested by MoEF&CC in the TOR, marine biodiversity study were carried out by Department of Marine Biology, Microbiology & Biochemistry of Cochin University of Science & Technology. CRZ Categorization study was carried out through Institute for Remote Sensing (IRS) Anna University, Chennai, which is one of the authorized agency of MoEF&CC for High Tide Line/Low Tide Line demarcation. Compliance Statement of TOR is given in **Annexure-II.**

1.5 OBJECTIVES OF THE EIA STUDY

The major thrust of the EIA study shall be to assess the impacts of various activities of proposed project on various aspects of environment. The study shall cover the impacts on water quality, noise, air quality, terrestrial ecology, wildlife, aquatic ecology including fisheries, etc. The study will include collection of baseline data, prediction of impacts and formulation of Environmental Management Plan (EMP) for amelioration of adverse impacts. The Study Area for the EIA Study shall be the area within 10 km radius of the periphery of the proposed navigation channel. The objectives of the Environment Impact Assessment study are to:

- Determine the baseline status of the Marine Ecology, Terrestrial Environmental Conditions, Ambient Air Quality, Land use, Noise Level and Socio-economic aspects of the Study Area.
- Identify and assess the probable impacts of the project on marine and terrestrial environment in the study area during dredging and dumping operations of the project.
- Suggest adequate mitigation measures to minimize the negative impacts during dredging operation and operational phases of the project.
- Recommend Environment Management Plan to ensure that the project implementation does not impact the environment adversely.

1.6 STUDY AREA & STUDY PERIOD

As per the Ministry of Environment, Forests and Climate Change (MOEF&CC) guidelines, for primary data collection a 100 meters wide corridor (50 m from the centre line of the waterways of each canal and for secondary data collection 10 km wide corridor on both the sides of waterway of each canal will be considered. Socio-economic impact will be conducted based on secondary data. The Baseline survey for the propoes study is conducted from September 2020 to November 2020.

The study area is shown in Figure-1.3.

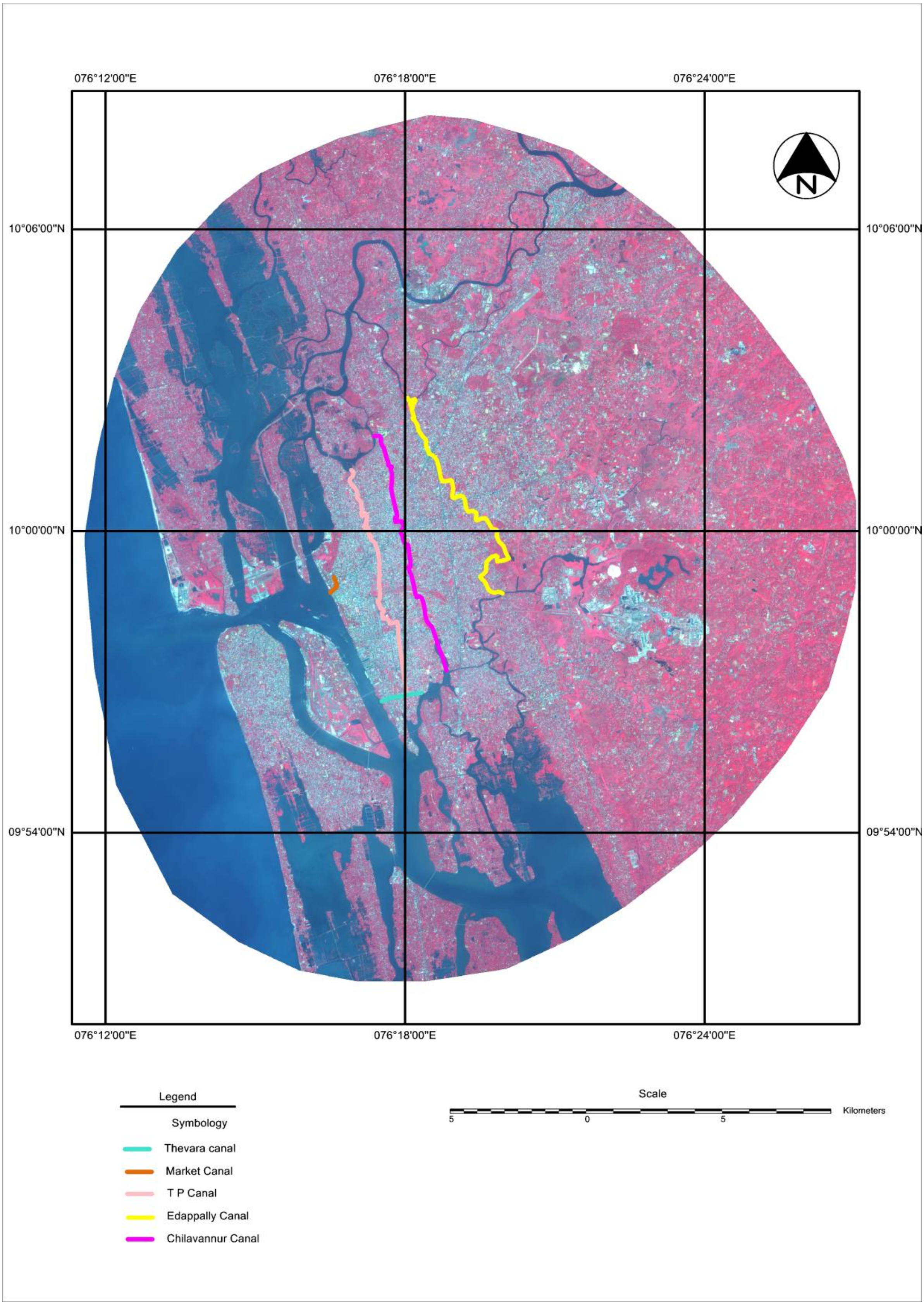


Figure-1.3: Study Area Map

1.7 STAGES IN AN EIA STUDY

The purpose of this section is to enumerate the steps involved in an Environmental Impact Assessment (EIA) Study. The same are given in following paragraphs.

Scoping: An exhaustive list of all likely impacts drawing information from as many sources as possible shall be prepared to assess the impacts due to various activities of the proposed Dredging Project. The next step shall be to select a manageable number of attributes, which are likely to be affected as a result of the proposed project.

Various criteria applied for selection of the important impacts are as follows:

- magnitude
- extent
- significance
- special sensitivity

Baseline Study: Before the start of the project, it is essential to ascertain the baseline levels of appropriate environmental parameters, which could be significantly affected by the implementation of the project. The planning of baseline survey emanated from shortlisting of impacts prepared during identification. The baseline study involved both field work and review of existing documents, which is necessary for identification of data which may already have been collected for other purposes.

Impact Prediction: is essentially a process to forecast the future environmental conditions of the project area that might be expected to occur as a result of the proposed project. An attempt was made to forecast future environmental conditions quantitatively to the extent possible. But for certain parameters which cannot be quantified, general approach is to discuss such intangible impacts in quantitative terms so that planners and decision-makers are aware of their existence as well as their possible implications.

Environmental Management Plan: For the proposed coastal development projects an Environmental Management Plan (EMP) is formulated to maximize the positive environmental impacts and minimize the negative ones. After selection of suitable environmental mitigation measures, the cost required for implementation of various management measures is estimated, to have an idea of their cost-effectiveness.

Risk Analysis and Disaster Management Plan: Risk Analysis and Outline of the Disaster Management Plan (DMP) has been prepared considering the proposed project activities.

Environmental Monitoring Programme: An Environmental Monitoring Programme for implementation during project dredging operation and operation phases shall be suggested to oversee the environmental safeguards, to ascertain the agreement between prediction and reality and to suggest remedial measures not foreseen during the planning stage but arising during operation and to generate data for further use.

1.8 OUTLINE OF THE REPORT

The contents of the EIA report are arranged as follows:

Chapter 1: The chapter gives an overview of the need for the project, objectives and need for EIA study etc. The methodology adopted for conducting the EIA study for the proposed navigation canal is also described in this chapter.

Chapter 2: A brief project description has been covered in this chapter.

Chapter 3: Baseline environmental conditions regarding physio-chemical and Biological and social environment have been described in this Chapter. The baseline study involved both field work and review of existing documents, which is necessary for identification of data which may already have been collected for other purposes.

Chapter 4: This chapter covers the anticipated impacts due to the proposed project and mitigation measures

Chapter 5: Delineates the alaysis of alternatives for the project and allied activities

Chapter 6: Delineates the Environmental Monitoring Programme for implementation during dredging of canal and other propsed activities is outlines in the chapter.

Chapter 7: This chapter covers the additional studies conducted for the project. Which includes the CRZ categorisation, marine biodiversity study, and modelling study for the project

Chapter 8: Benefits likely to accrue due to the project has been presented in this chapter.

Chapter 9: Outlines the cost benefit analysis for the proposed project activity

Chapter 10: Environmental Management Plan has been covered in this chapter.

Chapter 11: Summary of the Environmental Impact Assessment and Environmental Management Plan has been covered in this chapter.

Chapter 12: Delineates the Disclosure of Consultants.

CHAPTER-2
PROJECT DESCRIPTION

2.1 PROJECT BACKGROUND

Integrated Urban Regeneration and Water Transport System Project (IURWTS) is a comprehensive effort of Government of Kerala to rejuvenate the urban life of Kochi City by augmenting five Major canals which are the lifeline of City life in terms of water flow and movement of Vessels. The project also aims to upscale the standard of human life on both sides of the canal by providing healthy environment. About 95% of Kochi City is surrounded by water bodies and canals. Five major canals which are having total length of 35 km play a significant role in the urban life of Kochi City, especially with respect to travel and transportation of goods. Historians say that these canals were the major transportation means even upto 50-60 years ago. The tide occurred in the backwaters ensure the inflow and outflow of water through the canal. But the inland waterways have been neglected due to the repair development in the road and rail transportation sector.

The unscientific waste management and dumping of waste into the canal have also affected the waterway. At present, the Thevara - Perandoor Canal, Thevara Canal, and Market Canal, Chilavannoor Canal and Edappally Canal and their tributary canals have become drainage carrier of the city. Encroachments, illegal construction on banks, putting drainage outlets to the canal etc. have made a canal a sewage carrier of the city. At many locations, the above canals except, Thevara and Market Canal have a width of 2 to 4 m only.

The aim of the project is to develop transportation through canals, regeneration of Kochi city on development basis, strengthen the tourism, and improve the quality of life of the Kochi city and urbanization with proper waste management systems. With the completion of this project, Kochi will have a world-class standards waterway network, akin to cities like Venice, London and Amsterdam. The project will also improve Kochi's inter-city connectivity by making the canals navigable and double as feeder service to existing public transport systems.

Five of Kochi's major canals, covering a total distance of 34 km will be revived under this project. This includes the Edappally Canal (11.15 km), Chilavanoor Canal (11.023 km), Thevara–Perandoor Canal (9.84 km), Thevara Canal (1.41 km), and Market Canal (0.66 km).

As a part of the project, these canals will be thoroughly cleaned and freed from pollutants using high-efficiency independent sewage treatment plant and disposal methods. This will curb sewage outfalls, reduce the risk of flooding and help retain and replenish water by ensuring smooth flow. All five canals will be included in the Integrated Urban Regeneration and Water Transport System Project (IURWTS).

2.2 HISTORY OF COCHIN CANALS

Cochin (alternatively called as Kochi or Ernakulum) finds its way into modern history with the arrival of Vasco Da Gama in 1498 and the advent of European colonialism. In the early 16th century, Mattancherry and Cochin regions had grown to important trading posts where merchants and traders of various nationalities jostled. Cochin thereby developed as a converging point of water transport. In the emergent phase of waterfront development, settlements were established around a port with safe harbour suitable for cargo and passenger ships. During this period, the waterfront had only a few trails converging at a jetty. After that, a street pattern was slowly installed, buildings began to develop on the street pattern. The settlement resulted in Kochi city and maritime trade stimulated urban development. The shoreline road turned into a busy street. In 1905, Ernakulam got connected to the rest of the country by railroad, and thereby the process of urbanization picked momentum. The construction of highways largely changed the transportation pattern in Kochi city. The inter-woven canal network of Kochi and suburbs, which once brought fame for easy transportation at low cost became a sordid nightmare to the dwellers of the area. Several slums and encroachment resulted in wastes, including night soil from these slums, nearby houses and waste materials from shops, market, etc. being directly deposited in the canals.

Old Kochi Harbor (1850-1897)


Old photo of Kochi canal

2.3 PROJECT PROFILE

The proposed project is located in 27 Corporation Wards of Kochi Corporation and 12 Municipal Wards of Maradu, Trikkakara and Kalamaseery Municipalities of Ernakulam district Kerala. Geographically the area is situated between 9°58' N and 76°16' E. The project area is characterized by sandbars running in the north-south direction with tidal canals in between. The importance of the location in the region is evident from its population size and growth. The project area Agglomeration ranks seventeenth with a population of about 21.17 lakh. It is the largest urban agglomeration in the state. Being a coastal area majority of the project area is within low land regions. The average altitude towards the eastern fringes is about 7.5 m above

MSL, and towards the west the altitude is less than one meter on an average. The whole of the land slopes gradually from east to west. The flat terrain of the central part of the project area with the low altitude interspersed with a network of canal system provide link to the backwaters. The Goals and Objectives of the project is given in Figure-2.1.

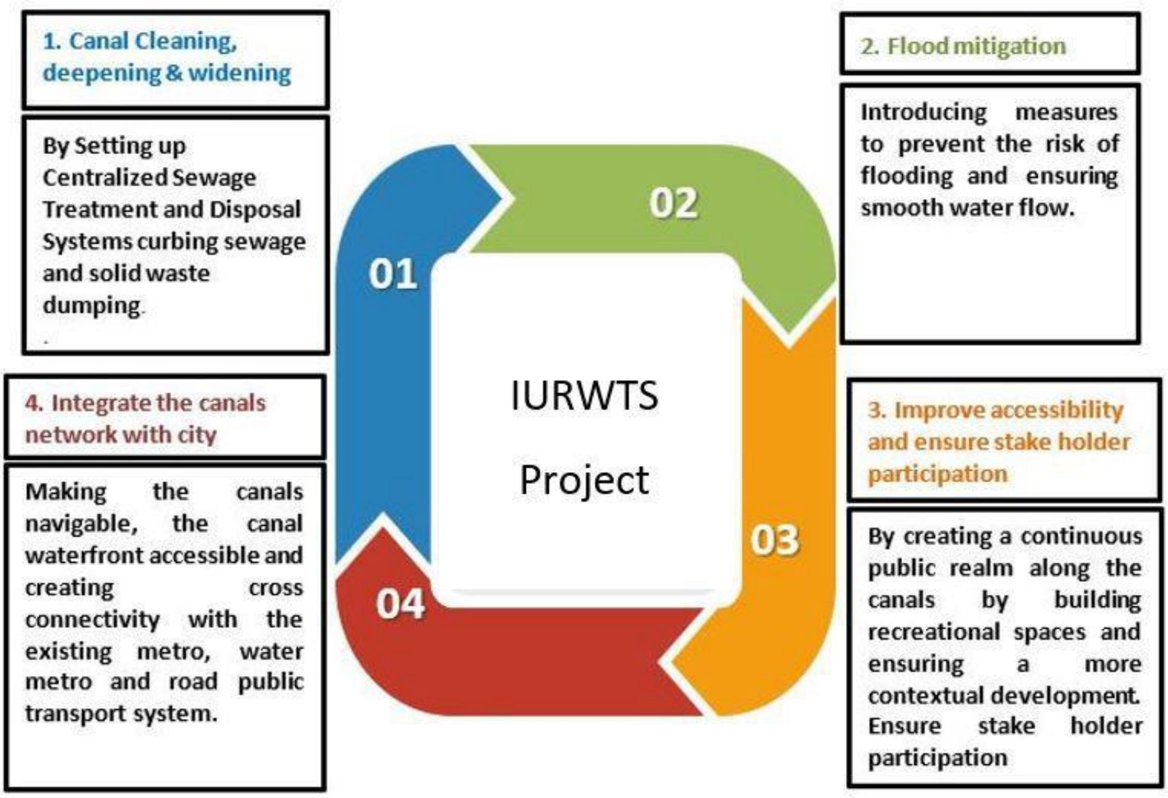


Figure-2.1: Goals and Objectives of the project

2.4 CANAL SYSTEM

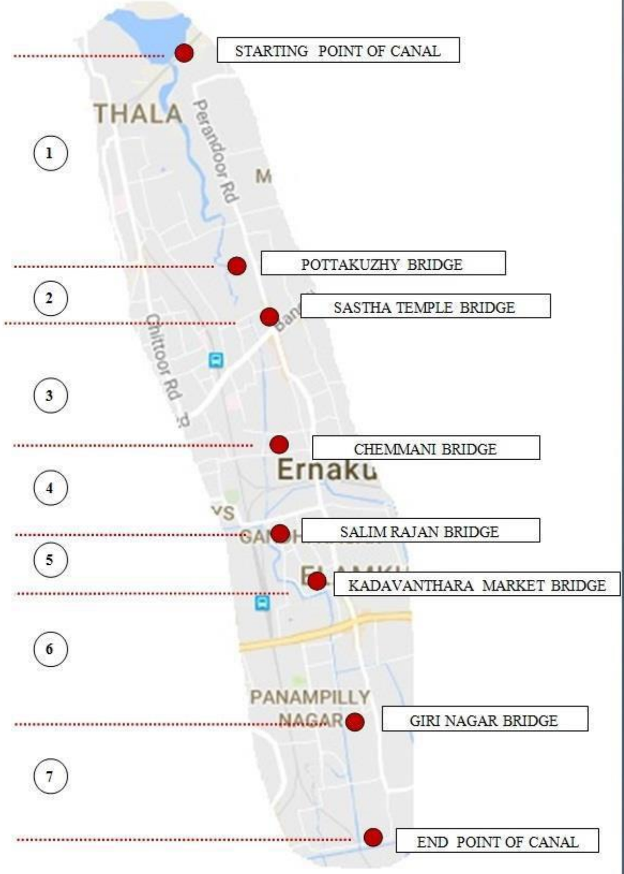
The proposed project envisages the development of the Edappally Canal (11.23 km), Thevara – Perandoor Canal (11.15 km), Chilavanoor Canal (9.88 km), Thevara Canal (1.405 km) and Market Canal (0.664 km). The details of each canal as follows:

a) Thevara Canal The canal originates from Venduruthy Puzha (9° 56' 37.20"N and 76° 17' 32.50"E) and connects with Kundanoor Puzha (9° 56' 47.18"N and 76° 18'17.57"E). This canal is linked with National Waterways No.3 and Thevera-Perandoor canal. The canal passes through Thevara market, Koithara and Kallumpalam. The canal after development will have a potential of connecting Chembakkara canal with Inland Water Authority of India (IWAI) terminal at Maradu. The total length of the canal is 1.41 km. The average width and depth of the canal is 18.5m and 1m-1.5m respectively. The flow is towards western side and it is affected by the settlers through dumping of solid waste into the canal. The waste generated from the fish market situated on right bank at 0.2 km chainage is another major source of pollution	

b) Thevara – Perandoor Canal

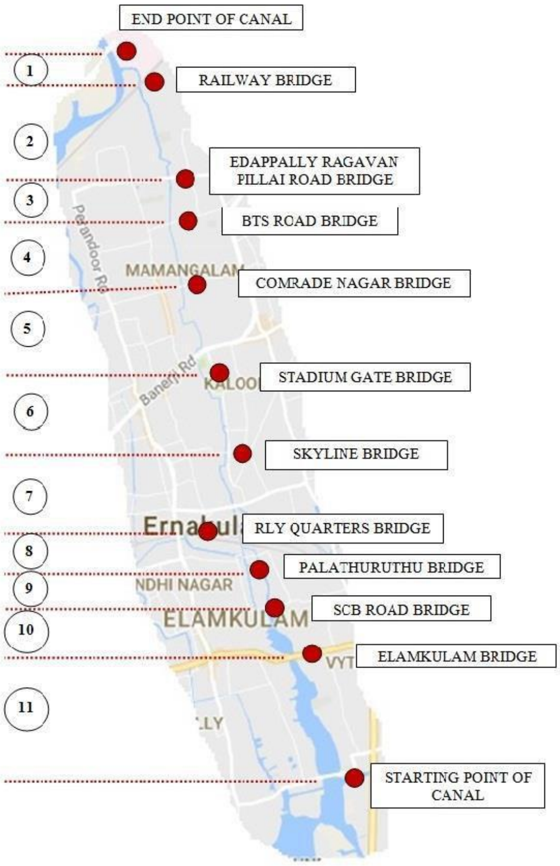
The canal starts from Perandoor Puzha at Railway bridge (10° 01' 12.00"N and 76° 16' 56.00"E) and connects Thevara canal at Railway bridge (9° 56' 44.37"N and 76° 18' 02.45"E). The canal passes through the major places like Perandoor, Vaduthala, Pachalam, Kaloor, Ernakulam South, Giri Nagar, Kadavanthara and Panampilly Nagar. The total length of the canal is 9.88 km. The width of canal is varying from 8.0 m to 48 m and the average width is 17.9 m. The depth of canal varies between 0.6 m and 1.0 m.

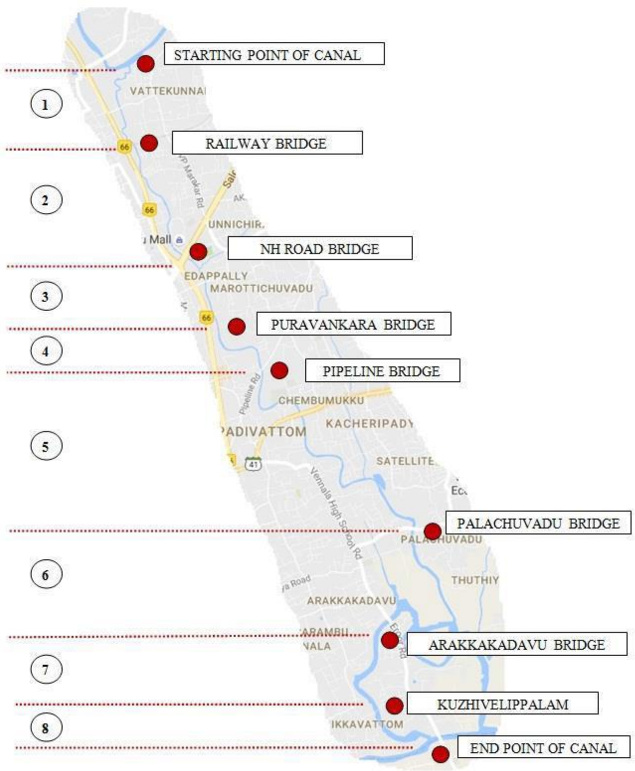
The canal flow is maintained by Perandoor puzha a branch of Periyar river at northern end and Thevera Canal a branch of Chembakkara canal on southern end. The wider portion of canal exists between staring point (0.00 km) and Sastha temple Road Bridge (3.45 km). Due to metro construction along Kaloor road corridor the canal is blocked at 3.78 km. The flow in canal is stagnant between this point and Judges Avenue road bridge due to absence of flow of water. Another bottleneck at chainage 5.33km – 5.356km is observed i.e., the canal is partially blocked and a small channel from 5.40km is started again. The weeds growth is intensive at the section 5.40km – 5.70km due to blockage of canal flow. The wider portion of the canal again starts from SalimRajan road bridge(5.75km) and extended up to ending point of the canal.



c) Chilavanoor Canal

Chilavanoor canal originates from Champakkara Canal (09° 57' 11.27"N and 76°18' 49.22"E) of National Waterway- 3 and ends at Perandoor Puzha (10° 01'53.39"N and 76° 17' 23.49"E) back side of the Amritha Institute of Medical Science (AIMS), Edapally. The canal passes through Chilavanoor, Elamkulam, Kathrikkadavu, Kaloor, International Stadium and Elamakkara. The wider portion of the canal is existing for the stretches starting point of the canal to SCB road bridge and Edapally Ragavan bridge to end point of the canal. The major bottle neck is missed link between 6.79km -6.86km i.e. the canal portiopassing Kaloor - Palarivattom road. Due to metro construction the canal is diverted through a pipeline and it passes through KSEB Sub-Station, Kaloor premise covered by concrete slabs. The same situation is extended up to the chainage 7.19km i.e., end of KSEB, Kaloor sub-station end. Again the canal is covered by RCC slab between the sections 7.25km – 7.30km and 7.585km – 7.65km. Similarly, average width of 1.5m RCC slabs of 5 Nos. exists between Keerthinagar bridge to BTS Road Bridge. The canal is divided in to eleven stretches according to width, depth, population density and accessibility. Total length of the canal is 11.15 km. Canal width varies from 3.5 m to 200 m and the average width is 34 m and depth ranges between 0.6m to 1.1m.



d) Edappally Canal Edapally canal starts from Muttar Bridge (10° 02’ 36.78” N and 76° 18’ 12.40”E) and connects with Champakkara Canal (part of NW-3) near Eroor Bridge (09°58’ 46.47” N and 76° 19’ 56.29” E) as its end point. It passes through Edapally, Vennala, Chakkaraparambu and Chalikkavattom. This canal provides the shortest link between the two industrial hubs of Kochi namely - Udyogamandal and Ambalamugal. Improvement of this canal will facilitate reduction in transportation cost of cargo movement between these two industrial hubs. The total length of the canal is 11.23 km. Canal width varies from 28.72 m (average) and depth ranges between 0.8 m to 1.30 m (average). It is a perennial water body and presently, there is no visible water flow in most of the portions of the canal.	
e) Market Canal The canal starts from Ernakulam channel at Rainbow bridge (09° 58 47.65 N and 76° 16 30.15 E) and it ends at Banerji Road (09° 59 05.09 N and 76° 16 34.31 E). The Market Canal is passing through Broadway and the Market road - the commercial hub of the City - where the bulk of wholesale and retail activities of the city take place. Even though the length of the canal is small, is having tourism potential at starting point i.e., The Marine drive and possibility of cargo movement through Rainbow bridge to market area. The total length of the canal is 0.66 km. The average width and depth of the canal is 9.94 m and 0.6 m-1.0 m respectively.	

2.5 CURRENT STATUS OF THE CANALS

2.5.1 Edapally Canal

Edapally canal starts from Muttar bridge and connects with Champakkara Canal (part of NW-3) near Eroor bridge its end point. Total length of the canal is 11.15km. Canal width varies from 28.72m (average) and depth ranges between 0.8m to 1.30m (average). Canal is highly silted and polluted by domestic waste, commercial waste, construction waste, weeds growth and other sources. There are 18 cross structures along the canal which included 15 road bridges, 2 rail bridges and one foot over bridge. The desired limit of horizontal and vertical clearances of the cross structures are 20m and 4m respectively. Out of 18 cross structures, 3 had desired vertical clearance.

Edapally Canal

2.5.2 Chilavanoor Canal

Chilavanoor canal originates from Champakkara Canal of National Waterway- 3 and ends at Perandoor Puzha, Edapally. Total length of the canal is 11.023 km. Canal width varies from 3.5m to 200m and the average width is 34m and depth ranges between 0.6m to 1.1m. There are 38 cross structures exists along the canal which included 30 road bridges, 3 rail bridges and 5 foot over bridges. None of the cross structures has got the stipulated clearances and were recommended to reconstruct/modify the same.

Chilavanoor Canal

2.5.3 Thevara – Perandoor Canal

The canal starts from Perandoor Puzha at Railway bridge and connects Thevara canal at Railway bridge. The total length of the canal is 9.84km. The width of canal is varying from 8.0m to 48m and the average width is 17.9m. The depth of canal varies between 0.6m and 1.0m. There are 38 cross structures along the canal which included 30 road bridges, 3 rail bridges and 5 foot over bridges.

Thevara – Perandoor Canal

2.5.4 Thevara Canal

The canal originates from VenduruthyPuzha and connects with KundanoorPuzha. The total length of the canal is 1.41km. The average width of the canal is 18.5m and width varies between 1m and 1.5m respectively. 3 cross structures exist across the canal out of which, 2 are road bridges and 1 rail bridge. The vertical clearance and horizontal clearance of the structures do not meet the desired standards and recommended for reconstruction/modification.

Thevara Canal

2.5.5 Market Canal

The canal starts from Ernakulam channel at Rainbow bridge and ends at BanerjiRoad .Total length of the canal is 0.66km. The average width of the canal is 9.94m and depth varies between 0.6m and 1.0m respectively. Four cross structures passes across the canal out of which, three are road bridges and one foot over bridge. The vertical and horizontal clearance of the desired limit was met by Rainbow Bridge only and others do not meet the desired standards and recommended for reconstruction.

Market Canal

2.6. CONSTRAINTS FOR IMPROVEMENT OF CANAL

The major constraints for improvement of canal are listed out below;

- Missing links
- Cross structures
- Encroachment
- Inadequate width
- Water hyacinth
- Sewage and Sewerage discharge
- Solid waste disposal

Edapally canal, Thevara canal and Market canal does not have any missing links. In Chilavanoor canal, no connectivity is there at Kaloor stadium Jn. and the canal is covered with RCC slabs at Kaloor KSEB sub-station premises due to which the flow in the canal is obstructed. Similarly, missing link is there near PVS memorial hospital and at railway marshalling yard for Thevara-Perandoor canal. Due to Kochi metro construction, the canal flow is restricted at Kaloor stadium Jn. and PVS memorial hospital Jn.

Existing cross structures are the other major constraint for improvement of the canals. Especially most of the railway bridges are not having required horizontal and vertical clearances for navigation. Even the reconstruction of these structures can only fulfill the requirement of uninterrupted navigation but the vertical rail alignment has to change accordingly. Less possibility of redesign in rail alignment appears to be a major bottleneck for canal improvement.

The settlers on canal banks within the desired buffer zone are key players in canal improvement. The demarcated boundary of individuals will be prepared in DPR stage and actual Project Affected People (PAP) will also be assessed including the ownership.

The required width for canal development is insufficient at Muttar bridge-Ayyanad bridge section of Edapally canal, SCB bridge-Edapally Ragavan Pillai bridge section of Chilavanoor canal and Pottakuzhy bridge-End point of Thevara-Perandoor canal. Widening of canal in these sections required additional land acquisition which is the major concern of canal improvement.

Fresh water species such as water hyacinth and aquatic weeds spreaded over the wider portions of the canal causes the restriction of boat movement, mosquito breeding and water stagnation.

Sewage, sewerage and solid waste generated not only by the settlers but the whole city waste discharge and disposal poses serious threat to canal improvement. The disposal of waste into the canal affects the canal ecosystem which includes the flora and fauna and causes various health hazards to human being. It also allows to deposit the waste minerals on canal beds and it becomes barrier thereby restrict the canal flow.

The canal wise constraints on canal improvement is summarized and given below;

Edapally Canal

- Inadequate width of canal section between Muttar bridge and Ayyanad bridge (5.1 km).
- Near Lulu mall, the canal flow is blocked due to metro construction.
- Out of 18 cross structures only 8 are having sufficient vertical and horizontal clearances. The vertical clearance of Railway bridge at chainage 1.1km is inadequate.
- Water hyacinth/weeds spread over to 1.9 km restricts the vessel operation.
- Waste discharge/disposal from the residential and commercial activities.

Chilavanoor Canal

- Missing link at Kaloor Stadium Jn.(100m) i.e., Kaloor-Kadavanthara Road.
- Canal is covered with RCC slab at KSEB, Kaloor Sub-station premises (600m).
- SCB bridge to Edapally RagavanPillai bridge section having length of (7.0 km), the width of canal is inadequate.
- All 38 cross structures including one rail bridge at chainage 10.6 km passing through the canal do not have required vertical and horizontal clearances.
- 3.5 km length of the wider portions of canal is covered with water hyacinth and aquatic weeds.

- Waste discharge/disposal into the canal from various sources.

Thevara-Perandoor Canal

- Missed link Near PVS Memorial Hospital (50m), due to metro construction.
- Missed link at Railway marshalling yard (60m).
- Pottakuzhy road bridge to end point (7.63km)of the canal, the width is not sufficient.
- All 40 cross structures including one rail bridge at starting point existing across the canal does not have required vertical and horizontal clearances.
- Length of 3.6km is spreaded with water hyacinths and aquatic weeds.
- Waste discharge from the residential, commercial and other activities.

Thevara Canal

- Absence of tidal action, the siltation is more at both ends of the canal.
- Out of 3 Cross structures, one is not having desired clearances.
- Turning radius at Thevara-Perandoor canal connecting point.
- Waste discharge from the residential and commercial activities.

Market Canal

- Canal is closed at end point and the siltation is more towards the end.
- Two cross structures are not having sufficient clearances.
- Waste discharge from the residential and commercial activities.

2.7 PROJECT DESCRIPTION

The project aims to achieve better living conditions and tourism promotion in the canal catchments by focusing on canal-oriented transport development approach. It has been ascertained that the activities proposed in the Integrated Urban Regeneration and Water Transport System (IURWTS) project are economically viable, environmentally sustainable, and socially acceptable. This project is in line with the overall objective of improvement of transport system of Kochi city and for integration with the Rail Metro and Water Metro to enhance the last mile connectivity. This is proposed to be achieved by canal restoration and urban regeneration of the canal catchment. The Urban Regeneration and Canal Oriented Development (COD) is not considered as a simple form of renovation or rehabilitation of the obsolete and dilapidated canal infrastructure. The restoration of canals and urban regeneration is aimed at restructuring the urban fabric and renewal of the urban economy and thereby overall improvement of city's image.

Five canals are proposed to be taken up under the project, i.e., Edappally Canal (11.23 km), Thevara – Perandoor Canal (9.88 km), Chilavanoor Canal (11.15 km), Thevara Canal (1.41 km), and Market Canal (0.66 km). The project command of these canals falls in a rapidly urbanized coastal and estuarine region, which delimits within the Kochi corporation and three municipalities, viz., Kalamassery, Thrikkakkara, Thripunithura of Kochi city. Out of these, Edappally Canal, Thevara - Perandoor Canal and Chilavanoor Canal are three major canals in

Kochi City aligned in the North - South direction, cutting across the heartland of Ernakulam mainland. Improving Edappally canal will facilitate to connect the Edappally Metro Station with the water metro route between Vyttila and Kakkanad. Chilavanoor canal and Thevara-Perandoor canal are also connected with Periyar river. The development of Thevara Canal will reduce the navigable distance between Kundannur and Venduruthy backwaters. The development of these canals will facilitate passenger movement through canal waterways "Canal Metro" and between Rail Metro stations and Water Metro. In addition, the proposed development will augment tourism potential for Kochi city.

Various activities proposed under the project are grouped into following major components:

- Canal and canal bank development and Urban Regeneration.
- Infrastructure / property development by way of Value Capture Financing and Transit Oriented Development to generate revenue.

The restoration process also focuses on enhancement of water storage capacity of canals, thus mitigating floods and improving canal navigation for enhancing last mile connectivity. In the urban regeneration front, a catchment approach will be adopted to assess the sewer loads from the canal catchment rather than confining to the sewer loads to the main canal areas only.

2.8 SALIENT FEATURES

The salient features of Integrated Urban Regeneration and Water Transport System (IURWTS) Project in Kochi are given in Table-2.1.

Table 2.1: Salient Features of the Project

S. No	Item	Description
1.	Title of the project	**Integrated Urban Regeneration and Water Transport System (IURWTS) Project in Kochi.**
2.	Department	Coastal Shipping and Inland Navigation (CSIN), Govt. of Kerala
3.	Details of project location	
	District	Ernakulum
	Taluk	Kanayannur , Aluva
	Corporation/ Municipality/ Panchayath	Kochi Municipal Corporation, Thrikkakkara, Kalamassery and Thripunithura Municipalities
	Assembly Constituency	Ernakulum and parts of Thrikkakkara, Thripunithura and Kalamassery Legislative Assemblies.
4.	Implementing agency/SPV	Kochi Metro Rail Ltd. (KMRL)
5.	DPR Prepared by	Antea Group (Antea Netherland and Antea India JV)
6.	Project Outlay	1528.27 Crores
7.	Budget speech reference	GO (Rt) No. 2010/2019/RD dated 23rd July 201 Rs 566.52 Crores (Only for land acquisition and building compensation cost).

<table>
<tr><th>S. No</th><th colspan="2">Item</th><th colspan="5">Description</th></tr>
<tr><td>8.</td><td colspan="2">Administrative sanction</td><td colspan="5">GO (Rt) No. 2010/2019/RD dated 23rd July 2019. The present DPR is prepared based on above Govt. order.(GO (Rt) No. 457/2017/CLAD dated 19/07/2017 for DPR by KSINC)</td></tr>
<tr><td>9.</td><td colspan="2">Nature of the project</td><td colspan="5">Canal restoration and navigation, flood mitigation and urban regeneration</td></tr>
<tr><td>10.</td><td colspan="2">Present status of existing canals/roads bridges/building/jetties</td><td colspan="5">Inland canals running through the project command are in a dilapidated state due to dumping of waste, and rampant encroachments of canal banks. This has resulted in reduction in canal width thereby making the canals not suitable for navigation.
Poor sanitation facilities have resulted in direct sewage disposal into the canals by the inhabitants of canal catchments. This has resulted in poor water quality, creating foul smell in the surrounding areas, and affecting local environment and health of people.
Loss of life and property due to inundation/floods in the canal catchment during extreme rainfall events.
Reduction in canal width vent way and inadequate vertical clearance of existing road bridges/foot over bridges is hindering canal navigation and water flow.
Existing utilities (water pipelines, electric lines, transformers, culverts, etc.) hindering storm water drainage and canal navigation.</td></tr>
<tr><td>11.</td><td colspan="2">Need of the project</td><td colspan="5">Improve intermodal connectivity with the Rail Metro and Water Metro by way of restoration of canals.
Providing necessary infrastructure for navigation facilities and vessels.
Flood mitigation and flood plain management.
Canal bank development which includes beautification, walkways, recreation, and tourism.
Enhance sewerage network, establish sewage treatment plants, and provide sanitation facilities to the inhabitants of the project catchment and restrict dumping of waste, control encroachments, stop sewage mixing, etc.
Infrastructure / property development along the canals through Value Capture Financing & Transit Oriented Development for generating revenue.</td></tr>
<tr><td>12.</td><td colspan="7">Canals</td></tr>
<tr><td></td><td colspan="2">Existing canals to be taken up for canal navigation and canal bank development</td><td>Edappally</td><td>Thevaa</td><td>Thevara-Perandoor</td><td>Chilavanoor</td><td>Market</td></tr>
<tr><td></td><td rowspan="2">North Side</td><td>Latitude</td><td>10°2'39.59"N</td><td>9°56'46.93"N</td><td>10°1'12.27"N</td><td>10°1'53.12"N</td><td>9°59'4.29"N</td></tr>
<tr><td></td><td>Longitude</td><td>76°18'2.85"E</td><td>76°18'17.27"E</td><td>76°16'56.54"E</td><td>76°17'23.95"E</td><td>76°16'34.42"E</td></tr>
<tr><td></td><td rowspan="2">South Side</td><td>Latitude</td><td>9°58'46.63"N</td><td>9°56'36.98"N</td><td>9°56'44.36"N</td><td>9°57'14.56"N</td><td>9°58'47.28"N</td></tr>
<tr><td></td><td>Longitude</td><td>76°19'55.33"E</td><td>76°17'31.38"E</td><td>76°18'1.70"E</td><td>76°18'49.40"E</td><td>76°16'29.82"E</td></tr>
<tr><td></td><td colspan="7">Hydraulic Particulars</td></tr>
</table>

S. No	Item	Description				
	Max Width	181.52 m CH:8798	24.94 m	114.58 m	307.28 m	32.09 m
	Minimum Width	5.16 m	13.04 m	1.98 m	1.98 m	1.83 m
	Maximum Depth	6.00m	8.00m	5.00m	6.00m	4.00m
	Minimum Depth	0.30m	3.0m	0.40m	0.20m	1.00m
	Canal length (km)	11.23	1.41	9.88	11.15	0.66
	Canal beautification	4 km (either sides)	Landscaping with walkways in balance portion as per site availability			
	Roads bridges to be reconstructed (nos.)	11	2	23	20	0
	Foot bridges to be reconstructed (nos.)	1	0	13	16	1
	Foot bridges (new) (nos.)	5	2	5	2	1
	Jetties, terminal buildings, etc. (nos.)	9	2	10	9	0
13	Urban regeneration:					
	Sewerage network (Sewer load to be treated) (in MLD)	11.71	10.59		13.15	Existing scheme
	Sewerage Treatment Plant	Vennala + Muttar	Elamkulam	Elamkulam + Perand-oor	Elamkulam	
	Sanitation facilities	As per requirement				
	Solid waste management	Kochi Municipal Corporation will handle delivery and treatment as part of WTE proposal at Brahmapuram Plant Ambalamugal in Vadavucode – Puthencruz Grama Panchayat in Kunnathanadu taluk, but provision to collect solid waste for years is included as part of this project				
14	Rehabilitation, resettlement Compensation for project affected people	280 units, 94 buildings (Full) and 791 buildings partial				
	Details of land acquisition:					
	Canal Oriented Development (COD)	Area: 37.50 ha; Land cost - **437.27 crore**				
	Resettlement & Rehabilitation	Area: 3.13 ha (7.73 acres); Land cost - **29.61 crore**				
	Total Land Acquisition Cost	**466.88 crore**				

S. No	Item	Description	
	Total cost – COD and Urban regeneration (excluding land acquisition)	1061.39 crore	
	Total -COD + Urban Regeneration (Capital cost+ Land acquisition)	**1528.27 crore**	
15.	Details of Cost Benefit Analysis (CBR Value)	**EIRR (%)**	**FIRR (%)**
	Canal Oriented Development	26.41	5.24

2.9 PROJECT COMPONENTS

2.9.1 Canal Oriented Development

The canal-oriented development will meet the requirements and demands of various stakeholders as well as it will add value to the overall canal improvement and development.

Canal Cleaning

It is proposed to clean water hyacinth and other floating materials including plastic waste deposited in the canal. Provision has been included for cleaning the canal during the start and completion phase of the project i.e. during the preconstruction phase, and on completion of the project.

Desilting and Widening of Canals

The width of five canals is restored to the original width of canal as per village record and ensuring that the requirement for flood mitigation and navigation of vessels are met. The dredged level has been fixed taking into consideration the hydro-geological aspects and the minimum navigation depth to be maintained during low tide water level in the canal. Proposal to desilt the sub canals at essential locations is also proposed

As per the navigation standards of IWAI, for a canal influenced by tidal level fluctuations a minimum navigation requirement depth is to be maintained all throughout the year. To fulfil the depth requirement, the criteria as per standard guidelines for small canals were followed. A depth of 1.2 m below the low water level (LWL) of +0.3m MSL is estimated and the deepening quantity estimated accordingly. By considering the above criteria, quantity of deepening and widening of canals were reassessed, at closer intervals of 15 m along the canal reach. Twenty percent of the dredged material obtained from deepening and widening is proposed to be reutilised for developing the following:

- Low lying areas along the canal banks,
- Low lying areas of the land used for beautification and land scaping in Edappally canal

- Bio -engineering works for embankment formation

Total quantity for deepening and the quantity required for filling is given in Table-2.2.

Table-2.2: Quantity for deepening and filling

S No	Name of Canal	Deepening Quantity (cum)	Quantity to be filled (cum)
1	Edappally Canal	1,66,607.77	29,948.97
2	Thevara Perandoor Canal	1,14,539.16	20,859.05
3	Chilavanoor Canal	1,41,591.12	26,109.05
4	Thevara Canal	24,641.47	3,595.21
5	Market Canal	6,633.53	1,120.91
	Total	**4,54,013.05**	**81633.18123**

Shore protection: Based upon the different types of shore protection measures, detailed design and estimate will be proposed based on site-specific type requirement.

Reconstruction of roads along canal: The reconstruction of damaged roads along the canal affected due to the widening of canals will be carried out.

Reconstruction of road bridges: Based on the parametric analysis for different types of road structures chosen, site specific road bridges having a uniform and aesthetically pleasing appearance and in line with the canal-oriented development activities will be reconstructed in the detailed design and estimation stage. The reconstruction included is for 56 nos. bridges.

Reconstruction of foot bridges: Steel structure which are environmentally acceptable, aesthetically pleasing, and easy to assemble are proposed for the reconstruction of footbridges. Total 31-foot bridges for reconstruction and 15 nos. new for crossover of the utilities are included.

Construction of access road to road bridges: As the bridge heights are increased to provide a clearance height of 4 meters, it is proposed to carry out gradient correction to the access roads, reconstruction of damaged portion and demolishing charges.

Canal bank beautification with landscaping & promenade: Considering the availability of free space, limited encroachment and the location advantage, it is proposed to beautify a stretch of 4 km on either side of Edappally canal. The canal bank beautification benefits to the well-being of people and encourages lifelong tranquility that is in harmony with nature. It also adds value to the tourist infrastructure of the city and to increase the open area and parks inside the catchment. As per site availability, it is also proposed to provide walkways, fencing, and landscaping in limited stretches along other canal banks where space is available after implementation of the development activities.

Construction of Jetties and Jetties Terminal Buildings: The choice of location of the jetties are determined by the intermodal connectivity with the rail metro, water metro, and road modes, i.e. the first and last mile connectivity. The navigational width of 16.5 m was estimated for 2-way movement in the project canals. Jetties and jetty terminal are designed for an average plinth area of 70 sq.m considering minimum CAPEX and O&M cost. A total of 30 jetties is proposed to meet the navigation requirement. The details are given in Table-2.2 and the location map is shown in Figure-2.2. The concept of the jetty is given in Figure-2.3. Site photographs of each jetty location is given in the section.

Table-2.3: List of Jetties proposed.

Sl. No	Name Of The Canal	Jetty/Terminal		Coordinates	
		Location Name	Jetty No.	Latitude	Longitude
1	Edappally Canal	Muttar	1	10° 2'32.70"N	76°18'7.84"E
2	Edappally Canal	Indraji Road	2	10° 2'21.69"N	76°18'8.25"E
3	Edappally Canal	chembukadavu	3	10° 1'58.48"N	76°18'17.51"E
4	Edappally Canal	Edappally	4	10° 1'29.30"N	76°18'33.60"E
5	Edappally Canal	Pipeline Road	5	10° 0'51.48"N	76°18'57.54"E
6	Edappally Canal	Chembumukku	6	10° 0'37.24"N	76°19'12.03"E
7	Edappally Canal	Palachuvadu	7	10° 0'1.82"N	76°19'46.70"E
8	Edappally Canal	Arakkakadavu	8	9°59'27.80"N	76°19'40.88"E
9	Edappally Canal	Kuzhuvelipalam	9	9°58'58.25"N	76°19'37.82"E
10	Chilavanoor Canal	Near Edappalli Raghavan Pillai Road	10	10° 1'8.87"N	76°17'43.99"E
11	Chilavanoor Canal	Keerthi Nagar	11	10° 0'46.89"N	76°17'44.82"E
12	Chilavanoor Canal	Karukappalli(Near National Public school)	12	10° 0'23.65"N	76°17'49.34"E
13	Chilavanoor Canal	Near JLN Metro station	13	9°59'58.49"N	76°17'55.14"E
14	Chilavanoor Canal	Kaloor JLN Stadium	14	9°59'44.67"N	76°18'3.51"E
15	Chilavanoor Canal	Kathrikadavu	15	9°59'2.38"N	76°18'9.22"E
16	Chilavanoor Canal	SCB Road	16	9°58'20.74"N	76°18'24.00"E
17	Chilavanoor Canal	Elamkulam	17	9°58'4.47"N	76°18'31.47"E
18	Chilavanoor Canal	Chilavanoor Jetty	18	9°57'15.54"N	76°18'44.31"E
19	Thevara Perandoor Canal	Near Perandoor	19	10° 1'2.19"N	76°16'51.57"E
20	Thevara Perandoor Canal	Opposite to Chinmaya Vidyalaya	20	10° 0'46.78"N	76°17'2.62"E
21	Thevara Perandoor Canal	Near Karshaka Road	21	10° 0'36.64"N	76°17'3.54"E
22	Thevara Perandoor Canal	Near Pottakuzhy Bridge	22	10° 0'16.48"N	76°17'14.92"E
23	Thevara Perandoor Canal	Kaloor Metro	23	9°59'40.79"N	76°17'26.15"E
24	Thevara Perandoor Canal	Near KSRTC	24	9°58'33.12"N	76°17'28.46"E
25	Thevara Perandoor Canal	P&T	25	9°58'16.32"N	76°17'34.53"E
26	Thevara Perandoor Canal	Kadavanthra Metro	26	9°57'57.30"N	76°17'51.92"E
27	Thevara Perandoor Canal	Panampally Nagar-Near LAG	27	9°57'32.34"N	76°17'54.60"E
28	Thevara Perandoor Canal	Yuvajana Samajam	28	9°57'6.16"N	76°17'58.21"E
29	Thevara Canal	Kallupalam	29	9°56'46.54"N	76°18'11.17"E
30	Thevara Canal	Thevara Market	30	9°56'39.98"N	76°17'37.81"E

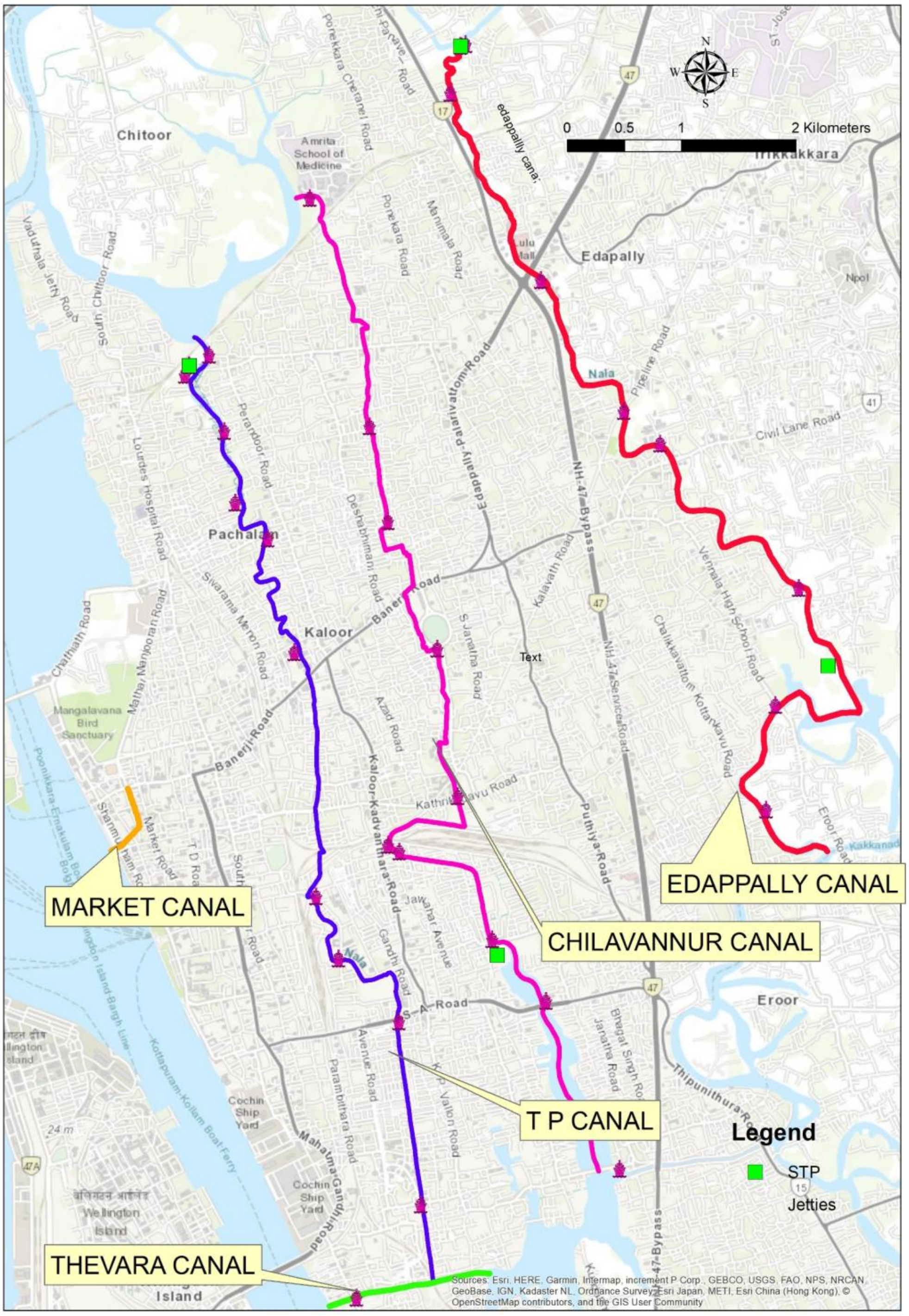


Figure-2.2: Location map for proposed Jetties

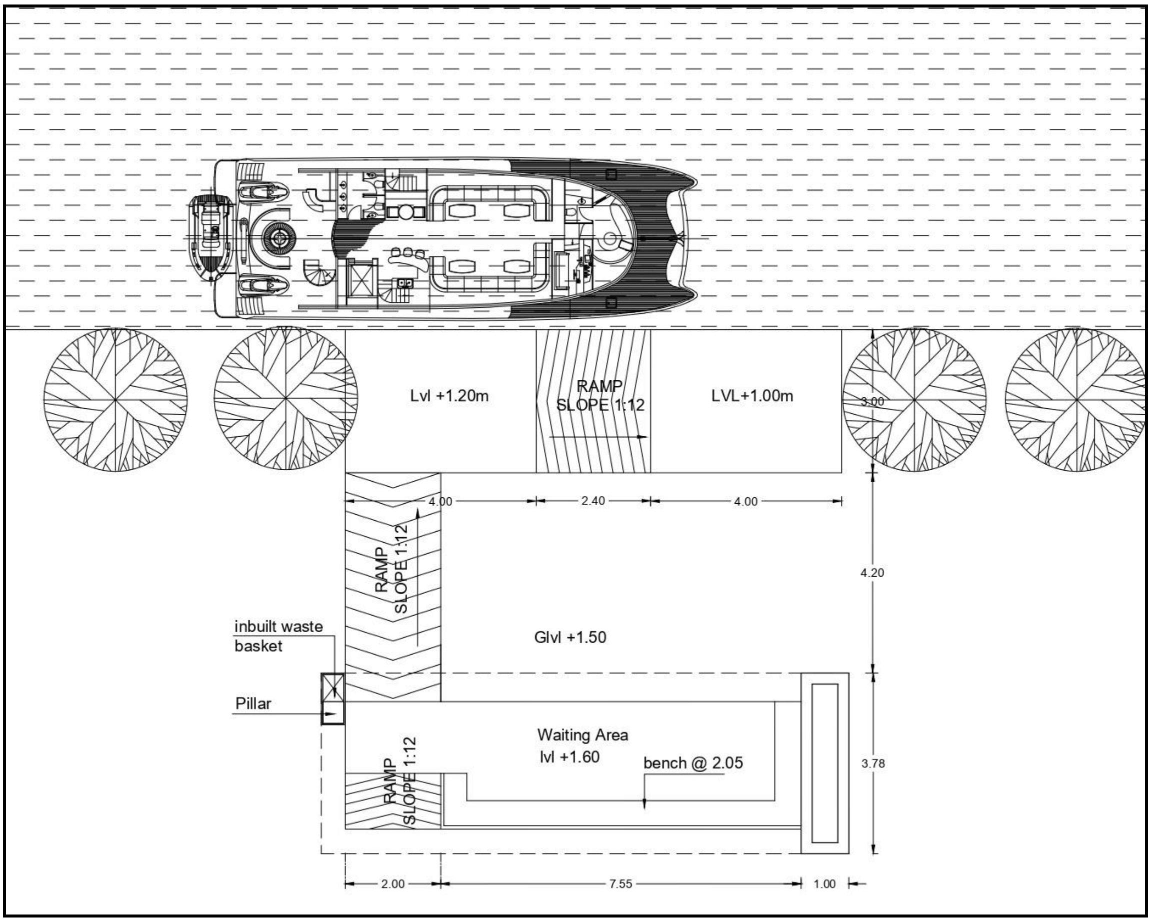


Figure-2.3: Concept design of proposed IURWTS jetty

Edappally Canal (Jetty Locations)

Muttar

Indraji Road

Chembukadavu

Edappally

Pipeline Road

Chembumukku

	
Palachuvadu	**Arakkakadavu**
	
Kuzhuvelipalam	

Chilavanoor Canal (Jetty Locations)

	
Near Edappalli Raghavan Pillai Road	**Keerthi Nagar**

Karukappalli(Near National Public school)

Near JLN Metro station

Kaloor JLN Stadium

Kathrikadavu

SCB Road

Elamkulam

	
Chilavanoor Jetty	

<u>Thevara Perandoor Canal (Jetty Locations)</u>

	
Near Perandoor	**Opposite to Chinmaya Vidyalaya**
	
Near Karshaka Road	**Near Pottakuzhy Bridge**

	
Kaloor Metro	**Near KSRTC**
	
Kadavanthra Metro	**Yuvajana Samajam**
	
Panampally Nagar-Near LAG	

Thevara Canal (Jetty Locations)

Kallupalam	Thevara Market

Construction of office building for Special Purpose Vehicle with testing laboratory: An institutional mechanism to monitor the post implementation stage activities has been proposed. To house the SPV office a plinth area 1200 m^2 is added to a jetty terminal near Lulu mall along Edappally canal. The other facilities provided in this building are a water quality testing laboratory, a tidal fluctuation measurement unit, and a control office connected to all the CCTV units along the 5 canals. The building cost has been estimated, and lump sum provision added for the other facilities proposed.

Construction of access roads to jetties and jetty terminals: Access roads to the jetty terminals will be improved.

Purchase of vessels / boats for navigation of passengers and tourism: Based on the traffic survey results, number of boats with various characteristics have been estimated to cater to the demand of the public.

Navigational aids, Signages, Markers and Way finding signages: Based on design considerations, the required navigation aids and related accessories have been estimated.

Miscellaneous items such as solar installations, EV chargers, electrical systems, non-motorized transport like electric buses, etc. for last mile connectivity are included to support the project operations.

2.9.2 Urban Regeneration

The urban regeneration works include the provision of sewer lines on both sides of the canals, sewage interceptors to collect the sewage load from the sub canals, and pumping systems to pump the sewer load from interceptors into the main sewer line. A total of 4 STPs is proposed to treat the sewer load generated in the project catchment. The catchment has been divided into 2 sectors along the NH 544 which cuts across the project catchment in the east-west direction. The southern side catchments of Thevara-Perandoor, Chilavanoor canals and Edappally are proposed to be treated by 2 STPs. The northern side catchments of the 3 canals are proposed to be individually treated by 2 STPS. Sanitation facilities for inhabitants who are not connected to the sewer lines are also proposed. As a transitional facility, bio-community toilets are proposed at every 500 m along the canals during the project implementation phase. These community toilets would prevent sewage being discharged into the canal. Hence, the activities proposed under urban regeneration are:

A full sewer network for the entire catchment with individual household, sewer network connectivity including interceptors, manholes, inspection chamber, pumping stations, etc.

Sewage Treatment plant

The sewer load of the entire project command to be treated over and above the existing and ongoing scheme has been estimated as 31 MLD. The summary of sewerage flow in each jetty is given in Table-2.4 and the flow in each canal shown in Figure-2.4.

Table-2.4: Summary of Sewerage Flow/Sewage

Sl. No.	**STPs**	**Sewerage Flow**			
		Sewage (2021) in MLD	Sewage (2031) In MLD	Sewage (2041) in MLD	Sewage (2051) in MLD
1	Elamkulam STP - Chilavanoor & TP south	13.48	13.84	13.86	13.68
2	Vennala STP - Edappally south	9.13	9.38	9.33	9.27
3	Muttar STP-Edappally north& Chilavannur north	7.96	8.16	8.21	8.08
4	Perandoor STP - TP north	4.35	4.46	4.51	4.41
	Total	**34.92**	**35.86**	**35.90**	**35.45**

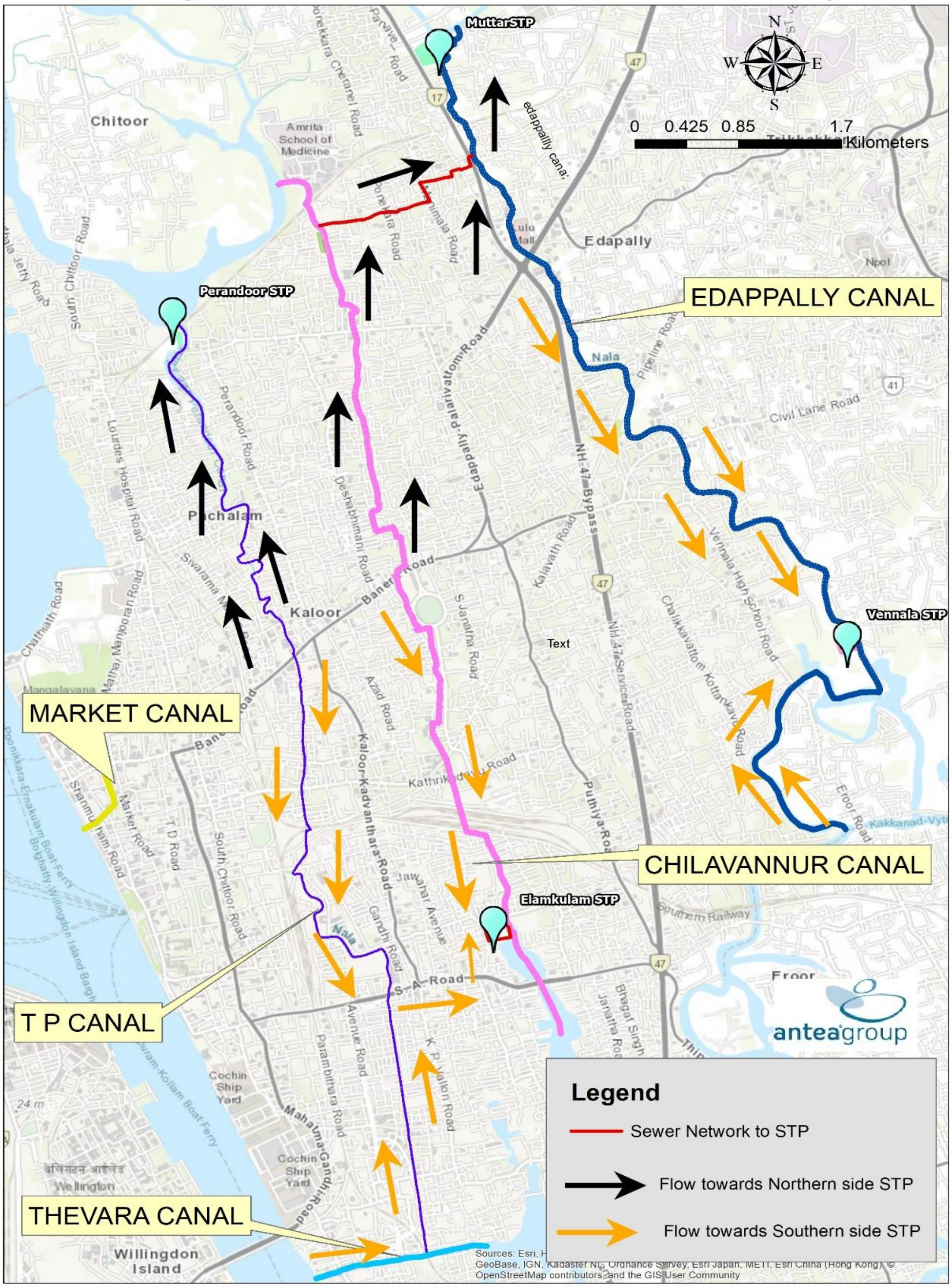


Figure-2.4: Sewage Flow to STP

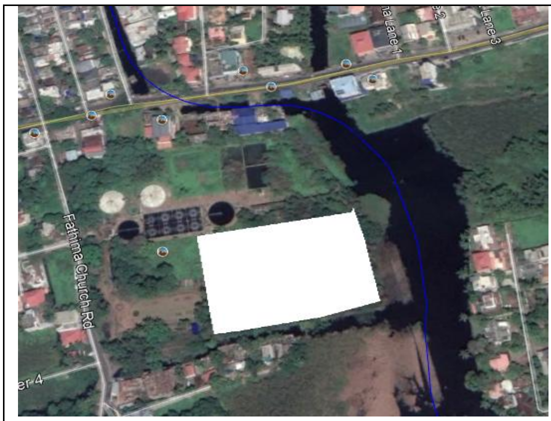
A Sequential Batch Reactor (SBR) technology has been selected for proposed under the IURWTS Catchment. SBR technology is widely used in India for treating domestic sewage and industrial effluents to the highest possible quality.

The sewer load of the southern side catchment of Thevara-Perandoor and Chilavanoor will be treated by a STP of 10 MLD at Elamkulam and the Edappally served by a 10 MLD STP at Vennala. For treatment of sewer load on the northern side catchment of Thevara-Perandoor, Chilavanoor and Edappally, 3 Individual STPs are proposed at Perandoor (5MLD), Puthukkalavattom (4MLD) and Muttar (7 MLD). Provision for 15 years operation and maintenance are also included.

Capacity of proposed STP's are given in Table-2.5 and the site layout shown in Figure-2.5.

Table-2.5: Capacity of proposed STP's.

Sl. No	STP location	Proposed STP
1	Elamkulam STP - Chilavanoor & TP south	10 MLD
2	Vennala STP - Edappally south	10 MLD
3	Muttar STP-Edappally north	7 MLD
4	Perandoor STP - TP north	4 MLD
	Total MLD	**31 MLD**


STP proposed area at Elamkulam

STP proposed area at Vennala

STP proposed area at Muttar


STP proposed area at Perandoor

Figure-2.5: Site Layout of STPs

Sanitation Facilities: The transitional sanitation facilities for population is not covered by the proposed sewage network has been included to prevent sewage being discharged into the canal.

Solid waste management: Kochi Municipal Corporation has already envisaged a proposal for converting the solid waste into energy at Brahmapuram, Kochi. The requirement of daily waste is 250 tons. IURWTS catchment falls within corporation municipality and occupies a major portion of Kochi municipal corporation area. Hence rather than having a separate plant, it is proposed to have a coordinated effort with KMC for solid waste management for the initial 3-year period. Provision for innovative collection methods are only proposed.

2.10 LAND REQUIREMENT

Total land needs to be acquired for the project is approximately 41 ha. Approximately 1151 structures are affected by the project. Out of it 311 are displaced. 33% of acquiring land is owned by Government. Only 41% of acquiring land is in the possession of title holders. All the acquiring land is commercial in nature except few hectares of land with Orchards. 32% of the land is having structures. 80% of the acquiring land is not having any type of road frontage. The details are given in Table-2.6.

Table-2.6: Land Requirement for the proposed project

Name of Canal	Land Required (ha)	Govt. Land(ha)	Govt. Land in Private	Private land(ha)	No. of Residence displaced											
					Squatter				Encroacher				Owner			
					Multi storied	Pucca	Hut with shed	Total	Multi storied	Pucca	Hut with shed	Total	Multi storied	Pucca	Hut with shed	Total
Thevara Canal	1.00	0.90	0.10	0	0	1	1	**2**	2	2	0	**4**	0	2	0	**2**
Thevara – Perando	12.5	4.20	3.40	4.90	0	13	123	**145**	5	12	0	**17**	3	17	0	**20**
Edappally Canal	9.00	3.90	2.30	2.80	0	0		**29**	4	9	0	**13**	4	6	0	**10**
Chilavanoor Canal	17.5	4.10	3.80	9.60	0	13	0	**31**	8	8	0	**16**	4	18	0	**22**
Market Canal	1.00	0.58	0.05	.07	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Total	**41.00**	**13.68**	**9.65**	**17.37**	**0**	**27**	**124**	**207**	**19**	**31**	**0**	**40**	**11**	**43**	**0**	**54**

2.11 COST ESTIMATES

The IUWRTS project aims to achieve better living conditions and tourism promotion in the canal catchments by focusing on canal-oriented transport development approach. Being a large infrastructure, it is a capital-intensive project with a long gestation period. The residents and businesses within 1000m distance on both sides of the project canal banks will be connected to the sewerage network, boat jetties and parks and canal metro connectivity into the urban fabric. This will help an intermodal connectivity with the rail metro, water metro and road transport. Therefore, other revenue generating models such as Value Capture Financing (VCF) and Transit Oriented Development (TOD) will be explored. VCF and TOD are methods of funding infrastructure improvements by recovering all or some of the increase in property value generated by the public infrastructure investment. The benefits accruing from the same may be transferred to the SPV undertaking this project. The summary of project cost is given in Table-2.7.

Table-2.7: Summary of Project Cost

Project Components	Amount (Rs. crore)	EIRR/FIRR
Canal Oriented Development	₹ 432.65	26.41/5.24
Urban Regeneration	₹ 393.13	
Land Acquisition cost for Canal oriented development & Urban regeneration	₹ 437.27	
Specific projects, Environmental monitoring, Project management cost, Specialized work like LIDAR survey, public campaign/social awareness management	₹ 34.50	
Rehabilitation & Resettlement including utilities shifting	₹ 196.72	
Development of Konthuruthy Canal (Additional work)	₹ 34.00	
Total	**₹ 1528.27**	

2.12 PROJECT BENEFITS

The project envisioned holistic Canal Oriented Development (COD), urban regeneration and alternative revenue streams that will bring the following expected outcome and create mixed use development.

- Canal development will create beautifully landscaped canal spaces for leisure and tourism, cute shops, and eateries for creating an illusion of urban vitality along the canal banks and enhanced livelihood opportunities. This would further improve the city's image.
- Enhanced utility of the canal waterfront as a natural attraction for social and economic activity for locals and tourists.
- A hassle-free inland water navigation system along the canals to enhance urban mobility and tourism with environmentally friendly ferry vessels, comfort, and innovative jetty terminal facilities.
- Sanitation facilities and sewage disposal system integrated to serve the inhabitants of the project command.
- Climate change, carbon credits, flood mitigation, boosting of regional economy by tourism, etc.

2.13 CONCLUSIONS

The IURWTS project addresses the issues of the Kochi city by restoring inland navigation, promoting last mile connectivity, protection from flood inundation in canal areas, improvement in urban spaces, and sanitation facilities. It aims to achieve better living conditions and enhance livelihood opportunities for the people as well as tourism. The development of inland canal navigation will enhance greater connectivity between Rail Metro and Water Metro and augment the tourism activities in the city.

Major project components include canal-oriented development and urban regeneration. The total project cost for canal-oriented development excluding the capital cost for revenue generation stream is ₹ 1528.27 crores, with good potential returns in next 25 years. The excess land available after the development process is suggested to be leased or sold out and the anticipated revenue is around 60 crores. This project, once implemented in the next three years, will be a milestone project in the inland navigation and urban regeneration sector and pave way for other similar projects in Kerala state.

2.14 PROJECT IMPLEMENTATION SCHEDULE

The IURWTS Project is a large size multi-disciplinary project and involves wide ranging activities and various institutions and contracting agencies. The project implementation schedule is 24 months and the details given in Figure-2.6.

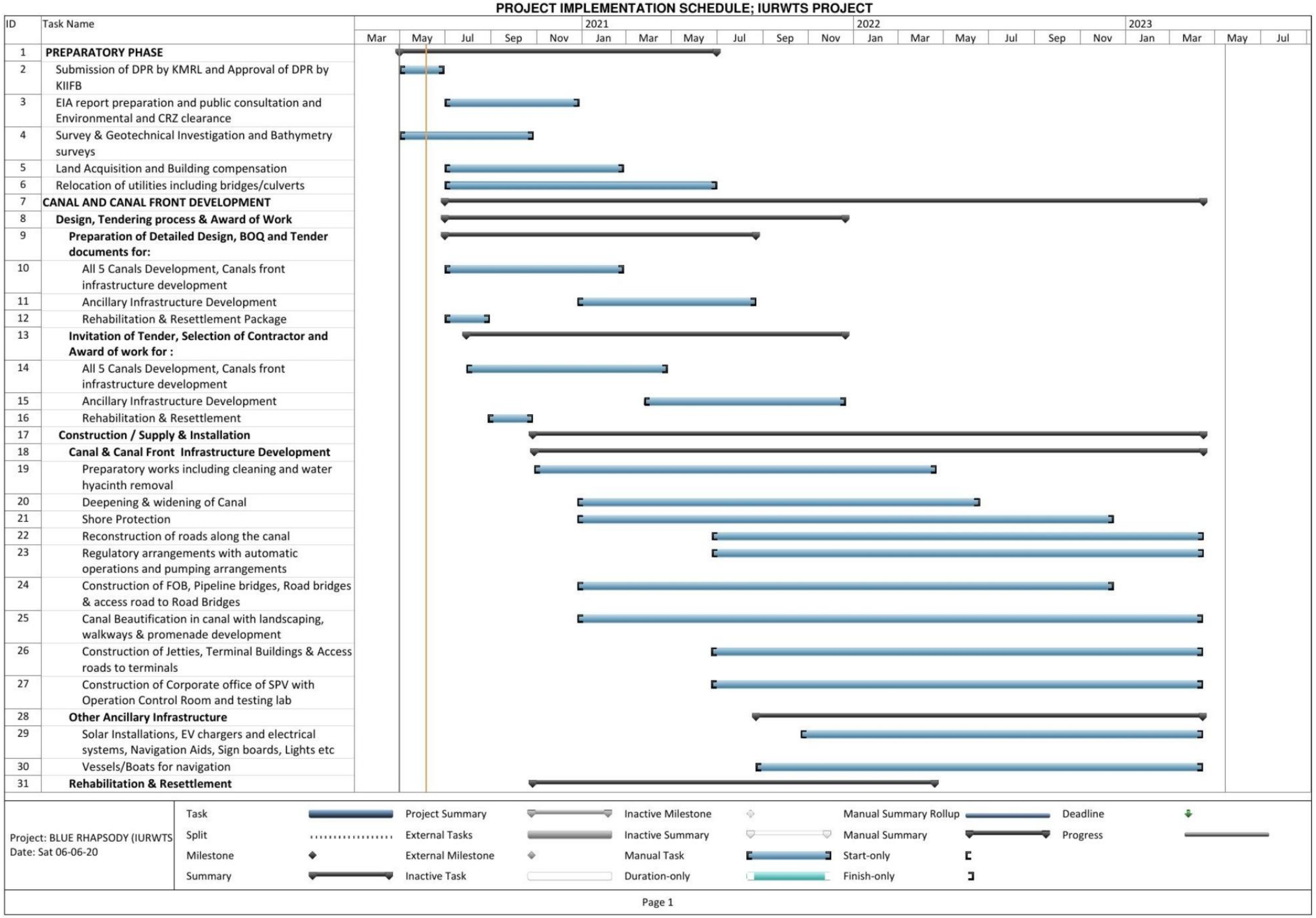


Figure-2.6 A Implementation Schedule for IURWTS Project (Part-1)

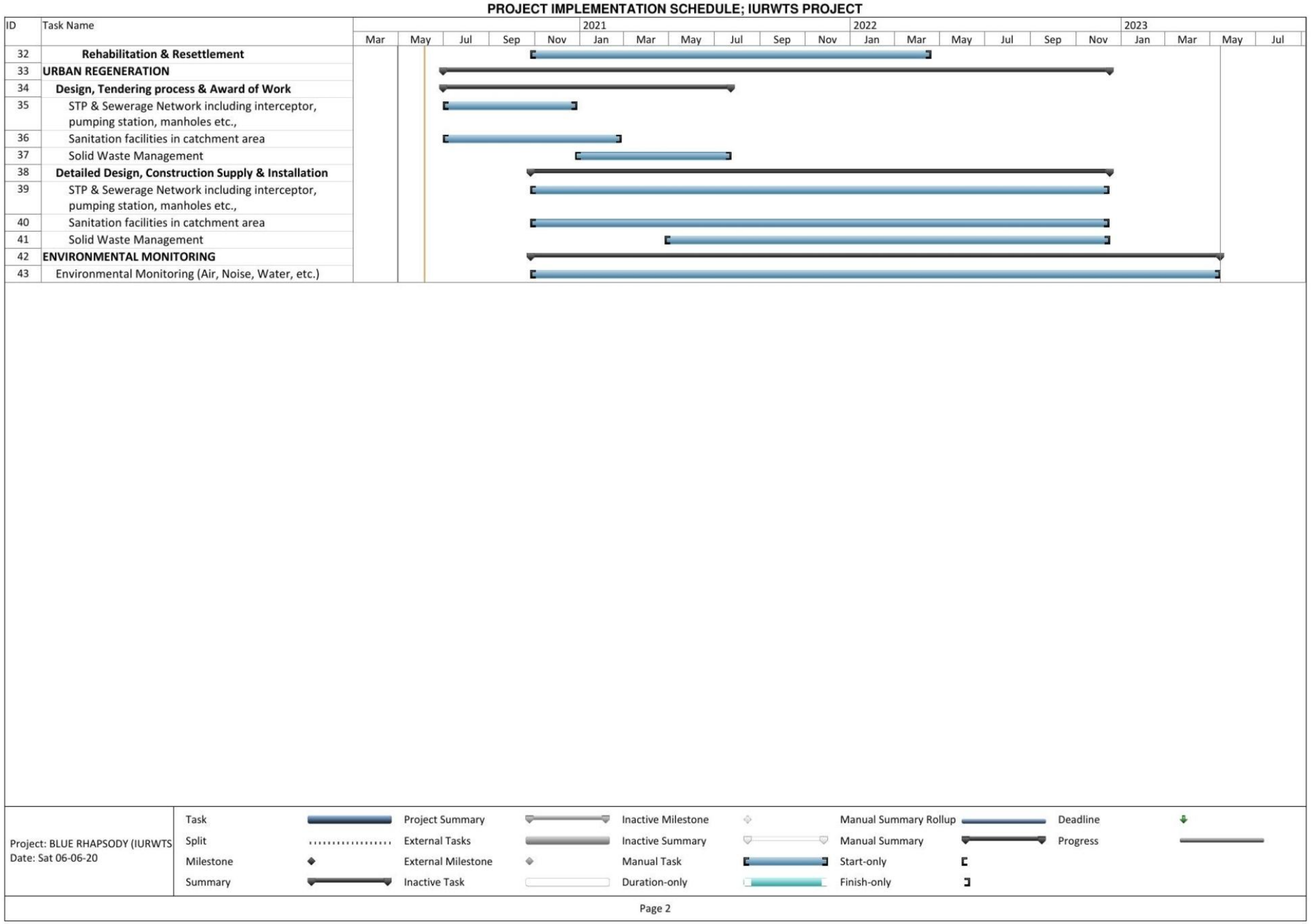


Figure-2.6 B Implementation Schedule for IURWTS Project (Part-2)

CHAPTER-3

DESCRIPTION OF THE ENVIRONMENT

3.1 GENERAL

The EIA study requires a comprehensive and scientific consideration of various environmental aspects and their interaction with natural resources, namely, physico-chemical parameters i.e. meteorology, air quality, noise quality, land use and water quality, biological parameters i.e. terrestrial flora and fauna, marine flora and fauna, fish species, etc. and socio-economic parameters i.e. demography, occupational profile, etc.

As a part of the study, a large quantum of related secondary data as available with departments like Forest, Fisheries, Revenue, etc. has been collected. Field surveys were conducted for primary data generation on various aspects including ambient air quality, water quality, noise, marine ecology etc.

The major portion of the study area is waterbodies (is both in canal water, kochi lagoon water bodies and land). Thus, as a part of the EIA study, appropriate emphasis has been given to aquatic environment. As a part of the EIA study, the baseline status has been ascertained for the following aspects:

- Meteorology
- Geology
- Seismicity
- Oceanographic Condition
- Land use pattern
- Ambient air quality
- Ambient noise level
- Aquatic water quality
- Terrestrial Flora, Fauna
- Aquatic Ecology
- Archeologically Important Area
- Socio-economic Aspects

3.2 METEOROLOGY

Rainfall: The average annual rainfall is reported as 3014.8 mm, and most of which is received in the period from May to October under the influence of south-west monsoons. June and July are the wettest months of the year, accounting for more than 50% of the annual rainfall. On an average, there are 124.1 rainy days in a year. The average monthly rainfall and rainy days recorded at IMD station Cochin is summarized in Table-3.1. The rainfall as received in various months of the year is as given in Table-3.1 and also is depicted in Figure-3.1.

Table-3.1: Monthly Rainfall for the India Meteorological Department (IMD) Station at Kochi

Month	Rainfall (mm)	No. of Rainy days
January	24.3	1.1
February	27.1	1.2
March	45.0	2.6
April	113.1	6.9
May	284.5	11.0
June	700.3	23.0
July	575.5	22.8
August	378.8	19.0
September	310.3	13.4
October	366.6	14.2
November	150.4	7.2
December	39.0	1.8
Total	**3014.8**	**124.1**

Source: Climatological Tables (1981-2010), IMD Kochi

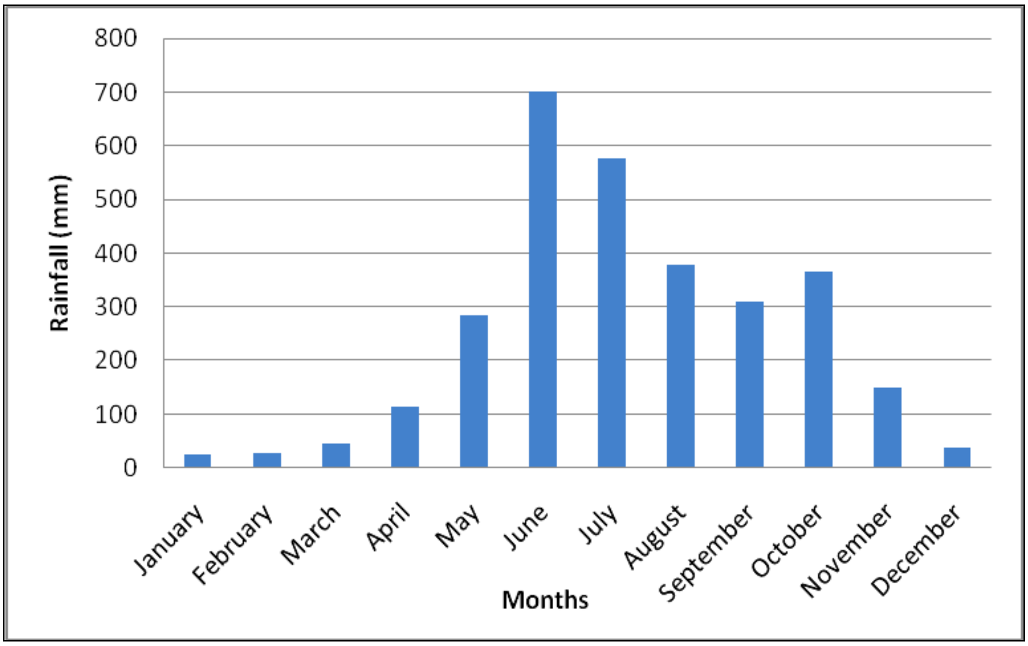


Figure-3.1 Month wise Rainfall Variation in Project Area

Temperature: The average monthly maximum and minimum temperatures recorded at IMD station Kochi is presented in Table 3.2. The mean monthly maximum temperature ranged from 29.5°C in August to 33.0°C in April and the mean monthly minimum temperature ranged from 23.0°C in January to 25.9°C in April. The month-wise temperature variations are depicted in Figure-3.2.

Table-3.2: Average monthly maximum and minimum temperatures at IMD station Kochi

Month	Temperature (°C)	
	Maximum	**Minimum**
January	31.9	23.0
February	32.0	24.2

Month	Temperature (°C)	
	Maximum	**Minimum**
March	32.6	25.5
April	33.0	25.9
May	32.4	25.7
June	30.3	24.2
July	29.6	23.8
August	29.5	24.0
September	30.2	24.2
October	30.7	24.1
November	31.3	24.1
December	31.9	23.2
Mean	**31.3**	**24.3**

Source: Climatological Tables (1981-2010), IMD Kochi

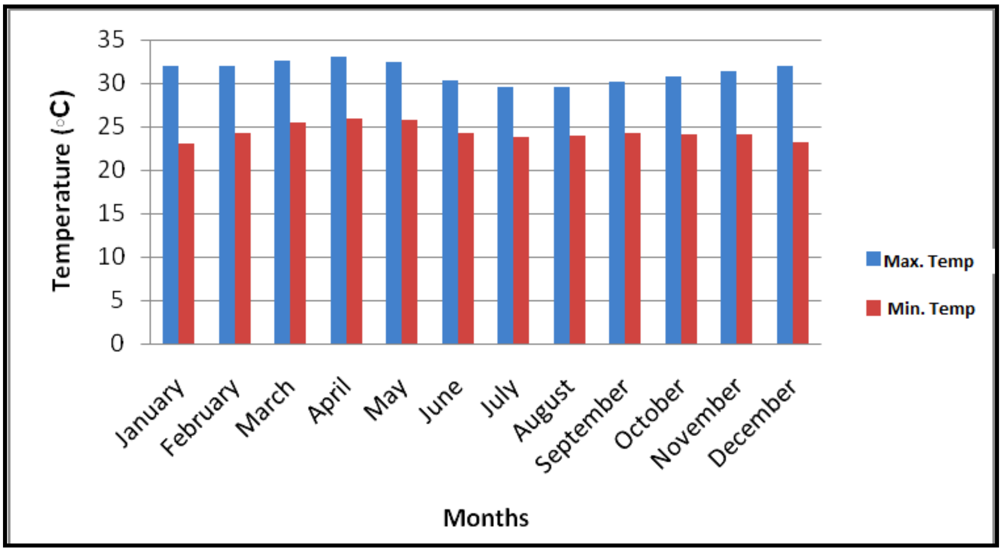


Figure-3.2: Month wise Temperature Variation in Project Area

Humidity: The relative humidity is generally high throughout the year, with highest during south-west monsoon months. With the retreat of south-west monsoons, there is a marginal decrease in humidity. The lowest humidity is observed for the period from December to March. The average monthly relative humidity data recorded at Kochi IMD station is given in Table-3.3. The month wise humidity variations are given in Figure-3.3.

Table-3.3: Monthly average relative humidity for the IMD Station at Kochi

Month	Relative humidity (%)	
	At 8.30 hrs	**At 17.30 hrs**
January	75	61
February	79	65
March	79	68
April	79	70
May	82	73
June	90	82
July	91	83
August	90	82
September	87	79
October	86	77

Month	Relative humidity (%)	
	At 8.30 hrs	At 17.30 hrs
November	82	72
December	76	64
Average	**83**	**73**

Source: Climatological Tables (1981-2010), IMD Kochi

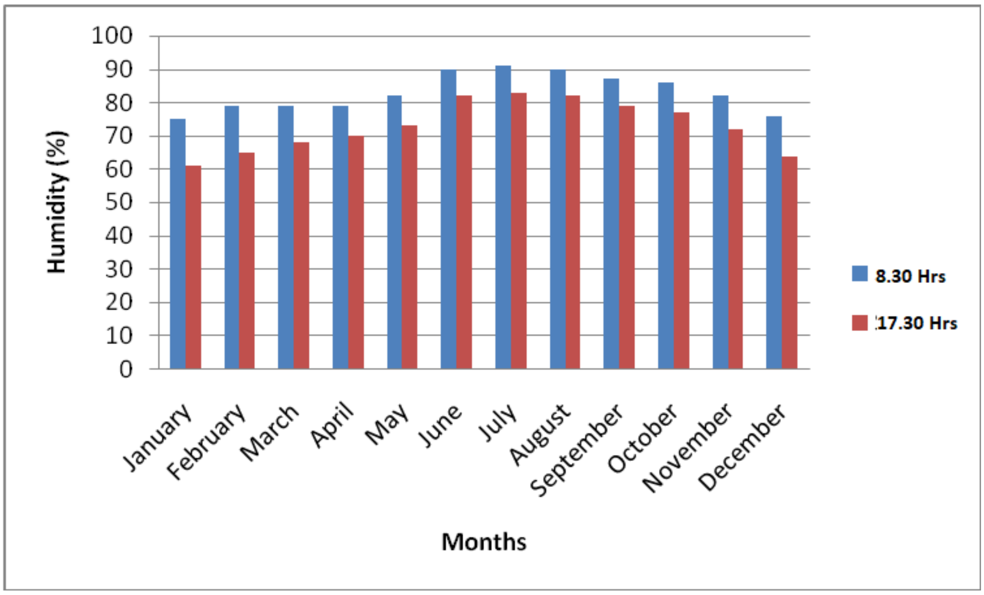


Figure-3.3: Month-wise Humidity Variation in Project Area

Wind Speed/Direction: Generally, light to moderate winds prevail throughout the year. Winds were light and moderate particularly during the morning hours. While during the afternoon hours the winds were stronger. The summary of wind pattern given in **Table-3.4**.

Table- 3.4: Summary of Wind Pattern – IMD Kochi

Month	Time	No. of Days With Wind Speed (km.p.h)				Percentage No. of Days Wind From								
		62 or more	20-61	1=19	0	N	NE	E	SE	S	SW	W	NW	CALM
JAN	08.30	0	0	25	6	2	30	33	4	0	0	0	0	31
	17.30	0	3	28	0	2	0	1	0	0	15	58	24	0
FEB	08.30	0	0	22	6	4	25	23	4	0	1	1	1	41
	17.30	0	5	23	0	2	0	0	0	0	12	56	30	0
MAR	08.30	0	0	22	9	6	17	18	3	1	0	0	1	54
	17.30	0	7	24	0	3	0	0	1	0	9	53	33	1
APR	08.30	0	0	21	9	6	14	13	4	0	0	0	4	59
	17.30	0	8	22	0	4	2	2	1	2	10	42	36	1
MAY	08.30	0	0	22	9	6	12	11	7	1	3	3	5	52
	17.30	0	6	25	0	4	1	2	2	2	11	38	38	2
JUN	08.30	0	1	22	8	8	6	5	3	2	6	13	15	42
	17.30	0	3	27	1	10	1	1	0	1	7	32	43	5
AUG	08.30	0	0	23	8	11	4	5	3	1	2	10	16	48
	17.30	0	4	26	1	10	1	0	0	0	7	33	46	3
SEP	08.30	0	0	22	8	10	8	7	7	3	3	7	8	47
	17.30	0	4	25	1	7	0	0	1	2	11	34	43	2
OCT	08.30	0	0	22	9	3	6	14	11	3	1	1	3	58
	17.30	0	2	28	1	3	0	1	1	5	21	40	26	3
NOV	08.30	0	0	21	9	2	12	14	9	2	0	1	1	59
	17.30	0	1	28	1	3	2	2	2	4	19	47	18	3

Month	Time	No. of Days With Wind Speed (km.p.h)				Percentage No. of Days Wind From								
		62 or more	20-61	1=19	0	N	NE	E	SE	S	SW	W	NW	CALM
DEC	08.30	0	0	25	6	2	35	23	5	0	0	0	0	35
	17.30	0	1	30	0	2	2	2	1	1	15	52	24	1
Annual		**0**	**3**	**268**	**94**	**5**	**14**	**14**	**6**	**2**	**2**	**4**	**5**	**48**
Mean		**0**	**46**	**312**	**7**	**5**	**1**	**1**	**1**	**2**	**12**	**43**	**33**	**2**

Source: Climatological Tables (1981-2010), IMD Kochi

Cloud: The details of cloud occurred in Kochi is given in Table-3.5.

Table-3.5: Details of Cloud in Kochi

MONTH	Time (hrs)	NO OF DAYS WITH CLOUD AMOUNT (ALL CLOUDS)OKTAS					NO OF DAYS WITH LOW CLOUD AMOUNT OKTAS					
		0	T-2	3=5	6=7	8	0	T-2	3=5	6=7	8	FOG 8
JAN	08.30	5	9	13	4	0	18	10	3	0	0	0
	17.30	8	9	10	4	0	19	10	2	0	0	0
FEB	08.30	4	9	12	3	0	11	14	3	0	0	0
	17.30	7	9	9	3	0	14	11	3	0	0	0
MAR	08.30	3	9	15	4	0	8	17	6	0	0	0
	17.30	4	7	16	4	0	7	15	9	0	0	0
APR	08.30	1	4	15	9	1	2	17	11	0	0	0
	17.30	0	3	15	11	1	0	9	20	1	0	0
MAY	08.30	0	2	12	15	2	1	11	18	1	0	0
	17.30	0	1	12	16	2	0	8	21	2	0	0
JUN	08.30	0	0	5	17	9	0	4	24	3	0	0
	17.30	0	0	5	18	8	0	3	26	2	0	0
AUG	08.30	0	0	7	18	6	0	5	24	2	0	0
	17.30	0	0	7	18	6	0	5	24	2	0	0
SEP	08.30	0	1	11	15	3	0	9	19	2	0	0
	17.30	0	1	9	17	3	0	8	21	1	0	0
OCT	08.30	0	2	12	14	3	1	13	16	1	0	0
	17.30	0	1	9	18	3	0	7	23	1	0	0
NOV	08.30	1	3	14	11	1	3	17	10	0	0	0
	17.30	1	3	10	14	2	2	11	16	1	0	0
DEC	08.30	4	7	15	5	0	13	14	4	0	0	0
	17.30	5	6	11	8	1	11	13	7	0	0	0
ANNUAL TOTAL		18	47	140	128	32	56	133	162	14	0	0
MEAN		25	40	115	152	33	52	102	196	15	0	0

Source: Climatological Tables (1981-2010), IMD Kochi

3.2.1 MICRO METEOROLOGICAL DATA OF THE PROJECT SITE

A temporary meteorological station was established near Palarivattam (10° 0'8.14"N, 76°18'14.60"E) location of meteorological parameters comprising air temperature, relative humidity, wind speed, wind direction and rainfall were carried out in the study period September to November 2020, average data as given in Table-3.6 and wind rose Figure-3.4.

Table-6: Micrometeorological Data for the Study Area (September to November 2020)

Month	Temperature (Deg.C)			Humidity(%)			Wind speed (m/s)			Rainfall (mm)	Dominant Wind Direction
	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min		
September	26.6	32.3	22.8	91	99	70	0.6	3.6	0	625	W & NW
October	27.6	32.6	23.1	86.5	99	66	0.7	2.7	0	274	W & NW
November	28.6	34.3	23.6	82	98	46	1	3	0	116	W & NW

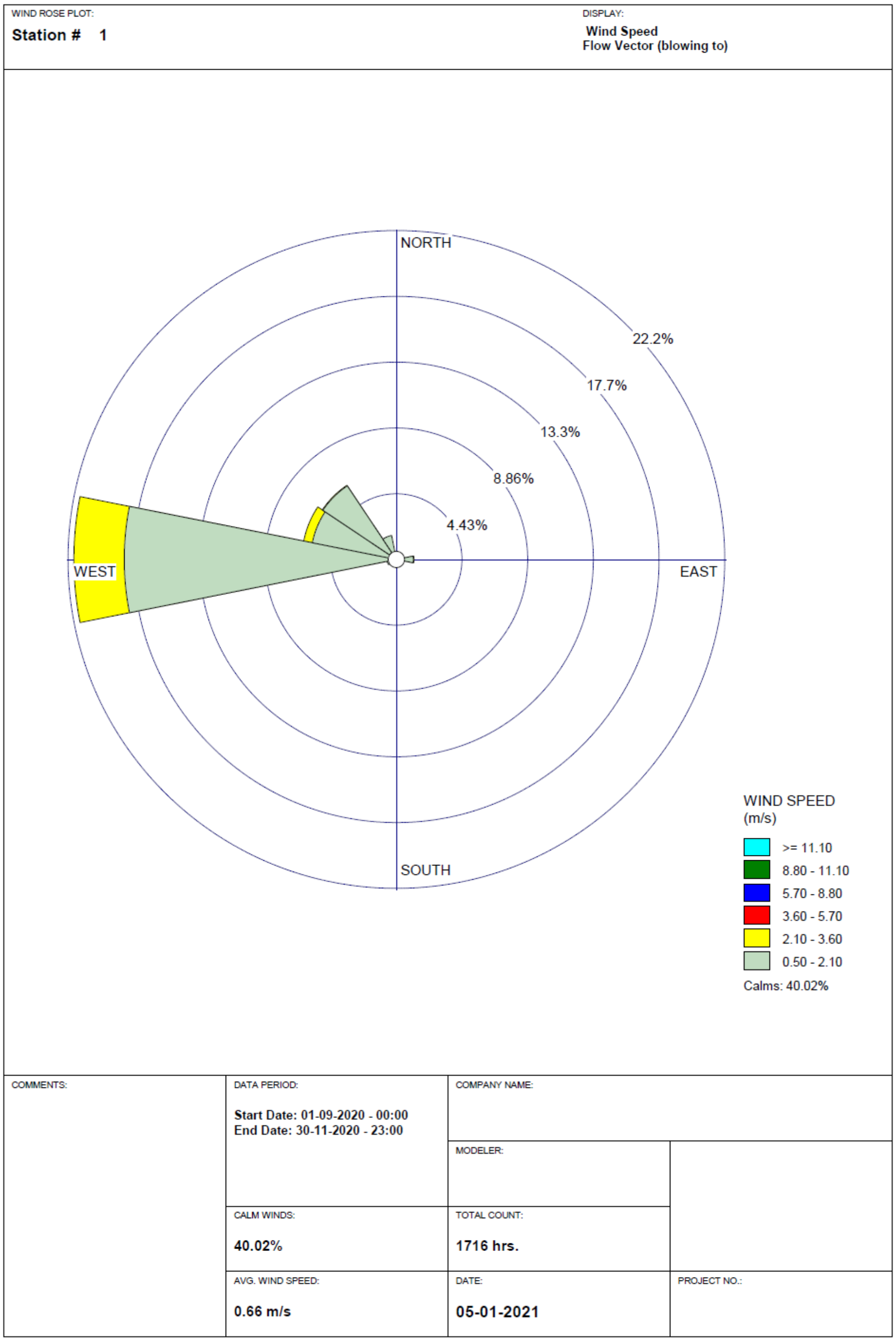


Figure-3.4: Wind Rose Diagram for the study period

3.3. GEOLOGY

The study area is a part of Ernakulam region. Geologically two distinct lithounits are discernible in the area. The eastern part is occupied by hard rocks representing Precambrian metamorphosed rocks while the coastal tract in the west is covered by soft rock or the unconsolidated coastal alluvium. Major part of the district is occupied by charnockite and moigmatite groups of rocks of Precambrian age. The charnockite group is composed of pyroxene granulite, magnetite quartzite and charnockite. Charnockite, which is very widely distributed, is coarsegrained, granulitic and dark coloured. Pyroxene granulite and magnetite quartzite occur as linear bands. Calc-gneiss and quartzite of khondalite group are the oldest rocks of the area and they are seen as linear lensoidal bodies within the charnockites. The migmatite group includes biotite gneiss and quartzofeldspathic gneiss which are next to charnockite in abundance. These older rocks are intruded by both acid (syenite) and basic (gabbro and dolerite) intrusive. Patchy outcrops of Warkalli beds, consisting of pebble bed, grit, friable sandstone and variegated clay is seen in the western part around Edappalli, kalamasseri areas. Both the Warkalli beds as well as the basement rocks are subjected to intense lateritisation, which is confined to the midland region only. The coastal tract is covered by Quaternary sediments like beach sand, palaeo-beach ridge deposits (sand), flood plain deposits (sand, silt, clay) and tidal deposits (clay, mud) (Figure-3.5).

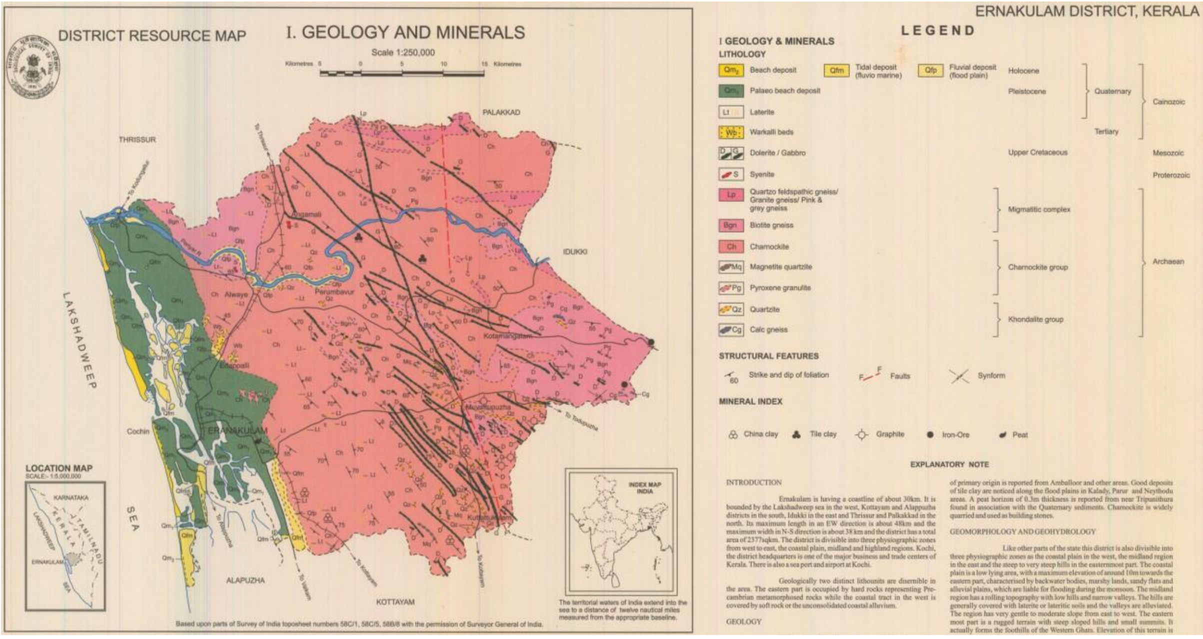


Figure-3.5: Geology and mineral resources of Ernakulam.

(Source: District Resource map, Ernakulam district, Geological Survey of India)

Geomorphology

Ernakulam district is divisible into three physiographic zones as (i) the coastal plains in the west, the midland region in the east and the steep to very steep hills in the easternmost part. The coastal plain is a low lying area, with a maximum elevation of around 10m towards the eastern part, characterised by backwater bodies, marshy lands, sandy flats and alluvial plains, which are liable for flooding during the monsoon. The midland region has a rolling topography with low hills and narrow valleys. The hills are generally covered with laterite or lateritic soils and the valleys are alleviated. The region has a very gentle to moderate slope from east to west. The easternmost part is a rugged terrain with steep sloped hills and small summits. It actually forms the foothills of the Western Ghats. Elevation of this terrain is generally more that 300m above mean sea level. As the area is covered by forest soil, thick forest and cultivation of cash crops like rubber abd pepper can be seen in the area (Figure 3.6)

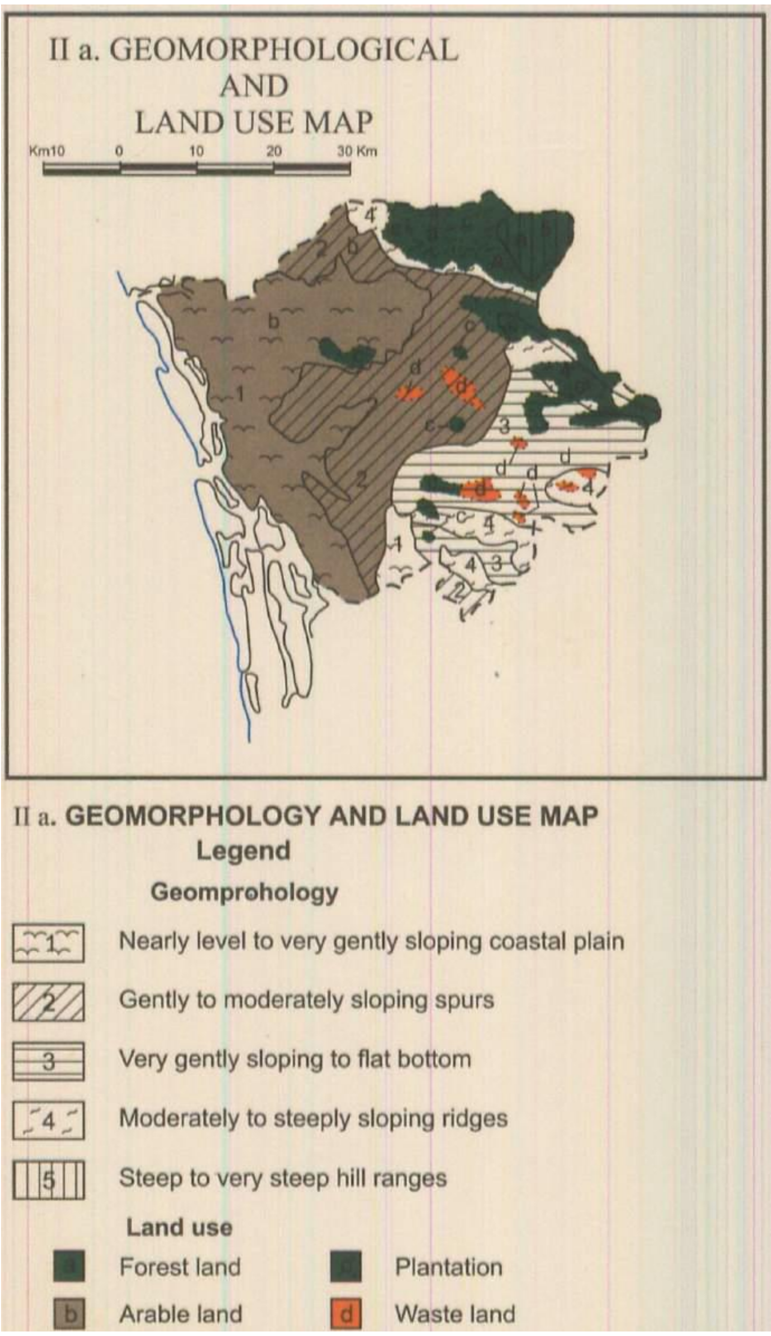


Figure-3.6: Geomorphology and landuse of Ernakulam.
(Source: District Resource map, Ernakulam district, Geological Survey of India)

On the basis of morphological features and physico-chemical properties, the soils of the district are classified as Lateritic, Hydromorphic saline, Brown hydromorphic, Riverine alluvium and Coastal alluvium. Lateritic soil is the most predominant soil type of the district. In Muvattupuzha, Kothamangalam, Kunnathunadu and parts of Aluva taluks lateritic soil is encountered. These soils are well drained, low in organic matter and plant nutrients. The major crops grown are coconut, tapioca, rubber, areacanut, pepper, cashew and spices. Small patches of hydromorphic saline soil are encountered in the coastal tracts of the district in Kanayannur and Cochin taluk. The tidal backwaters contribute to the salinity of the soil. Coconut is grown in these soils. Brown hydromorphic soil is the second most prevalent soil type of the district and they are encountered in valley bottoms. The soil is enriched in clay content and plant nutrients. The soil is suited for paddy cultivation. Riverine alluvium is restricted to the banks of rivers and their tributaries. They are composed of sandy to clayey loam and are enriched in plant nutrients. It is suited for a large variety of crops like coconut, paddy arecanut, pepper, vegetables etc. In Cochin taluk and the western parts of Paravur and Aluva taluk coastal alluviumis encountered and is composed of sand and clay. Coconut is the major crop in these soils.

3.4. SEISMICITY

The area falls a part of the peninsular India, which is considered seismically highly stable (Zone-III) as per Seismic Zoning Map of the country given in IS 1983 (part I): 2002. The seismic zoning map is enclosed as Figure-3.7.

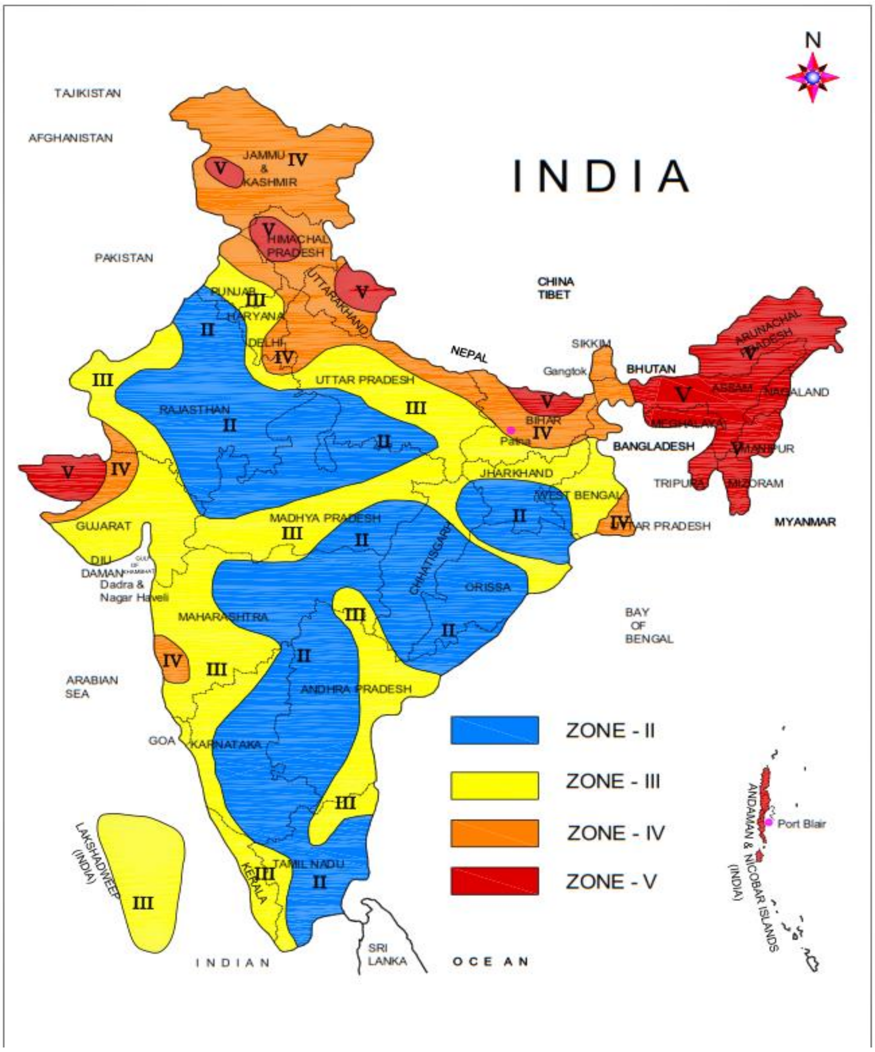


Figure-3.7: Seismic Zoning Map

3.5. OCEANOGRAPHIC CONDITION

Waves

The wave climate is governed by the south-west monsoons when wave action can be strong with prevailing wave direction from north-west to south-west. Deep water (15m) wave observation in the past indicate the significant wave heights of 4m, 2m and 1m at the water depths of 10m, 5m and 2m respectively, the predominant wave direction being west.

Wave action inside the Ernakulam Channel is insignificant because of narrow entrance between Cochin Gut and Fort Cochin and the configuration of the land. Generally calm conditions prevail throughout the year except during the times of extreme wind action.

The present study area is in inland waterways and these are protected by land masses. The wave action in most of the jetties is insignificant. The following maximum wave heights under normal conditions are considered:

- Fort Kochi and Vypeen – 1.0 m
- Other locations – 0.5 m

Tides

Cochin experiences semi diurnal tides with marked daily inequality. The tidal levels as per Naval Hydrographic Chart for the Port of Kochi are as follows:

Highest Astronomical Tide (HAT)	+ 1.20 m CD
Mean Higher High Water Level (MHHWL)	+ 0.90 m CD
Mean Lowest High Water Level (MLHWL)	+ 0.80 m CD
Mean Sea Level (MSL)	+ 0.60 m CD
Mean Highest Low Water Level (MHLWL)	+ 0.60 m CD
Mean Lower Low Water Level (MLLWL)	+ 0.30 m CD

Currents

The currents along the coast of Cochin consists of tide, wave and wind induced components. As per observations the maximum current velocities at the Cochin Gut during the non-monsoon periods is of the order of 3 knots, which could increase to as high as 5.5 knots during the monsoon periods. Inside the Ernakulam Channel the current velocities are low, of the order of 0.5 knots only, with directions varying at different locations.

Littoral Drift

The littoral drift influenced by the monsoon is southwards during south–west monsoon period and northwards during non–monsoon period. Though this contributes to the siltation in the approach channel, it has no direct impact in the Ernakulam Channel.

3.6. LANDUSE PATTERN

Landuse describes how a patch of land is used (e.g. for agriculture, settlement, Vegetation, water body etc.), whereas land cover describes the materials (such as vegetation, rocks or buildings) that are present on the surface. Accurate land use and land cover identification is the key to most of the planning processes. The land use pattern of the study area for propose IURWTS Project, Kochi has been studied through digital satellite imagery data. Remote sensing satellite data of Resource Sat-2 Satellite (LISS-IV, Sensor) Path 099 Row 066, sub scene-D dated 14.01.2019 was procured from National Remote Sensing Agency (NRSA), Hyderabad. The data was processed through ERDAS imagine software package. Ground truth studies were conducted in the project area to validate various signature in the satellite images and correlate them with different land use domains. The study area considered for the study has been taken as the area within 10 km from the periphery of Proposed canal alignment. The landuse pattern of the study area is given in Table-3.7. The FCC and Classified imagery of the study area is given in Figure-3.8 & 3.9.

Table- 3.7: Landuse pattern of the study area

Type	Area (ha)	Area (%)
Vegetation	27969	40.85
Water/River	18775	27.42
Aquaculture	1152	1.68
Agricultural Land	391	0.57
mangrove	1213	1.77
Built up area/Settlement	18969	27.70
Total	**68469**	**100.00**

The major landuse category in the study area of IURWTS project is vegetation, as it accounts for about 40.85% of the study area followed by Built up area (27.70%) and Waterbody (27.42%). The area under Aquaculture and Mangroove is 1.68% and 1.77% of the study area respectively. The area under Agricultural land is negligible and it account for for about 0.57%.

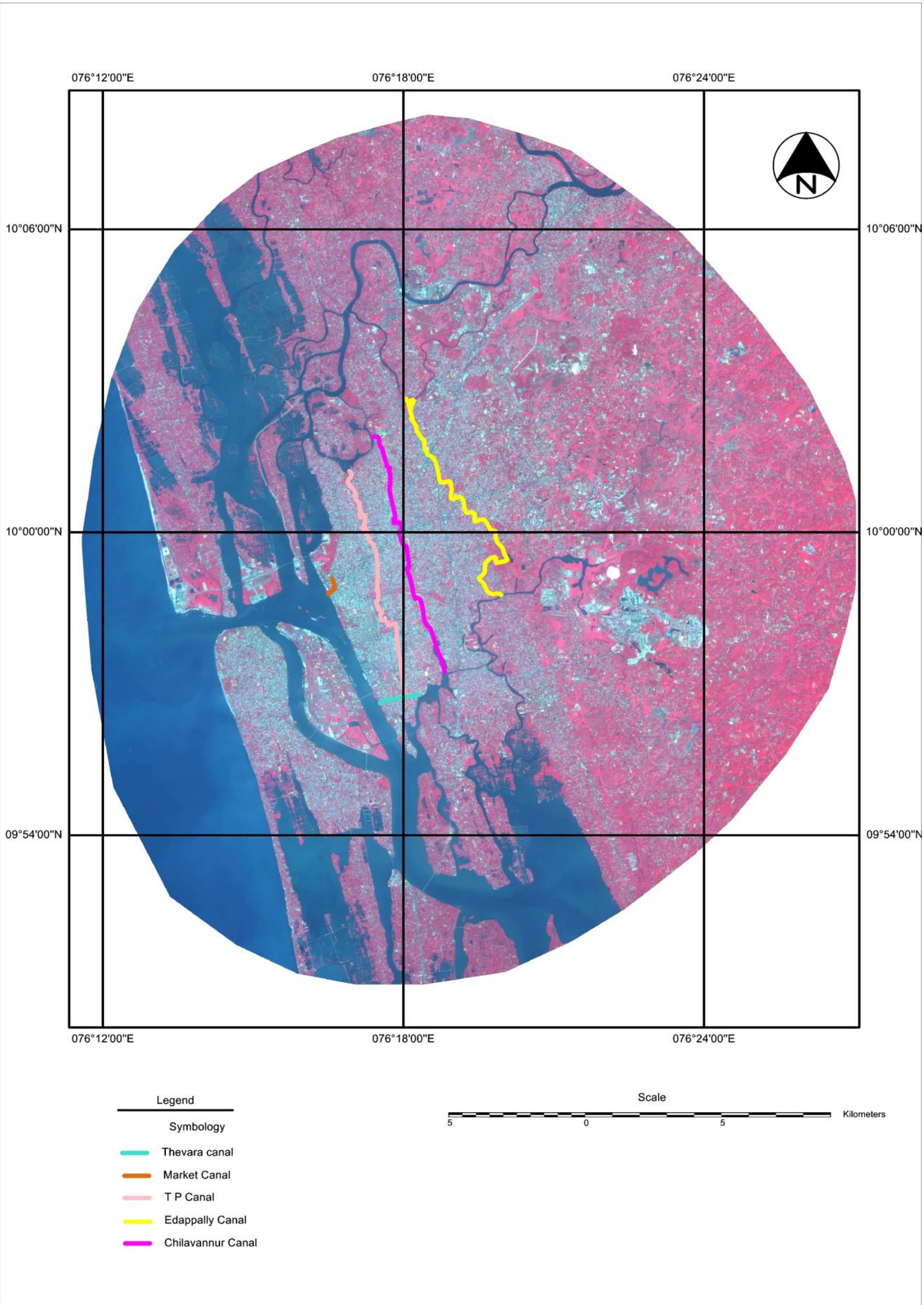


Figure-3.8: FCC of the study area

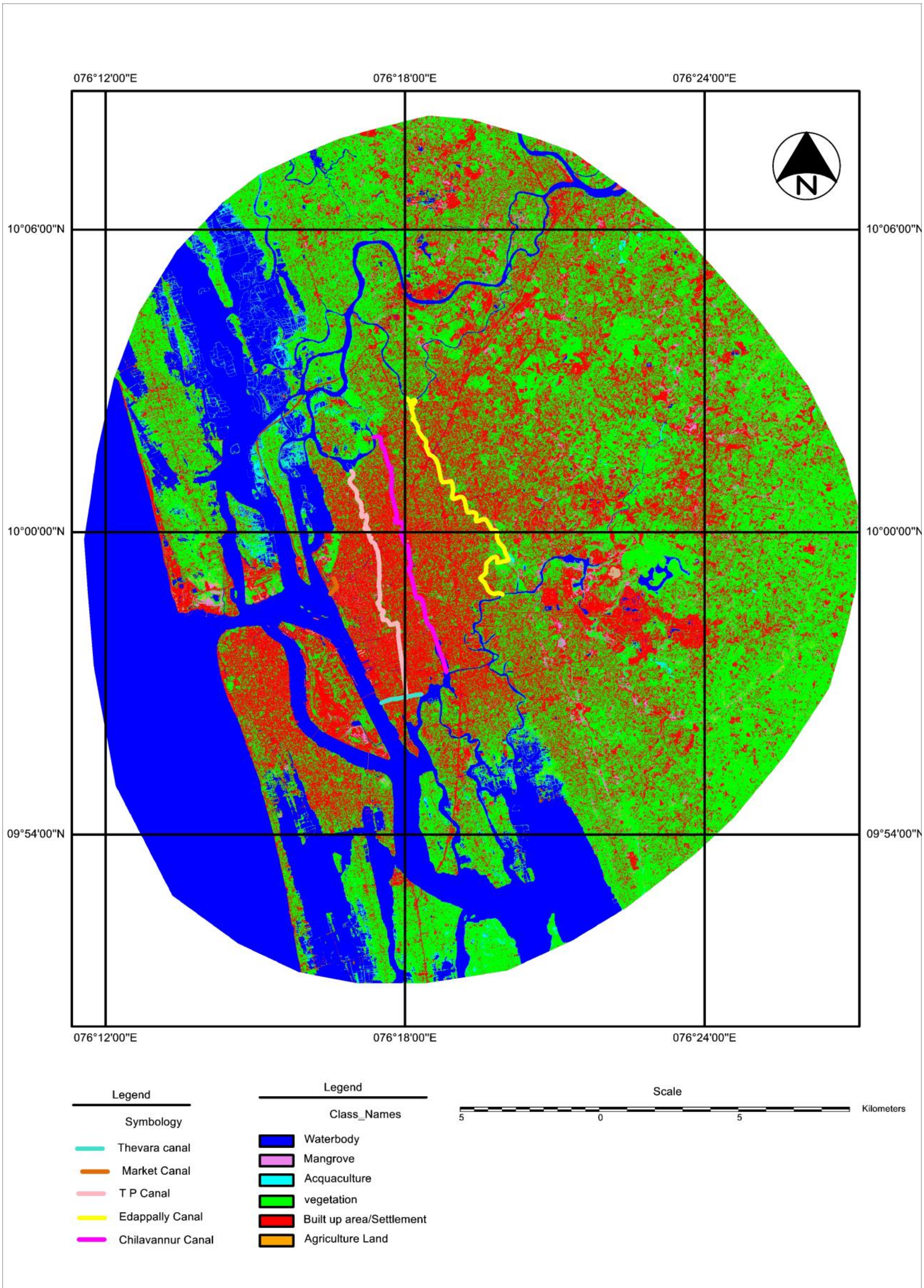


Figure-3.9: Classified Imaginary of Study Area

3.7. SOIL QUALITY

To assess the impacts of the proposed activities on the soils in the area, the physicochemical characteristics of soils within the study area have been examined by Soil Characteristics obtaining soil samples from Ten locations and is given in Table-3.8. The Analysis is done through, NABL Accredited Standards Environmental & Analytical Laboratories, Ernakulam. The location of the soil sampling is given in Figure-3.10. The physicochemical characteristics of the soils in the study area, as obtained from the analysis of the soil samples are presented in Table-3.9.

Table-3.8: Soil Sampling Location

S No	Location	Latitude	Longitude
S 1	Thevara	N 09^0 56.765'	E 76^0 17.977'
S 2	Kaloor	N 09^0 59.303'	E 076^0 17.464'
S 3	Perandoor Railway Line	N 10^0 01.101'	E 76^0 16.916'
S 4	Karukappally, Mamamgalam	N 10^0 00.365'	E 76^0 17.564'
S 5	Elamkulam	N 09^0 58.322'	E 076^0 18.282'
S 6	Near Chilavannoor Bridge	N 09^0 57.305'	E 76^0 19.001'
S 7	Arakkakadavu	N 09^0 59.509'	E 76^0 19.679'
S 8	Ayyanadu Bridge	N 10^0 00.688'	E 76^0 19.165'
S 9	Near Muttar	N 10^0 02.715'	E 76^0 18.091'
S10	St Mary's Cathedral Basilica ,Ernakulam	N 09^0 58.937'	E 76^0 16.539'

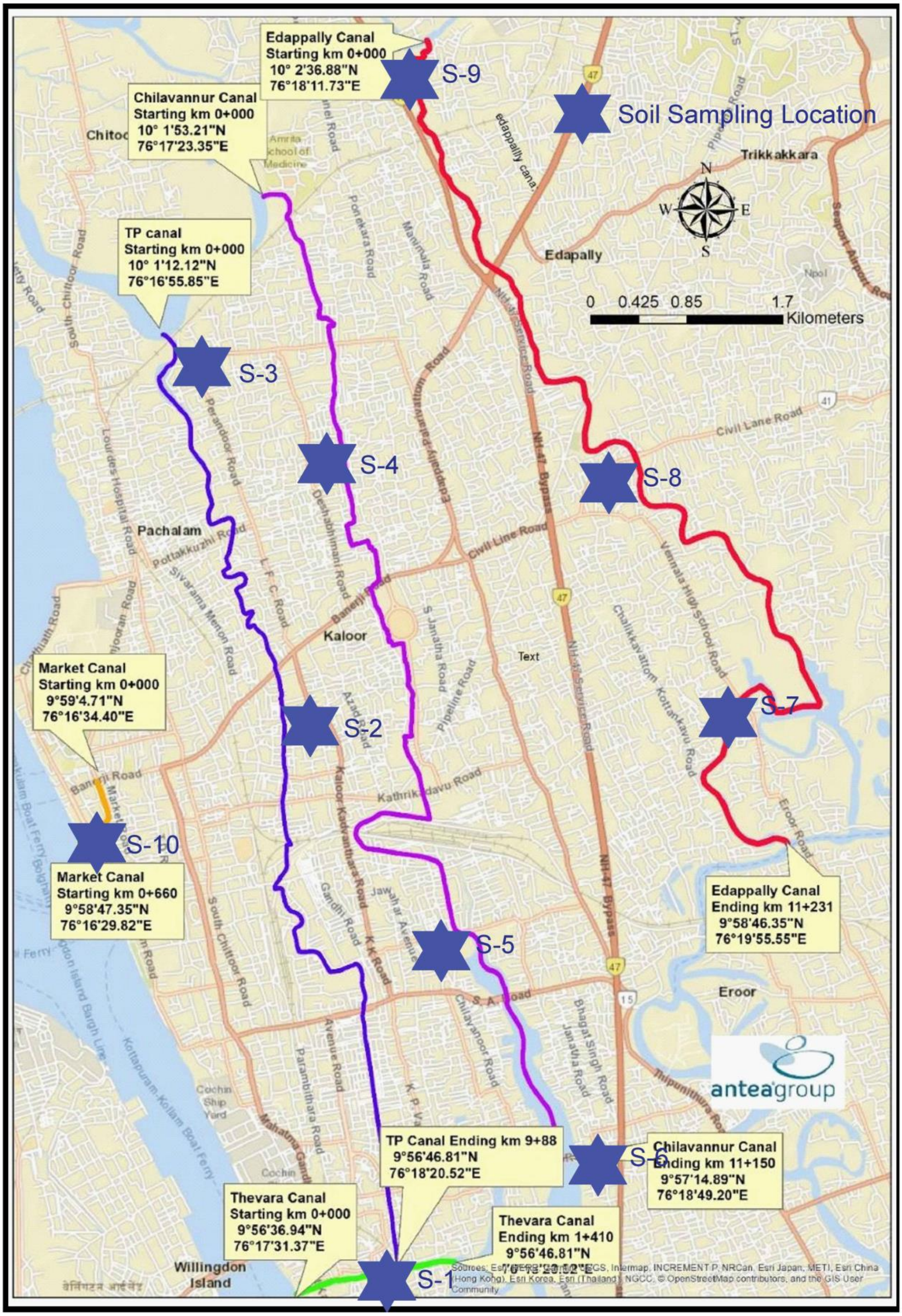


Figure-3.10: Soil Sampling Locations

Table-3.9: Results of Soil Quality

SL NO	PARAMETERS TESTED		Unit	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
1	Colour		---	Black	Grayish Black	Grayish Black	Reddish Black	Grayish Black	Black	Grayish Black	Black	Reddish Black	Grayish Black
2	Texture		---	Sandy Clay	Sandy Clay	Sandy Clay	Sandy Clay	Sandy Clay	Sandy Clay	Sandy Clay	Sandy Clay	Sandy Clay	Sandy Clay
3	Particle Size Distribution	Clay	%	22.8	22.7	27.4	23.4	19.1	27.6	26.8	27.4	27.3	27
		Sand	%	59.5	55.7	50.6	58.6	63.1	54.6	54	53.9	46.8	55.1
		Silt	%	17.7	21.6	21.9	18	17.8	17.7	18	17.2	25.9	17.9
4	Water Holding Capacity		%	68	68.2	24	42	56	54	38	28	46	56
5	Bulk Density		g/cc	0.93	0.99	1.14	1.48	1.45	1.29	1.46	1.16	1.11	1.16
6	Porosity		%	48	48	20	28	36	32	24	20	20.4	36
7	pH		---	8.09	8.1	5.4	5.79	7.2	6.83	5.95	6	6.55	7.83
8	Conductivity		µS/cm	274	280	94	46	114	102	74	199	69	401
9	Cation Exchange Capacity		meq/100g	10.5	15.1	13.6	14.8	11.9	14.9	13.8	12.6	13.4	15.3
10	Organic Matter		%	1.27	1.18	2.15	1.04	1.36	2.11	1.58	3.31	1.21	1.48
11	Organic Carbon		%	0.74	0.68	1.25	0.6	0.79	1.22	0.92	1.92	0.7	0.86
12	Available Nitrogen as N		mg/kg	2541	4787	1118	613	734	2068	746	1551	684	1988
13	Available Phosphorous as PO_4		mg/kg	601	499	621	459	581	535	594	868	628	627
14	Available Potassium as K		mg/kg	880	616	398	155	950	317	149	370	1309	479
15	Sodium		mg/kg	735	653	1004	822	679	766	753	870	842	781
16	Magnesium		mg/kg	2870	2060	280	230	380	370	260	480	730	960
17	Calcium		mg/kg	4314	4160	542	414	746	758	387	691	1000	1222
18	Chlorides		mg/kg	541	595	687	769	680	760	887	989	579	824
19	Exchangeable Sodium Percentage		%	8.35	8.72	28.5	27.6	24.6	28.4	26.8	24.5	21.7	22.6
20	Sodium Adsorption Ratio		---	12.2	11.7	36.7	35.8	20.6	27.9	31.9	26.6	24.3	20.8

- Bulk density of soils in the study area varied between 0.93 – 1.48%
- Porosity of soils varied between 20– 48 %, which is in normal range for such soils.
- Water holding capacity of the soils varied between 24 – 68.2 ml/l..
- pH range 5.4-8.1.
- Electrical conductivity (EC) was found varying between 46-401 µs/cm.
- Avialable Potassium in this study area was found varying between 459-868 mg/kg
- Avialable Nitrogen level in this study area varied between 613-4787 mg/kg.
- Avialable Phosphorous in the study area soils was found normal ranging between 459 – 868 mg/kg.
- Cation exchange capacity (CEC) varied between 10.5-15.3 meq/100 gm.

3.8. GROUND WATER QUALITY

The water table in the open well in the project site vicinity (post monsoon season) varies between 1 m to 6 m. The project site is categorized as "*Safe Zone*" by Central Ground Water Board. Ground water availability report prepared by CGWB, Kerala is used to know the ground water level and quality in the district. (The categorization of blocks in to safe, semicritical etc. stating the ground water resource status prepared by Ground Water Board, Kerala region for Ernakulam District.)

Ground water samples were collected from nine locations and analysed. The water samples were examined for physico-chemical parameters as well as for bacteriological parameters. The Analysis is done through, NABL Accredited Standards Environmental & Analytical Laboratories,Ernakulam. The details of Ten sampling locations are presented in Table-3.10 and Figure-3.11. Analysis results of groundwater are presented in Table-3.11.

Table-3.10: Ground Water Sampling Locations

S No	Location	Latitude	Longitude
GW 1	Thevara	N 09^0 56.765'	E 76^0 17.977'
GW 2	Kaloor	N 09^0 59.303'	E 076^0 17.464'
GW 3	Perandoor Railway Line	N 10^0 01.101'	E 76^0 16.916'
GW 4	Karukappally, Mamamgalam	N 10^0 00.365'	E 76^0 17.564'
GW 5	Elamkulam	N 09^0 58.322'	E 076^0 18.282'
GW 6	Near Chilavannoor Bridge	N 09^0 57.305'	E 76^0 19.001'
GW 7	Arakkakadavu	N 09^0 59.509'	E 76^0 19.679'
GW 8	Ayyanadu Bridge	N 10^0 00.688'	E 76^0 19.165'
GW 9	Near Muttar	N 10^0 02.715'	E 76^0 18.091'
GW 10	St Mary's Cathedral Basilica ,Ernakulam	N 09^0 58.937'	E 76^0 16.539'

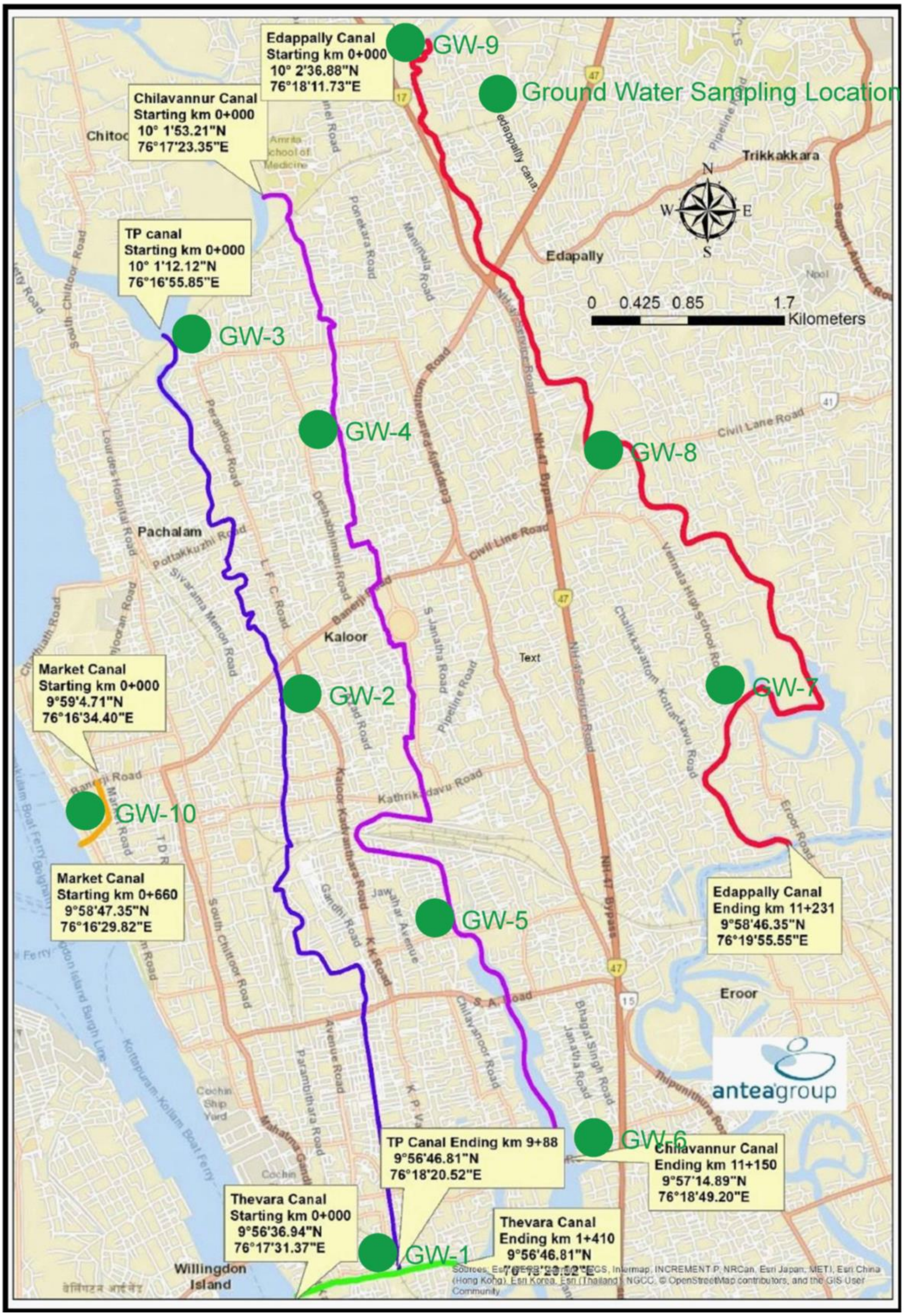


Figure-3.11: Ground water Sampling Locations

Table-3.11: Ground Water Sampling Results

SL NO	TEST PARAMETER	UNIT	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8	GW9	GW10
1	Colour	Hazen	1	1	1	1	1	1	1	1	1	1
2	Odour	--	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
3	Temperature	^{o}C	30	30	30	30	30	30	30	30	30	30
4	Conductivity	µS/cm	3611	282	2564	240	822	1088	451	555	418	215
5	Total Dissolved Solids	mg/L	2347	183	1666	155	534	707	293	360	271	140
6	Total Alkalinity (as $CaCO_3$)	mg/L	623	100	593	80.4	261	311	100	173	84.4	60.3
7	Total Hardness (as $CaCO_3$)	mg/L	316	65.3	561	63.2	184	194	131	139	110	44.8
8	Chloride (as Cl)	mg/L	850	17.9	475	14.9	69.9	84.9	19.9	37.9	27.9	13.9
9	Sulphate (SO_4)	mg/L	36.2	4.03	50.7	2.6	5.29	34.3	34.4	16.8	43.2	25.7
10	Ammonia (Total ammonia as N)	mg/L	16.6	< 0.01	1.79	1.02	< 0.01	< 0.01	0.51	0.37	0.41	< 0.01
11	Nitrite as NO_2	mg/L	1.7	< 0.02	0.06	< 0.02	< 0.02	< 0.02	< 0.02	0.06	< 0.02	< 0.02
12	Nitrate as NO_3	mg/L	10.9	2.86	5.82	4.09	8.48	4.26	18.1	9.34	1.93	3.31
13	Fluoride as F	mg/L	0.86	0.32	0.35	< 0.10	0.75	0.83	< 0.10	0.19	< 0.10	0.19
14	Phosphate as P	mg/L	1.28	0.32	0.82	0.17	1.5	0.59	0.14	1.26	0.12	0.18
15	Calcium as Ca	mg/L	48.9	16.3	159	22.8	65.3	69.4	48.9	48.9	35.9	14.7
16	Magnesium as Mg	mg/L	47.2	5.96	39.7	1.49	4.96	4.96	1.98	3.97	4.96	1.98
17	Sodium as Na	mg/L	303	6.78	155	6.66	35.3	76.4	12.2	28.8	19	4.43
18	Potassium as K	mg/L	24.8	2.31	4.11	1.64	11.6	7.01	6.97	13.5	5.1	3.67
19	Iron (as Fe)	mg/L	0.48	0.58	0.83	< 0.10	0.54	0.25	0.13	< 0.10	1.3	1.21
20	Manganese as Mn	mg/L	BDL (LOD-0.016)	BDL (LOD-0.016)	BDL (LOD-0.016)	BDL (LOD-0.016)	BDL (LOD-0.016)	BDL (LOD-0.016)	BDL (LOD-0.016)	BDL (LOD-0.016)	BDL (LOD-0.016)	BDL (LOD-0.016)
21	Lead as Pb	mg/L	BDL (LOD-0.01)	BDL (LOD-0.01)	BDL (LOD-0.01)	BDL (LOD-0.01)	BDL (LOD-0.01)	BDL (LOD-0.01)	BDL (LOD-0.01)	BDL (LOD-0.01)	BDL (LOD-0.01)	BDL (LOD-0.01)
22	Copper as Cu	mg/L	BDL (LOD-0.016)	BDL (LOD-0.016)	BDL (LOD-0.016)	BDL (LOD-0.016)	BDL (LOD-0.016)	BDL (LOD-0.016)	BDL (LOD-0.016)	BDL (LOD-0.016)	BDL (LOD-0.016)	BDL (LOD-0.016)
23	Cadmium as Cd	mg/L	BDL (LOD-0.03)	BDL (LOD-0.03)	BDL (LOD-0.03)	BDL (LOD-0.03)	BDL (LOD-0.03)	BDL (LOD-0.03)	BDL (LOD-0.03)	BDL (LOD-0.03)	BDL (LOD-0.03)	BDL (LOD-0.03)
24	Mercury as Hg	mg/L	BDL (LOD-0.001)	BDL (LOD-0.001)	BDL (LOD-0.001)	BDL (LOD-0.001)	BDL (LOD-0.001)	BDL (LOD-0.001)	BDL (LOD-0.001)	BDL (LOD-0.001)	BDL (LOD-0.001)	BDL (LOD-0.001)

SL NO	TEST PARAMETER	UNIT	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8	GW9	GW10
25	Zinc as Zn	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
			(LOD-0.008)	(LOD-0.008)	(LOD-0.008)	(LOD-0.008)	(LOD-0.008)	(LOD-0.008)	(LOD-0.008)	(LOD-0.008)	(LOD-0.008)	(LOD-0.008)
26	Arsenic as As	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
			(LOD-0.001)	(LOD-0.001)	(LOD-0.001)	(LOD-0.001)	(LOD-0.001)	(LOD-0.001)	(LOD-0.001)	(LOD-0.001)	(LOD-0.001)	(LOD-0.001)
27	Dissolved Oxygen	mg/L	2.41	4.42	2.81	5.91	3.21	5.02	5.62	5.22	5.62	5.32
28	Biochemical Oxygen Demand (3 days at 27 OC)	mg/L	5.93	2.01	< 2.00	< 2.00	3.01	3.01	< 2.00	< 2.00	< 2.00	5.02
29	Chemical Oxygen Demand	mg/L	69.9	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	19.9
30	Oil & Grease	mg/L	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
31	Total Coliforms		Absent/100 ml	Present/100 ml	Present/100 ml	Present/100 ml	Present/100 ml	Present/100 ml	Present/100 ml	Present/100 ml	Present/100 ml	Present/100 ml
32	Faecal Coliform	MPN/100 ml	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2

From the observation, it was found that:

- TDS values were found in the range of 140 to 2347 mg/l which is high from prescribed limit of drinking water.
- Conductivity of groundwater was found 215 to 3611 µs/cm.
- Hardness values were in the range of 44.8 to 561 mg/l.
- Presence of heavy metals such as Arsenic, Cadmium, Chromium, copper, lead, Mercury, Phenol, and Zinc are found below detectable limit.

3.9. AMBIENT AIR QUALITY

The study area mainly covers the sides of the canal of IURWTS project. There are no major point sources of air pollution in the project area. The sources of air pollution in the region are vehicular traffic, dust emissions from unpaved village roads and domestic fuel burning. As per the secondary data, ambient air quality in the study area was found to be well within permissible limit.

Ambient air quality (AAQ) monitoring was conducted 6 locations in the study area by WAPCOS from 3rd September 2020 to 28th November 2020, as a part of the EIA study. Ambient air quality (AAQ) monitoring was carried out as per the Notification issued by MoEF&CC on 16.1.2009. The ambient air quality monitoring was carried out with a frequency of two samples per week for twelve consecutive weeks at six locations in the study period. A total 12 parameters were monitored and findings of the same are described in this section to assess the ambient air quality status in the area. The parameters monitored as a part of the study are listed as below:

- Particulate Matter less than 2.5 microns ($PM_{2.5}$)
- Particulate Matter less than 10 microns (PM_{10})
- Sulphur dioxide (SO_2)
- Nitrogen dioxide (NO_2)
- Carbon Monoxide (as CO)
- Ozone (as O3)
- Lead (as Pb)
- Ammonia (as NH3)
- Benzene (as C6H6)
- Benzo (O) Pyrene (as BaP)
- Arsenic (as As)
- Nickel (as Ni)

The location of ambient air quality monitoring stations is given in Table-3.12. The Analysis is done through, NABL Accredited Standards Environmental & Analytical Laboratories, Ernakulam. The results of ambient air quality survey conducted during the study period are given in Table-3.13 to Table-3.18. The summary of ambient air quality monitoring is given in Table-3.19. The ambient air quality standards specified by Central Pollution Control Board (CPCB) are given in Table-3.20. The location of Ambient Air Quality Monitoring station was selected based on the prominent wind directions during the monitoring period. The ambient air quality monitoring stations were selected considering that the upwind, downwind, and cross wind direction with respect to proposed project site are covered. The location of ambient air quality monitoring stations is shown in Figure-3.12.

Table-3.12: Location of Ambient Air Quality Monitoring Stations

S. No.	Station Code	Location	Coordinates
1	AAQ-1	Edappally	09°56.913' N, 076°18.015'E
2	AAQ-2	Elamkulam	09°58.101' N, 076°18.566'E
3	AAQ-3	Kaloor	10°00.040' N, 076°17.960'E
4	AAQ-4	Pachalam	10°01.101' N, 076°16.916'E
5	AAQ-5	Thevara	09°56.913' N, 076°18.015'E
6	AAQ-6	Vennala	10°00.013' N, 076°19.890'E

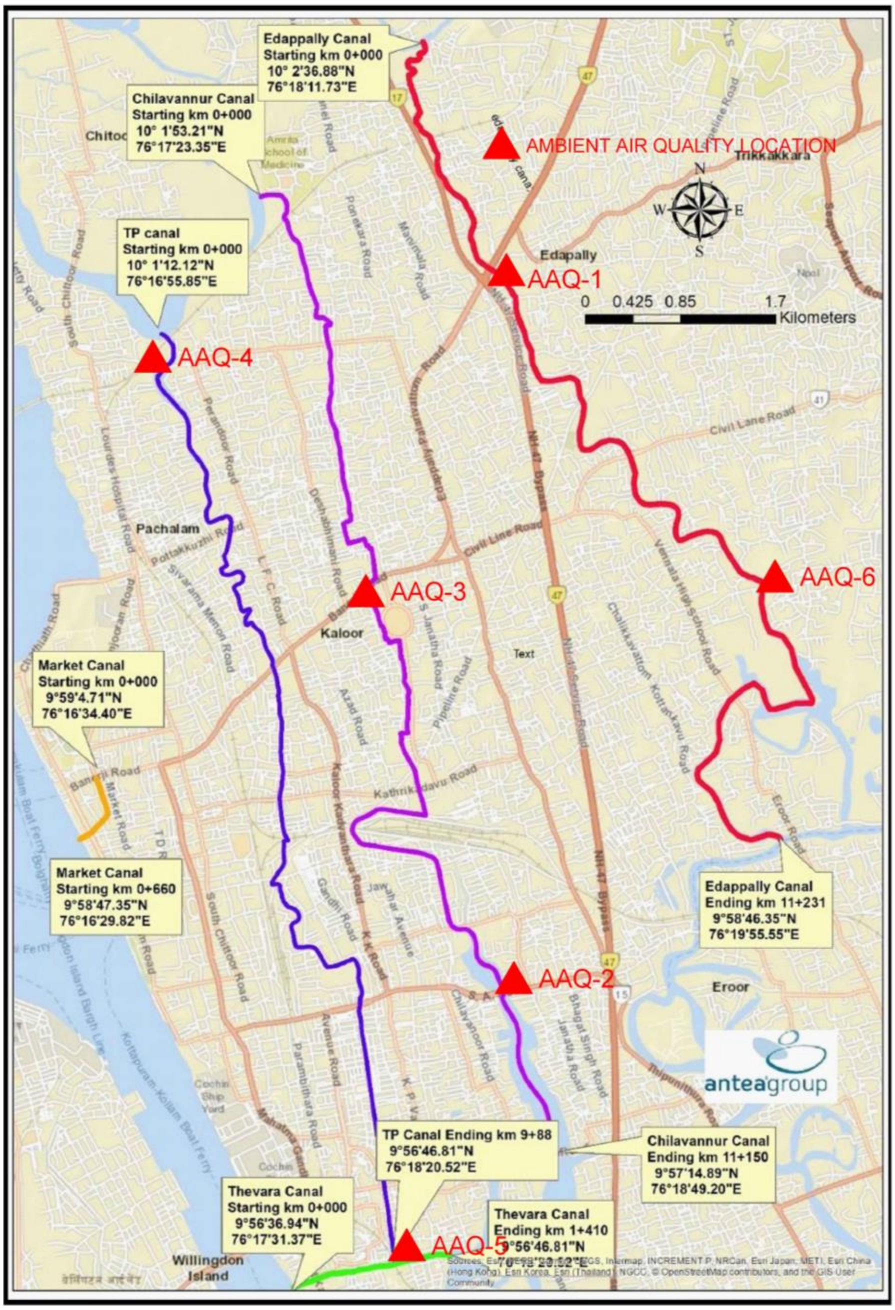


Figure-3.12: Ambient Air Quality Sampling Location Map

Table-3.13: Ambient air quality status at AAQ-1

S. No.	Date of Sampling	Parameter											
		PM_{10}	$PM_{2.5}$	SO_2	NO_2	CO	Lead (Pb)	Arsenic (as As)	Nickel (as Ni)	Ammonia (NH_3)	Ozone (O_3)	C_6H_6	BaP
		(µg/m³)	(µg/m³)	(µg/m³)	(µg/m³)	(mg/m³)	(µg/m³)	(ng/m³)	(ng/m³)	(µg/m³)	(µg/m³)	(µg/m³)	(ng/m³)
1	03.09 20-04.09.20	61.3	28.6	3.34	5.79	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
2	04.09 20-05.09.20	59.8	27.4	2.37	6.62	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
3	08.09 20-09.09.20	41.2	28.2	2.91	8.02	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
4	09.09.20-10.09.20	44.9	31.6	2.98	3.46	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
5	17.09 20-18.09.20	36.7	25.3	2.69	7.21	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
6	18.09 20-19.09.20	63.5	27.8	3.11	7.93	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
7	24.09.20-25.09.20	72.5	31.2	3.97	4.21	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
8	25.09.20-26.09.20	61.9	28.3	3.97	4.21	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
9	30.09.20-01.10.20	41.5	23.9	2.98	4.34	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
10	01.10.20-02.10.20	52.8	24.5	2.75	4.12	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
11	08.10.20-09.10.20	64.2	27.3	3.99	5.94	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
12	09.10.20 -10.10.20	62.9	29.9	2.84	6.86	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
13	13.10.20-14.10.20	44.6	25.7	3.1	8.23	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
14	14.10.20-15.10.20	48.3	28.1	3.16	3.95	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
15	23.10.20-24.10.20	40.7	26.8	2.98	7.82	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
16	24.10.20-25.10.20	67.9	29.7	3.47	8.1	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
17	29.10.20-30.10.20	75.4	33.9	4.11	4.67	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
18	30.10.20-31.10.20	63.9	30.6	4.13	4.59	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
19	06.11.20-07.11.20	58.3	25.2	4.11	6.42	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
20	07.11.20-08.11.20	66.2	33.1	3.42	6.27	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
21	12.11.20-13.11.20	48.3	23.4	3.53	7.84	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
22	13.11.20-14.11.20	52.7	30.3	3.38	4.11	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
23	19.11.20-20.11.20	43.8	27.4	3.11	7.76	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
24	20.11.20-21.11.20	64.3	23.9	3.81	7.95	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
25	26.11.20-27.11.20	69.3	31.8	4.32	5.16	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
26	27.11.20-28.11.20	71.5	33.8	4.59	5.38	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80

Table-3.14: Ambient air quality status at AAQ-2

S. No.	Date of Sampling	Parameter											
		PM_{10}	$PM_{2.5}$	SO_2	NO_2	CO	Lead (Pb)	Arsenic (as As)	Nickel (as Ni)	Ammonia (NH_3)	Ozone (O_3)	C_6H_6	BaP
		(µg/m^3)	(µg/m^3)	(µg/m^3)	(µg/m^3)	(mg/m^3)	(µg/m^3)	(ng/m^3)	(ng/m^3)	(µg/m^3)	(µg/m^3)	(µg/m^3)	(ng/m^3)
1	03.09 20-04.09.20	26.4	13.8	< 2.00	2.89	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
2	04.09 20-05.09.20	30.2	14.1	< 2.00	3.25	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
3	07.09 20-08.09.20	25.8	13.8	< 2.00	2.14	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
4	08.09 20-09.09.20	23.7	12.6	< 2.00	2.26	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
5	17.09 20-18.09.20	24.1	14.3	< 2.00	2.87	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
6	18.09 20-19.09.20	30.8	13.6	< 2.00	2.11	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
7	24.09.20-25.09.20	32.6	14.5	< 2.00	2.97	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
8	25.09.20-26.09.20	25.7	13.8	< 2.00	2.39	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
9	30.09.20-01.10.20	34.2	15.9	< 2.00	3.13	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
10	01.10.20-02.10.20	31.8	13.9	< 2.00	2.96	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
11	08.10.20-09.10.20	30.3	14.2	<2.00	2.32	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
12	09.10.20 -10.10.20	34.2	17.1	<2.00	3.16	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
13	13.10.20-14.10.20	28.2	13.8	<2.00	2.45	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
14	14.10.20-15.10.20	26.9	14.3	<2.00	2.51	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
15	23.10.20-24.10.20	28.1	16.9	<2.00	2.96	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
16	24.10.20-25.10.20	32.7	15.3	<2.00	2.48	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
17	29.10.20-30.10.20	35.9	17.3	<2.00	3.11	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
18	30.10.20-31.10.20	29.6	16.1	<2.00	2.48	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
19	06.11.20-07.11.20	35.6	18.1	<2.00	3.11	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
20	07.11.20-08.11.20	38.6	19.1	<2.00	3.98	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
21	12.11.20-13.11.20	31.7	12.4	<2.00	2.79	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
22	13.11.20-14.11.20	30.6	16.3	<2.00	2.93	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
23	19.11.20-20.11.20	32.3	17.9	<2.00	3.12	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
24	20.11.20-21.11.20	32.7	15.3	<2.00	2.48	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
25	26.11.20-27.11.20	39.6	19.8	<2.00	3.11	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
26	27.11.20-28.11.20	34.3	18.6	<2.00	2.67	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80

Table-3.15: Ambient air quality status at AAQ-3

S. No.	Date of Sampling	Parameter											
		PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	SO_2 (µg/m³)	NO_2 (µg/m³)	CO (mg/m³)	Lead (Pb) (µg/m³)	Arsenic (as As) (ng/m³)	Nickel (as Ni) (ng/m³)	Ammonia (NH_3) (µg/m³)	Ozone (O_3) (µg/m³)	C_6H_6 (µg/m³)	BaP (ng/m³)
1	03.09 20-04.09.20	58.9	30.4	4.36	4.55	1.54	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
2	04.09 20-05.09.20	65.1	33.4	5.7	7.62	1.67	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
3	08.09 20-09.09.20	71.7	33.5	5.61	12.7	1.79	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
4	09.09.20-10.09.20	68.4	36.1	4.11	8.91	1.65	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
5	17.09 20-18.09.20	56.1	30.6	4.25	8.88	1.53	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
6	18.09 20-19.09.20	68.7	34.8	3.98	8.79	1.87	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
7	24.09.20-25.09.20	74.9	35.9	4.38	9.76	1.94	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
8	25.09.20-26.09.20	64.3	31.6	3.65	10.8	1.66	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
9	30.09.20-01.10.20	62.8	32.9	4.11	9.86	1.59	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
10	01.10.20-02.10.20	59.3	28.6	3.79	8.95	1.51	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
11	08.10.20-09.10.20	61.7	33.4	4.53	5.13	1.71	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
12	09.10.20 -10.10.20	69.6	36.8	5.91	6.84	1.85	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
13	13.10.20-14.10.20	73.9	35.9	5.86	11.5	1.97	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
14	14.10.20-15.10.20	72.8	38.7	4.58	8.64	1.83	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
15	23.10.20-24.10.20	60.4	33.8	4.91	9.72	1.75	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
16	24.10.20-25.10.20	69.3	36.5	4.11	9.14	1.84	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
17	29.10.20-30.10.20	78.4	37.9	4.59	10.9	2.00	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
18	30.10.20-31.10.20	67.3	33.4	3.98	11.1	1.87	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
19	06.11.20-07.11.20	60.9	31.6	4.28	5.67	1.69	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
20	07.11.20-08.11.20	71.2	37.6	6.28	7.16	1.59	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
21	12.11.20-13.11.20	74.3	36.8	6.32	10.9	2.10	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
22	13.11.20-14.11.20	68.9	36.4	4.17	7.55	1.93	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
23	19.11.20-20.11.20	69.3	35.6	5.11	10.6	1.97	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
24	20.11.20-21.11.20	76.9	39.1	5.24	8.96	1.76	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
25	26.11.20-27.11.20	75.7	36.4	5.11	9.76	2.06	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
26	27.11.20-28.11.20	71.9	32.6	4.36	10.9	1.76	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80

Table-3.16: Ambient air quality status at AAQ-4

S. No.	Date of Sampling	Parameter											
		PM_{10}	$PM_{2.5}$	SO_2	NO_2	CO	Lead (Pb)	Arsenic (as As)	Nickel (as Ni)	Ammonia (NH_3)	Ozone (O_3)	C_6H_6	BaP
		($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)	(mg/m^3)	($\mu g/m^3$)	(ng/m^3)	(ng/m^3)	($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)	(ng/m^3)
1	03.09 20-04.09.20	20.8	9.87	< 2.00	< 2.00	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
2	04.09 20-05.09.20	27.3	13.9	< 2.00	< 2.00	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
3	07.09 20-08.09.20	24.7	12.8	< 2.00	< 2.00	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
4	08.09 20-09.09.20	19.4	9.10	< 2.00	< 2.00	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
5	17.09 20-18.09.20	28.3	15.1	< 2.00	< 2.00	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
6	18.09 20-19.09.20	20.6	11.3	< 2.00	< 2.00	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
7	24.09.20-25.09.20	26.3	14.2	< 2.00	< 2.00	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
8	25.09.20-26.09.20	25.6	13.2	< 2.00	< 2.00	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
9	30.09.20-01.10.20	29.1	16.6	< 2.00	< 2.00	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
10	01.10.20-02.10.20	26.5	14.9	< 2.00	< 2.00	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
11	08.10.20-09.10.20	24.3	12.9	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
12	09.10.20 -10.10.20	30.8	18.3	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
13	13.10.20-14.10.20	28.9	19.6	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
14	14.10.20-15.10.20	23.6	13.70	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
15	23.10.20-24.10.20	31.9	15.6	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
16	24.10.20-25.10.20	25.9	14.9	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
17	29.10.20-30.10.20	30.7	16.3	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
18	30.10.20-31.10.20	28.4	15.9	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
19	06.11.20-07.11.20	28.1	13.1	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
20	07.11.20-08.11.20	34.7	19.6	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
21	12.11.20-13.11.20	31.5	21.8	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
22	13.11.20-14.11.20	26.9	16.5	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
23	19.11.20-20.11.20	34.8	18.3	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
24	20.11.20-21.11.20	29.3	17.2	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
25	26.11.20-27.11.20	35.2	19.6	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
26	27.11.20-28.11.20	31.3	14.2	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80

Table-3.17: Ambient air quality status at AAQ-5

S. No.	Date of Sampling	Parameter											
		PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	SO_2 (µg/m^3)	NO_2 (µg/m^3)	CO (mg/m^3)	Lead (Pb) (µg/m^3)	Arsenic (as As) (ng/m^3)	Nickel (as Ni) (ng/m^3)	Ammonia (NH_3) (µg/m^3)	Ozone (O_3) (µg/m^3)	C_6H_6 (µg/m^3)	BaP (ng/m^3)
1	03.09 20-04.09.20	28.1	10.2	< 2.00	3.89	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
2	04.09 20-05.09.20	27.6	12.3	< 2.00	3.37	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
3	07.09 20-08.09.20	25.7	11.9	< 2.00	3.42	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
4	08.09 20-09.09.20	29.6	13.8	< 2.00	3.46	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
5	17.09 20-18.09.20	23.8	9.80	< 2.00	4.24	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
6	18.09 20-19.09.20	25.9	10.7	< 2.00	5.12	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
7	24.09.20-25.09.20	33.2	13.9	< 2.00	4.32	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
8	25.09.20-26.09.20	38.5	14.5	< 2.00	3.64	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
9	30.09.20-01.10.20	24.5	11.1	< 2.00	4.89	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
10	01.10.20-02.10.20	26.7	13.2	< 2.00	5.28	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
11	08.10.20-09.10.20	32.8	13.7	<2.00	4.31	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
12	09.10.20 -10.10.20	33.1	14.8	<2.00	3.89	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
13	13.10.20-14.10.20	29.6	15.5	<2.00	3.64	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
14	14.10.20-15.10.20	34.7	14.7	<2.00	3.81	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
15	23.10.20-24.10.20	27.8	11.3	<2.00	4.97	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
16	24.10.20-25.10.20	29.1	12.9	<2.00	5.56	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
17	29.10.20-30.10.20	37.3	16.3	<2.00	4.48	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
18	30.10.20-31.10.20	40.6	19.3	<2.00	3.96	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
19	06.11.20-07.11.20	36.9	15.9	<2.00	4.11	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
20	07.11.20-08.11.20	38.6	17.4	<2.00	3.65	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
21	12.11.20-13.11.20	34.5	16.9	<2.00	3.76	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
22	13.11.20-14.11.20	39.6	18.1	<2.00	3.99	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
23	19.11.20-20.11.20	30.8	13.6	<2.00	4.97	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
24	20.11.20-21.11.20	33.9	14.3	<2.00	5.53	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
25	26.11.20-27.11.20	40.7	20.3	<2.00	4.36	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
26	27.11.20-28.11.20	43.7	21.2	<2.00	4.11	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80

Table-3.18: Ambient air quality status at AAQ-6

S. No.	Date of Sampling	Parameter											
		PM_{10}	$PM_{2.5}$	SO_2	NO_2	CO	Lead (Pb)	Arsenic (as As)	Nickel (as Ni)	Ammonia (NH_3)	Ozone (O_3)	C_6H_6	BaP
		(µg/m^3)	(µg/m^3)	(µg/m^3)	(µg/m^3)	(mg/m^3)	(µg/m^3)	(ng/m^3)	(ng/m^3)	(µg/m^3)	(µg/m^3)	(µg/m^3)	(ng/m^3)
1	03.09 20-04.09.20	31.2	14.1	< 2.00	< 2.00	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
2	04.09 20-05.09.20	26.4	12.8	< 2.00	< 2.00	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
3	07.09 20-08.09.20	30.9	13.9	< 2.00	< 2.00	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
4	08.09 20-09.09.20	24.9	11.8	< 2.00	< 2.00	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
5	17.09 20-18.09.20	39.6	15.2	< 2.00	< 2.00	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
6	18.09 20-19.09.20	47.8	14.3	< 2.00	< 2.00	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
7	24.09.20-25.09.20	43.2	14.6	< 2.00	< 2.00	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
8	25.09.20-26.09.20	32.9	13.4	< 2.00	< 2.00	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
9	30.09.20-01.10.20	27.9	13.9	< 2.00	< 2.00	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
10	01.10.20-02.10.20	29.4	12.7	< 2.00	< 2.00	< 1.15	< 0.01	< 0.10	< 5.00	< 20.0	< 5.00	< 4.00	< 0.80
11	08.10.20-09.10.20	34.5	16.3	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
12	09.10.20 -10.10.20	29.6	14.6	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
13	13.10.20-14.10.20	33.8	15.7	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
14	14.10.20-15.10.20	28.7	13.1	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
15	23.10.20-24.10.20	41.3	14.4	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
16	24.10.20-25.10.20	50.6	17.1	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
17	29.10.20-30.10.20	47.5	16.9	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
18	30.10.20-31.10.20	35.9	15.8	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
19	06.11.20-07.11.20	40.8	20.3	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
20	07.11.20-08.11.20	34.7	16.9	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
21	12.11.20-13.11.20	36.9	18.4	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
22	13.11.20-14.11.20	31.9	15.8	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
23	19.11.20-20.11.20	44.6	21.7	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
24	20.11.20-21.11.20	49.1	18.6	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
25	26.11.20-27.11.20	50.8	20.4	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80
26	27.11.20-28.11.20	39.6	18.5	<2.00	<2.00	<1.15	<0.01	<0.10	<5.00	<20.0	<5.00	<4.00	<0.80

Table- 3.19: Summary of ambient air quality monitoring

Station	Maximum	Minimum	Average	98 Percentile
Particulate Matter less than 10 micron(PM_{10}) (µg/m^3)				
Edappally	75.4	36.7	56.8	73.9
Elamkulam	39.6	23.7	31.0	39.1
Kaloor	78.4	56.1	68.2	77.7
Pachalam	35.2	19.4	27.9	35.0
Thevara	43.7	23.8	32.6	42.2
Vennala	50.8	24.9	37.1	50.7
Particulate Matter less than 2.5 micron($PM_{2.5}$) (µg/m^3)				
Edappally	33.9	23.4	28.3	33.8
Elamkulam	19.8	12.4	15.5	19.5
Kaloor	39.1	28.6	34.6	38.9
Pachalam	21.8	9.1	15.3	20.7
Thevara	21.2	9.8	14.5	20.8
Vennala	21.7	11.8	15.8	21.1
Sulphur Dioxide (SO_2) (µg/m^3)				
Edappally	4.6	2.4	3.4	4.5
Elamkulam	< 2.00	< 2.00	< 2.00	< 2.00
Kaloor	6.3	3.7	4.7	6.3
Pachalam	< 2.00	< 2.00	< 2.00	< 2.00
Thevara	< 2.00	< 2.00	< 2.00	< 2.00
Vennala	< 2.00	< 2.00	< 2.00	< 2.00
Nitrogen Dioxide (NO_2) (µg/m^3)				
Edappally	8.2	3.5	6.0	8.2
Elamkulam	4.0	2.1	2.8	3.6
Kaloor	12.7	4.6	9.0	12.1
Pachalam	<2.00	<2.00	<2.00	<2.00
Thevara	5.6	3.4	4.3	5.5
Vennala	<2.00	<2.00	<2.00	<2.00

Observations on ambient PM_{10} levels

It is observed from Table-3.19 that average concentration of PM_{10} at various stations ranged from 68.2 to 27.9 µg/m^3. The highest PM_{10} value was recorded as 78.4 µg/m^3 near Kaloor and lowest values of 19.4 µg/m^3 were recorded at Pachalam. The PM_{10} values monitored during the field survey were well below the permissible limit of 100 µg/m^3 for industrial, residential, rural and other areas..

Observations on $PM_{2.5}$ levels

The average concentration of $PM_{2.5}$ at various stations monitored ranged from 34.6 to 14.5 µg/m^3. The highest $PM_{2.5}$ value was recorded as 39.1 µg/m^3 near Kaloor and lowest values of 9.1 µg/m^3 were recorded at Pachalam. The $PM_{2.5}$ values monitored during the field survey were below permissible limit of 60 µg/m^3 for industrial, residential, rural and other areas.

Observations on ambient SO_2 levels

It can be seen from Table-3.19 that during the study period, average SO_2 concentration at various sampling stations ranged from <2.00 µg/m^3 to 4.7 µg/m^3. The highest SO_2value was recorded as 6.3 µg/m^3 at Kaloor. The average concentration of SO_2 at various stations in the study area was observed to be well below the prescribed limits of 80 µg/m^3 specified for industrial, residential, rural and other areas.

Observations on ambient NO_2 levels

The average concentration of **NO_2** at various stations monitored ranged from 9.0 to 2.8 µg/m^3. The highest **NO_2** value was recorded as 12.7 µg/m^{3}at Kaloor. The average concentration of NO_2 at various stations in the study area was observed to be well below the prescribed limits of 80 µg/m^3 specified for industrial, residential, rural and other areas

Observations on other parameters

It is observed that CO, SO_2, Ozone, Ammonia, Benzene, Benzo Pyrene, Arsenic and Nickel was found to be below detectable limit during the field survey.

Table- 3.20:National Ambient Air quality Standards (NAAQS)

Parameter	**Industrial, Residential, Rural & other areas**	**Ecologically Sensitive Area Central Government**
Particulate Matter $PM_{2.5}$	60	60
Particulate Matter PM_{10}	100	100
Sulphur Dioxide (as SO_2)	80	80
Oxides of Nitrogen (as NO_2)	80	80
Carbon Monoxide (as CO),	4	4
Ozone (as O_3)	100	100
Lead (as Pb)	1	1
Ammonia (as NH_3)	400	400
Benzene (as C_6H_6)	5	5
Benzo (O) Pyrene (as BaP) (ng/m^3)	1	1
Arsenic (as As) (ng/m^3)	6	6
Nickel (as Ni) (ng/m^3)	20	20

* 24 hourly or 08 hourly or 01 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceeded the limits but not on two consecutive days of monitoring.

3.10. AMBIENT NOISE LEVELS

Baseline noise data has been measured using a weighted sound pressure level meter. The survey was carried out in calm surroundings. Sound Pressure Level (SPL) measurement in the outside environment was made using sound pressure level meter. Hourly noise meter readings were taken at each site, and equivalent day time and night time noise levels were estimated. The ambient noise levels were recorded at 6 locations as the same as location of Ambient Air Quality on 30 to 31.10.2020 and details are listed Table- 3.21. The hourly ambient noise levels recorded at various locations and day time equivalent noise levels are listed in Table-3.22. The Ambient Noise standards are given in Table-3.23.

Table-3.21: List of Noise monitoring stations

S. No.	Noise monitoring station
1	Edappally
2	Elamkulam
3	Kaloor
4	Pachalam
5	Thevara
6	Vennala

Table-3.22: Ambient Noise Level in the study area [Unit: dB(A)]

Time	Noise monitoring stations					
	S1	S2	S3	S4	S5	S6
06.00 Hrs	40.8	36.6	43.1	35.0	38.6	37.1
07.00 Hrs	43.8	39.2	46.2	37.5	41.4	39.7
08.00 Hrs	48.4	43.4	51.1	41.5	45.8	43.9
09.00 Hrs	52.2	46.7	55.1	44.8	49.4	47.4
10.00 Hrs	54.7	49.0	57.7	46.9	51.7	49.7
11.00 Hrs	58.1	52.0	61.3	49.8	54.9	52.7
12.00 Hrs	55.2	49.4	58.2	47.3	52.1	50.0
13.00 Hrs	54.3	48.6	57.3	46.6	51.3	49.3
14.00 Hrs	54.7	49.0	57.7	46.9	51.7	49.7
15.00 Hrs	55.2	49.4	58.2	47.3	52.1	50.0
16.00 Hrs	56.4	50.5	59.5	48.4	53.3	51.2
17.00 Hrs	56.8	50.9	59.9	48.7	53.7	51.6
18.00 Hrs	50.9	45.6	53.7	43.7	48.2	46.2
19.00 Hrs	47.2	42.2	49.7	40.4	44.6	42.8
20.00 Hrs	42.9	38.5	45.3	36.8	40.6	39.0
21.00 Hrs	42.4	38.0	44.8	36.4	40.1	38.5
22.00 Hrs	39.6	35.4	41.7	33.9	37.4	35.9
23.00 Hrs	37.0	31.6	38.7	31.5	33.6	32.6
00.00 Hrs	39.6	33.9	41.5	33.8	36.0	34.9
01.00 Hrs	40.4	34.6	42.3	34.5	36.7	35.6
02.00 Hrs	40.0	34.2	41.9	34.1	36.3	35.3
03.00 Hrs	40.8	34.9	42.7	34.8	37.0	36.0
04.00 Hrs	39.6	33.9	41.5	33.8	36.0	34.9
05.00 Hrs	41.5	35.5	43.5	35.4	37.7	36.6
Day-Leq	**53.2**	**47.5**	**56.2**	**45.4**	**50.2**	**48.1**
Night-Leq	**40**	**34.2**	**41.9**	**34.1**	**36.3**	**35.3**

Table-3.23: Ambient Noise Standards

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

Notes: 1. Day time 6 AM and 9 PM
2. Night time is 9 PM and 6 AM
3. Silence zone is defined as areas upto 100 metres around such premises as hospitals, educational institutions and courts. The silence zones are to be declared by competent authority. Use of vehicular horns, loudspeakers and bursting of crackers shall be banned in these zones.
4. Environment (Protection) Third Amendment Rules, 2000 Gazettee notification, Government of India, date 14.2.2000.

It may be seen from the Table-3.22, that day time equivalent noise level ranged from a minimum of 45.4 dB(A) to a maximum of 56.2 dB(A) and night time equivalent noise level ranged from a minimum of 34.1 dB(A) to a maximum of 41.9 dB(A) . The day and night equivalent noise level recorded at various locations were compared with Ambient Noise Standards and were observed to be well below the permissible limit specified for commercial areas.

3.11. TERRESTRIAL FLORA

The floristic diversity in and around selected canals under IURWTS project is composed of 73 species of aquatic macrophytes, 48 species of other terrestrial angiosperms, 7 true mangroves species and 40 species of invasive plant species (include species from aquatic macrophytes and terrestrial angiosperms) (Table-3.24 & 3.25). Water Hyacinth (*Eichhornia crassipes*) was dominated in aquatic macrophytes followed by Giant salvinia (*Salvinia molesta*), both are invasive aquatic weeds. In terrestrial angiosperms Jamaican Cherry (*Muntingia calabura*) and Bitter vine (*Mikania micrantha*) was dominated in terrestrial angiosperms followed by Messina creeper/ Cairo morning glory (*Ipomoea cairica*), all these three species belonged to the high risk invasive category.

3.11.1. Invasive plants

Invasive plants are non-native species that upset the biodiversity and economy of a region through their rapid spread across landscapes. These species are introduced either accidentally or purposefully to new areas (Table 3.26).

The survey in selected canals under IURWTS project revealed 40 species of invasive plants were present along canals. Of these, 16 belonged to the high risk category, which are capable of wiping out indigenous species and causing economic and ecological losses. The species such as Water Hyacinth (*Eichhornia crassipes*) and Giant salvinia (*Salvinia molesta*) over grown in canal waters and cause threat to native aquatic flora and fauna, as well as cause clogging and blockage of waterways. Invasive non-native species on waterways can reduce intrinsic biodiversity value, pose safety risks or cause expensive damage to structures. The vegetation along the banks are dominated by invasive terrestrial angiosperms such as Jamaican Cherry (*Muntingia calabura*), Bitter vine (*Mikania micrantha*) and Messina creeper/ Cairo morning glory (*Ipomoea cairica*). Here, Bitter vine (*Mikania micrantha*) and Messina creeper/ Cairo morning glory (*Ipomoea cairica*) engulf most of the vegetation along the canal bank and cause serious threat to native flora. It is also harmful to be associated to fauna (butterflies, birds), those are dependent to native flora for their food, shelter and larval host plants. So, fast actions should be required to rehabilitate native flora and removal of these high risk invasive species from in and around canals of Kochi, otherwise it may lead to serious biodiversity lose.

Plate. Images of alien species invasion in and around Kochi canals.

Table-3.24: List of Aquatic macrophytes in IURWTS project, Kochi

Scientific Name	Thevara	Perandoor	Chilavannoor	Edapally	Market
Aeschynomene indica	-	+	+	+	-
Alternanthera philoxeroides	+	-	+	+	-
Alternanthera tenella	-	+	+	-	+
Aniseia martinicensis	+	-	-	+	-
Aponogeton natans	-	-	+	+	-
Azolla pinnata	-	-	-	+	-
Bacopa monnieri	-	+	-	+	-
Centella asiatica	-	+	+	+	-
Ceratophyllum demersum	+	+	+	+	-
Ceratopteris thalictroides	-	+	-	+	-
Clerodendrum inerme	+	-	-	-	+
Colocasia esculenta	+	+	+	+	+
Cynodon dactylon	+	+	+	+	-

Scientific Name	Thevara	Perandoor	Chilavannoor	Edapally	Market
Cyperus cephalotes	-	+	+	+	-
Cyperus difformis	-	+	-	-	-
Cyperus dubius	+	-	+	+	-
Cyperus iria	+	+	+	+	-
Cyperus haspan	-	+	+	+	-
Cyperus javanicus	-	+	+	+	-
Eclipta prostrata	+	+	+	+	-
Eichhornia crassipes	+	+	+	+	+
Eleocharis dulcis	-	+	-	+	-
Elodea canadensis	-	+	+	+	-
Eragrostis atrovirens	+	+	+	+	-
Eragrostis gangetica	-	+	-	+	-
Eriocaulon setaceum	-	+	+	+	-
Evolvulus alsinoides	-	+	+	+	-
Fimbristylis quinquangularis	-	+	-	+	-
Fuirena ciliaris	-	-	+	+	-
Hydrilla verticillata	+	+	+	+	+
Hygrophila auriculata	-	-	-	+	-
Hygrophila ringens	-	-	-	+	-
Hygroryza aristata	+	+	+	+	-
Hymenachne amplexicaulis	-	+	+	+	-
Ipomoea aquatica	+	+	+	+	-
Ipomoea carnea		+	+	+	-
Ipomoea pes-caprae	+	-	-	+	-
Leersia hexandra	-	-	+	+	-
Lemna perpusilla	-	+	+	+	-
Limnophila aquatica	-	-	-	+	-
Limnophila indica	-	-	+	+	-
Limnophila repens	+	+	-	+	-
Lindernia antipoda	+		+	+	-
Lindernia rotundifolia	+	+	+	+	
Ludwigia adscendens	+	+	+	+	+
Ludwigia hyssopifolia	+	+	+	+	-
Marsilea quadrifolia	-	+	+	+	-
Melochia corchorifolia	-	+	-	+	-
Merremia tridentata	+	+	+	+	-
Mollugo pentaphylla	+	+	+		-
Myriophyllum oliganthum	-	-	-	+	-
Najas sp.	+	+	+	+	-
Nitella mucronata	-	-	+	+	-
Nymphoides crystata	-	-	-	+	-
Nymphoides indica	-	-	-	+	-
Nymphaea pubescens	-	-	-	+	-
0Nymphaea nouchali	-	-	+	+	-
Oldenlandia brachypoda	-	-	+	-	-
Oldenlandia corymbosa	+	+	+	+	-
Oldenlandia herbacea	+	-	+	+	-
Paspalum sp.	-	-	+	-	-
Persicaria pulchra	-	+	+	+	-
Persicaria glabra	-	-	-	+	-
Pistia stratiotes	+	+	+	+	+
Rotala macrandra	-	-	-	+	-

Scientific Name	Thevara	Perandoor	Chilavannoor	Edapally	Market
Sacciolepis interrupta	-	+	-	+	-
salvinia molesta	+	+	+	+	+
Salvinia adnata	+	+	+	+	-
Schoenoplectiella supina	-	-	-	+	-
Sphaeranthus africanus	+	+	-	+	-
Sporobolus virginicus	+	+	-	-	-
Utricularia sp.	-	+	-	+	-
Vallisneria natans	-	-	-	+	-
* +Present -Absent					

Source: Biodiversity Assesment Study by Cochin University of Science & Technology (CUSAT) during Study Period (September-November, 2020).

Table-3.25: List of Terrestrial Flora along IURWTS canals

Common Name	Scientific Name
Yellow Allamanda	*Allamanda cathartica*
Thoothed Leaf Allophylus	*Allophylus serratus*
Blackboard Tree	*Alstonia scholaris*
Jackfruit Tree	*Artocarpus heterophyllus*
Wild Jack	*Artocarpus hirsutus*
Neem Tree	*Azadirachta indica*
Cotton Silk Tree	*Bombax ceiba*
Official Breynia	*Breynia vitis-idaea*
Alexandrian laurel	*Calophyllum inophyllum*
Toddy Palm	*Caryota urens*
Golden Shower Tree	*Cassia fistula*
Suicide Tree	*Cerbera odollam*
Crepe Ginger	*Chiliocostus speciosus*
Hill Glory Bower	*Clerodendron infortunatum*
Coconut Tree	*Cocos nucifera*
Lemon Grass	*Cymbopogon citratus*
Flamboyant	*Delonix Regia*
Common derris	*Derris trifoliata*
Indian Banyan	*Ficus benghalensis*
Brown Woolly Fig Tree	*Ficus drupacea*
Sacred Fig	*Ficus religiosa*
Madre de cacao	*Gliricidia sepium*
Chinese hibiscus	*Hibiscus hispidissimus*
Chaulmoogra	*Hydnocarpus pentandrus*
Mignonette Tree	*Lawsonia inermis*
Common Macaranga	*Macaranga peltata*
Mango Tree	*Mangifera indica*
Drumstick Tree	*Moringa oleifera*
Neerium	*Nerium oleander*
Screw Pine	*Pandanus Kaida*
Shiny Bush	*Peperomia pellucida*
Stone Breaker	*Phyllanthus niruri*
Pongamia Tree	*Pongamia pinnata*
Guava	*Psidium guajava*
Castor Oil Plant	*Ricinus communis*
Rain Tree	*Samanea saman*
Broom Weed	*Sida acuta*
Arrow Leaf Sida	*Sida rhombifolia*

Common Name	Scientific Name
African Tulip tree	*Spathodea campanulata*
Mahogany	*Swietenia macrophylla*
Java Plum	*Syzygium cumini*
Tamarind Tree	*Tamarindus indica*
Indian Almond	*Terminalia catappa*
Portia Tree	*Thespesia populnea*
Malabar Gulbel	*Tinospora sinensis*
Pointed Guard	*Trichosanthes dioica*
Diamond Burbark	*Triumfetta rhomboidea*
Caesarweed	*Urena lobata*

Source: Biodiversity Assesment Study by Cochin University of Science & Technology (CUSAT) during Study Period (September-November, 2020).

Table-3.26: List of invasive plants along IURWTS canals.

Common Name	Scientific Name
Bristly starbur	*Acanthospermum hispidum*
Goat weed	*Ageratum conyzoides*
Alligator weed	*Alternanthera philoxeroides*
Joseph's coat	*Alternanthera tenella*
Mexican Creeper/Coral vine	*Antigonon leptopus*
Giant reed	*Arundo donax*
Crown flower	*Calotropis gigantea*
Chaksu Seed	*Cassia absus*
Windmill grass	*Chloris barbata*
Siam Weed	*Chromolaena odorata*
Ringed spider flower / Purple cleome	*Cleome rutidosperma*
Asian spider flower / Tick weed	*Cleome viscosa*
East Indian Mallow	*Corchorus aestuans*
White jute	*Corchorus trilocularis*
Rattle weed	*Crotalaria pallida*
Ban Tulsi	*Croton bonplandianum*
Giant dodder	*Cuscuta reflexa*
Variable Flat sedge	*Cyperus difformis*
Rice flat sedge / Umbrella sedge	*Cyperus iria*
Viper grass	*Dinebra retroflexa*
Jungle rice	*Echinochloa colona*
False daisy	*Eclipta prostrata*
Water hyacinth	*Eichhornia crassipes*
Red tassel flower	*Emilia sonchifolia*
Garden spurge	*Euphorbia hirta*
Pennsylvania cudweed	*Gnaphalium pensylvanicum*
Many-Stemmed Cudweed	*Gnaphalium polycaulon*
Messina creeper/ Cairo morning glory	*Ipomoea cairica*
West Indian Lantana	*Lantana camera*
Lead tree / River tamarind	*Leucaena leucocephala*
Bitter vine / Climbing hemp vine	*Mikania micrantha*
Giant sensitive plant	*Mimosa diplotricha*
Jamaican Cherry	*Muntingia calabura*
Giant salvinia / Kariba weed	*Salvinia molesta*
Emperor's candlesticks /Candle bush	*Senna alata*
Sicklepod	*Senna obtusifolia*
Septicweed / Coffeeweed	*Senna occidentalis*

Common Name	Scientific Name
Sickle Senna / Sicklepod	*Senna tora*
Prickly sesban	*Sesbania bispinosa*
Singapore daisy	*Sphagneticola trilobata*

Source: Biodiversity Assesment Study by Cochin University of Science & Technology (CUSAT) during Study Period (September-November, 2020).

3.11.2 IMPORTANT MEDICINAL PLANTS

Some important medicinal plants recorded during the present study are *Adhatoda zeylanica, Asparagus racemosus, Aegle marmelos, Phyllanthus emblica, Azadirachta indica, Boerhavia diffusa, Cassia fistula, Curculigo orchioides, Centela asiatica, Santalum album, Areca catechu, Centela asiatica, Clerodendrum inerme, Bacoba monnieri, Lawsonia inermis, Abutilon indicum, Piper longum, Phyla nodiflora, Leucas aspera* etc. The list of medicinal plants recorded in the study area during the present study period is given in the Table-3.27

Table-3.27: List of medicinal plants recorded in the study area during field study

Name of Species	Family	Habit
Asparagus racemosus	Asparagaceae	Shrub
Aegle marmelos	Rutaceae	Tree
Madhuca longifolia	Sapotaceae	Tree
Acalypha indica	Euphorbiaceae	Herb
Phyllanthus emblica	Euphorbiaceae	Tree
Leucas aspera	Lamiaceae	Herb
Cassia fistula	Fabaceae	Tree
Boerhavia diffusa	Nyctaginaceae	Herb
Azadirachta indica	Meliaceae	Tree
Curculigo orchioides	Hypoxidaceae	Herb
Blumea lacera	Asteraceae	Herb
Sida acuta	Malvaceae	Herb
Cuscuta reflexa	Convolvulaceae	Climber
Centela asiatica	Apiaceae	Herb
Justicia procumbens	Acanthaceae	Herb
Tridax procumbens	Asteraceae	Herb
Santalum album	Santalaceae	Tree
Solanum torvum	Solanaceae	Shrub
Wrightia tinctoria	Apocynaceae	Tree
Nyctanthes arbor-tristis	Oleaceae	Tree
Clerodendrum inerme	Verbenaceae	Shrub
Datura metal	Solanceae	Shrub
Bauhinia racemosa	Caesalpiniaceae	Tree
Erythrina indica	Fabaceae	Tree
Cassia tora	Caesalpiniaceae	Herb
Eclipta alba	Asteraceae	Herb
Areca catechu	Arecaceae	Tree
Zanthoxylum sp	Rutaceae	Tree

Name of Species	Family	Habit
Butea monosperma	Fabaceae	Tree
Murraya paniculata	Rutaceae	Shrub
Abrus precatorius	Fabaceae	Climber
Mukia maderaspatana	Cucurbitaceae	Climber
Morinda tinctoria	Rubiaceae	Tree
Leanotis nepetiifolia	Lamiaceae	Herb
Mimusops elengi	Sapotaceae	Tree
Urena lobata	Malvaceae	Herb
Phyla nodiflora	Verbenaceae	Herb
Piper longum	Piperaceae	Climber
Passiflora edulis	Passifloraceae	Climber
Costos speciosus	Costaceae	Herb
Holoptelea integrifolia	Ulmaceae	Tree
Alysicarpus rugosus	Fabaceae	Herb
Abutilon indicum	Malvaceae	Shrub
Garcinia gummi-gutta	Clusiaceae	Tree
Ficus hispida	Moraceae	Tree
Lawsonia inermis	Lythraceae	Shrub
Bacoba monnieri	Scrophulariaceae	Herb

Source: Biodiversity Assesment Study by Cochin University of Science & Technology (CUSAT) during Study Period (September-November, 2020).

3.12. FAUNA

From selected canals under IURWTS project (including vegetation and marsh lands adjacent to it 111 vertebrate and species have been recorded, consisting of 11 species of mammals, 72 species of bird, 20 species of reptiles and amphibians, and 8 species of fishes. Forty seven species of butterflies and 21 species of odonates also recorded from the canal regions. Of the animals found so far in Kochi Canals, one is of immediate global conservation concern, the Smooth-coated otter being considered Vulnerable on the IUCN Red List of Threatened Species. This means that they are facing an extremely high risk of extinction in the wild.

3.12.1. Birds

From the study area, 72 species of birds have been recorded (Table-3.28), some typical wetland bird species, such as Lesser Whistling Duck (*Dendrocygna javanica*), Cotton Pygmy Goose (*Nettapus coromandelianus*), Black Headed Ibis (*Threskiornis melanocephalus*), Striated Heron (*Butorides striata*), Indian Pond Heron (*Ardeola grayii*), Grey Heron (*Ardea cinerea*), Purple Heron (*Ardea purpurea*), Great Egret (*Ardea alba*), Darter (*Anhinga melanogaster*) and Indian Cormorant (*Phalacrocorax fuscicollis*). Overall the area's avifauna is not rich in bird species of international conservation. Scarcity of wetland birds in the canal area was notable and it might be due to poor water quality and degrading ecosystem of the canals. So, proper measures to improve water quality and wetland ecosystem health should be mandatory.

3.12.2. Mammals

Ten species (Table-3.29) of mammals was so far detected. The thickets along canals is habitat for various species of mammals, including several rodent species, Indian grey mongoose (*Herpestes edwardsii*), Indian jackal (*Canis aureus*)and smooth coated otters. (LIPI,2012). The vulnerable Smooth-coated otter (*Lutrogale perspicillata*) needs access to dense aquatic vegetation as a place to hide, hunt or rest, and with access to prey populations and water. The population of these species are in urgent need of mangrove cover expansion to meet their ecological needs.

3.12.3. Herpatofauna (Reptiles and amphibians)

The surveys in selected canals under IURWTS project have so far recorded 14 species of reptiles and 3 species of amphibians (Table-3.30), and none of the reptiles and amphibians encountered so far in Kochi canals are of global conservation concern. Scarce population of amphibians indicates the deterioration of water quality of canals and fringing vegetation.

3.12.4. Fishery

Fishery composition during the present study included 10 species from the canals (*Etroplus maculatus*, *Danio sp.*, *Megalops cyprinoides, Caranx sp., Trichopodus trichopterus, Trypauchen vagina Oreochromis sp., Channa striata, Anabas testudineus* and *Aplocheilus panchax* and 13 species from the reference stations (*Mugil cephalus*, *Etroplus maculatus*, *Danio* sp., *Megalops cyprinoides*, *Caranx* sp., *Clarias* sp., *Trichopodus trichopterus*, *Trypauchen vagina*, *Etroplus suratensis*, *Oreochromis* sp., *Channa striata*, *Anabas testudineus and Aplocheilus panchax*) (Table-3.31). *Megalops cyprinoides* (Palankanni) was most dominating species. Being a benthopelagic, euryhaline species, it was reported from all the canals as well as reference stations. The second most dominant fish species was *Trypauchen vagina* (Burrowing goby) reported from Thevara canal as well as all the reference stations. *Trypauchen vagina* being a euryhaline, omnivorous detritus feeder inhabiting river mouths and estuaries burying themselves in the bottom mud. This fish was mainly observed in T1 of Thevara canal .The prevalence of *T. vagina* in T1 might be due to the reason that this study location is adjoining the Cochin estuary from where it has migrated to the nearby canal. Salinity fluctuation due to rainfall prevailed during the sampling period could also be another reason. *Anabas testudineus* was reported from 3 reference stations (Thevara, Maradu and Bolghatty). *Etroplus suratensis* was reported from Thevara and S. chittoor while it was absent in the canal. *Etroplus maculatus* was reported from Edappally canal and S. Chittoor. In general, the fishery was more diverse in the reference station than that of the canals. Meanwhile, Edappally canal was the most diverse (4 spp.) in terms of fishery followed by Thevara and Chilavanoor canals (2 spp.),Perandoor canal and Market canal (1 sp.)

3.12.5. Butterflies

The surveys in selected canals under IURWTS project have so far recorded 47 species of butterflies (Table-3.32), such as Common Mormon, Blue Mormon, Lime Butterfly, Common Jezebel, Common emigrant, Psyche, Common Crow, Common Blue tiger and Tawny Coster. Overall diversity of butterflies are in good side, but their abundance and density along canal vegetation was very poor, this might be due to loss of nectar plants and larval host plants and over growth of invasive species along canal ecosystem. So, appropriate measures are to be taken for planting of host and nectar plants for rehabilitation of butterflies.

3.12.6. Odonates

From the study area, 21 species of odonates have been recorded (Table-3.33), among these seven species belongs to sub order zygoptera (damselflies) and remaining 14 species was sub oreder Anispotera (dragonflies). The most dominated species of dragonfly in canals is Ditch jewel (*Brachythemis contaminata*), a common species found in stagnant and sluggish waters. Generally, Odonata is good indicator of environmental changes as their larvae and adult both are sensitive to habitat degradation. So, higher abundance of Ditch jewel (*Brachythemis contaminata*) and scarce population of other odonates indicates the degradation of water quality of canals.

Table-3.28: List of birds from the study stations under the IURWTS project

Common Name	Scientific Name	Thevara	Perandoor	Chilavannoor	Edapally	Market
Lesser Whistling Duck	*Dendrocygna javanica*	-	+	+	+	-
Cotton Pygmy Goose	*Nettapus coromandelianus*	-	-	+	+	-
Garganey	*Anas querquedula*	-	-	+	+	-
Black Headed Ibis	*Threskiornis melanocephalus*	+	+	+	+	+
Striated Heron	*Butorides striata*	+	+	-	-	-
Black Crowned Night Heron	*Nycticorax nycticorax*	-	-	+	+	+
Indian Pond Heron	*Ardeola grayii*	+	+	+	+	+
Grey Heron	*Ardea cinerea*	+	-	+	+	-
Purple Heron	*Ardea purpurea*	-	-	+	+	-
Cattle Egret	*Bubulcus ibis*	-	+	+	+	-
Great Egret	*Ardea alba*	+	-	+	+	-
Intermediate Egret	*Ardea intermedia*	+	+	+	+	-
Little Egret	*Egretta garzetta*	+	+	+	+	+
Darter	*Anhinga melanogaster*	-	-	-	+	-
Little Cormorant	*Microcarbo niger*	+	+	+	+	+

Common Name	Scientific Name	Thevara	Perandoor	Chilavannoor	Edapally	Market
Indian Cormorant	*Phalacrocorax fuscicollis*	+	-	-	+	-
Black Kite	*Milvus migrans*	+	+	+	+	+
Brahminy Kite	*Haliastur indus*	+	+	+	+	+
Shikra	*Accipiter badius*	-	-	+	+	-
Crested Serpent Eagle	*Spilornis cheela*	-	+	-	-	-
White Breasted Waterhen	*Amaurornis phoenicurus*	-	+	+	+	-
Grey Headed Swamphen	*Porphyrio poliocephalus*	-	+	-	+	-
Red Wattled Lapwing	*Vanellus indicus*	-	+	+	+	-
Common Sandpiper	*Actitis hypoleucos*	+	+	+	+	+
Common Pigeon	*Columba livia*	+	+	+	+	+
Spotted Dove	*Spilopelia chinensis*	-	+	+	+	-
Rose Ringed Parakeet	*Psittacula krameri*	+	+	+	+	+
Asia Koel	*Eudynamys scolopaceus*	-	+	+	+	+
Southern Coucal	*Centropus (sinensis) parroti*	-	+	+	+	-
Barn Owl	*Tyto alba*	-	+	+	+	+
Spotted Owlet	*Athene brama*	-	+	-	+	-
Jungle Owlet	*Glaucidium radiatum*	-	-	+	+	-
Mottled Wood Owl	*Strix ocellata*	-	-	+	+	-
Brown Fish Owl	*Bubo zeylonensis*	-	-	-	+	-
Brown Hawk Owl	*Ninox scutulata*	-	-	-	+	-
Asian Palm Swift	*Cypsiurus balasiensis*	+	+	+	+	+
Stork Build Kingfisher	*Pelargopsis capensis*	+	+	+	+	-
White Throated Kingfisher	*Halcyon smyrnensis*	+	+	+	+	+
Common Kingfisher	*Alcedo atthis*	+	+	+	+	+
Green Bee Eater	*Merops orientalis*	-	+	+	+	-
Blue Tailed Bee Eater	*Merops philippinus*	+	+	+	+	+
White Cheeked Barbet	*Megalaima viridis*	+	+	+	+	+
Lesser Goldenback	*Dinopium benghalense*	-	+	+	+	-
Common Iora	*Aegithina tiphia*	-	+	-	-	-
Greatter Racket Tailed Drongo	*Dicrurus paradiseus*	-	+	-	+	-
Black Drongo	*Dicrurus macrocercus*	+	+	+	+	+
Ashy Drongo	*Dicrurus*	-	-	-	+	-

Common Name	Scientific Name	Thevara	Perandoor	Chilavannoor	Edapally	Market
	leucophaeus					
Indian Golden Oriole	*Oriolus kundoo*	-	-	+	+	-
Black Hooded Oriole	*Oriolus xanthornus*	-	+	-	+	-
Rufos Treepie	*Dendrocitta vagabunda*	+	+	+	+	-
House Crow	*Corvus splendens*	+	+	+	+	+
Indian Jungle Crow	*Corvus culminatus*	-	+	+	+	+
Barn Swallow	*Hirundo rustica*	-	+	+	+	-
Red Whisked Bulbul	*Pycnonotus jocosus*	-	+	+	+	-
Red Vented Bulbul	*Pycnonotus cafer*	-	+	+	+	+
Ashy Prinia	*Prinia socialis*	-	+	+	+	-
Plain Prinia	*Prinia inornata*	+	+	+	+	-
Zitting Cisticola	*Cisticola juncidis*	-	+	-	+	-
Common Tailer Bird	*Orthotomus sutorius*	+	+	+	+	+
Blyths Reed Warbler	*Acrocephalus dumetorum*	+	+	+	+	+
Green Warbler	*Phylloscopus trochiloides*	-	+	-	+	-
Common Myna	*Acridotheres tristis*	+	+	+	+	+
Jungle Myna	*Acridotheres fuscus*	-	+	+	+	-
Oriental Magpie Robin	*Copsychus saularis*	+	+	+	+	+
Pale Build Flower Plucker	*Dicaeum erythrorhynchos*	-	+	+	+	+
Purple Rumped Sunbird	*Leptocoma zeylonica*	+	+	-	+	-
Purple Sunbird	*Cinnyris asiaticus*	+	+	+	+	+
Lotens Sunbird	*Cinnyris lotenius*	-	+	+	+	+
House Sparrow	*Passer domesticus*	+	+	+	+	+
Scaly Breasted Munia	*Lonchura punctulata*	+	+	+	-	+
Black Headed Munia	*Lonchura atricapilla*	+	-	+	+	-
Grey Wagtail	*Motacilla cinerea*	-	+	-	-	+
*** +Present -Absent**						

Source: Bidivesity Asesment Study by Cochin University of Science & Technology (CUSAT) CUSAT during Study Period (September-November, 2020).

Table-3.29: List of Mammals from the study stations under the IURWTS project

Common Name	Scientific Name	Thevara	Perandoor	Chilavannoor	Edapally	Market
Smooth Coated Otters	*Lutrogale perspicillata*	+	+	-	+	-
Indian Grey Mongoose	*Herpestes edwardsii*	-	+	+	+	-
Indian Flying Fox	*Pteropus giganteus*	+	+	+	+	+
Indian Jackal	*Canis aureus*	-	+	-	+	-
Asian palm civet	Paradoxurus hermaphroditus					
Brown Rat	*Rattus norvegicus*	+	+	+	+	+
Black Rat	*Rattus rattus*	-	+	-		+
Lesser Bandicoot Rat	*Bandicota bengalensis*	+	+	+	+	+
Greater Bandicoot Rat	*Bandicota indica*	-	+	-	+	+
House Mouse	*Mus musculus*	+	+	+	+	+
Indian Palm Squirrel	*Funambulus palmarum*	-	+	+	+	-
* +Present -Absent						

Source: Bidivesity Asesment Study by Cochin University of Science & Technology (CUSAT) CUSAT during Study Period (September-November, 2020).

Table-3.30:List of Reptiles and Amphibians from the study stations under the IURWTS

Common Name	**Scientific Name**
Herpatofauna	
Indian Black Turtle	*Melanochelys trijuga*
Oriental Garden Lizard	*Calotes versicolor*
Day Gecko	*Cnemaspis sp.*
Common House Gecko	*Hemidactylus frenatus*
Golden Skink	*Eutropis carinata*
Green Vine Snake	*Ahaetulla nasuta*
Common Bronzeback	*Dendrelaphis tristis*
Indian Wolf Snake	*Lycodon aulicus*
Indian Rat Snake	*Ptyas mucosa*
Russell's Boa	*Eryx conicus*
Common Krait	*Bungarus caeruleus*
Indian Cobra	*Naja naja*
Checkered Keelback	*Fowlea piscator*
Indian Python	*Python molurus*
Russell's Viper	*Daboia russelii*
Trinket snake	Coelognathus helena monticollaris
Monitor lizards	*Varanus bengalensis*
Amphibians	
Common Name	**Scientific Name**
Common Asian toad	*Duttaphrynus melanostictus*
Skittering frog	*Euphlyctis cyanophlyctis*
Indian bullfrog	*Hoplobatrachus tigerinus*

Source: Bidivesity Asesment Study by Cochin University of Science & Technology (CUSAT) CUSAT during Study Period (September-November, 2020).

Table-3.31: List of Fishes from the study stations under the IURWTS project

Common Name	Scientific Name	Habitat	Stations					
			Reference stations	Thevara	Perandoor	Edappally	Chilavanoor	Market
Mullet	*Mugil cephalus*	E	+	-	-	-	-	-
Orange chromide	*Etroplus maculatus*	F/B/E	+	-	-	+	-	-
Gaint Danio	*Danio sp.*	F	+	-	-	+	-	-
Indo-Pacific tarpon	*Megalops cyprinoides*	M/ F	+	+	+	+	+	+
Bluefin trevally	*Caranx sp.*	M	+	-	-	+	-	-
Walking catfish	*Clarias sp.*	F	+	-	-	-	-	-
Three spotted gourami	*Trichopodus trichopterus*	F	+	-	-	-	+	-
Burrowing goby	*Trypauchen vagina*	B/ M	+	+	-	-	-	-
Pearlspot	*Etroplus suratensis*	F	+	-	-	-	-	-
Thilapia	*Oreochromis sp.*	F/ B	+	-	-	+	-	-
Snakehead murrel	*Channa striata*	F	+	-	-	+	-	-
Climbing perch	*Anabas testudineus*	F/E	+	-	-	-	+	-
White spot	*Aplocheilus panchax*	F	+	+	+	+	+	-
*F –Fresh water : * B – Brackish ; *E- Estuarine ;* M- Marine; +Present; -Absent								

Source: Bidivesity Asesment Study by Cochin University of Science & Technology (CUSAT) CUSAT during Study Period (September-November, 2020).

Table-3.32: List of Butterflies from the study stations under the IURWTS project

Common Name	Scientific Name	Thevara	Perandoor	Chilavannoor	Edapally	Market
Common Banded Awl	*Hasora chromus*	+	-	-	-	+
Rice Swift	*Borbo cinnara*	-	-	+	+	-
Grass Demon	*Udaspes folus*	-	-	+	+	-
Common Blue Bottle	*Graphium sarpedon*	-	+	+	+	-
Tailed Jay	*Graphium agamemnon*	-	-	+	+	-
Common Mime	*Papilio clytia*	-	-	+	+	-
Common Mormon	*Papilio polytes*	+	+	+	+	+
Blue Mormon	*Papilio polymnestor*	-	+	+	+	-
Lime Butterfly	*Papilio demoleus*	-	-	+	+	-
Common Rose	*Pachliopta aristolochiae*	-	+	+	+	-
Crimson Rose	*Pachliopta hector*	-	+	+	+	-
Common Grass Yellow	*Eurema hecabe*	+	+	+	+	-
Three Spot Grass Yellow	*Eurema blanda*	-	+	+	+	-
Common Emigrant	*Catopsilia pomona*	+	+	+	+	+
Mottled Emigrant	*Catopsilia pyranthe*	-	+	+	+	
Common Jezebel	*Delias eucharis*	-	+	+	+	+

Common Name	Scientific Name	Thevara	Perandoor	Chilavannoor	Edapally	Market
Psyche	*Leptosia nina*	+	+	+	+	+
Common Pierrot	*Castalius rosimon*	-	+	+	+	-
Common Cerulean	*Jamides celeno*	-	+	+	+	-
Pea Blue	*Lampides boeticus*	-	-	+	-	-
Gram Blue	*Euchrysops cnejus*	+	+	-	+	-
Lime Blue	*Chilades lajus*	-	-	+	+	-
Grass Jewel	*Freyeria trochylus*	+	+	+	+	-
Dark Grass Blue	*Zizeeria karsandra*	-	+	+	-	-
Lesser Grass Blue	*Zizina otis*	-	-	+	+	-
Red Pierrot	*Talicada nyseus*	-	+	+	+	-
Dark Blue Tiger	*Tirumala septentrionis*	-	+	+	+	-
Common Blue Tiger	*Tirumala limniace*	-	+	+	+	-
Striped Tiger	*Danaus genutia*	-	+	+	+	-
Plain Tiger	*Danaus chrysippus*	+	+	+	+	-
Common Crow	*Euploea core*	+	+	+	+	+
Common Evening Brown	*Melanitis leda*	-	+	+	+	-
Common Palm Fly	*Elymnias hypermnestra*	-	+	+	+	-
Common Bush Brown	*Mycalesis perseus*	-	-	+	+	-
Towny Coster	*Acraea terpsicore*	-	+	+	-	-
Common Leopard	*Phalanta phalantha*	-	-	+	+	-
Commander	*Moduza procris*	-	-	-	+	-
Common Sailer	*Neptis hylas*	+	+	+	+	+
Chestnut Streaked Sailer	*Neptis jumbah*	-	-	+	+	
Common Baron	*Euthalia aconthea*	-	+	+	+	+
Common Castor	*Ariadne merione*	-	+	+	+	+
Chocalate Pansy	*Junonia iphita*	-	+	+	+	-
Grey Pansy	*Junonia atlites*	-	+	+	+	-
Peacock Pansy	*Junonia almana*	-	-	+	+	-
Lemon Pansy	*Junonia lemonias*	-	+	+	+	-
Great Eggfly	*Hypolimnas bolina*	-	+	-	+	-
Danaid Eggfly	*Hypolimnas misippus*	-	-	+	+	-
*** +Present -Absent**						

Source: Bidivesity Asesment Study by Cochin University of Science & Technology (CUSAT) CUSAT during Study Period (September-November, 2020).

Table-3.33: List of odonates (Damselflies & Dragonflies) from the study stations under the IURWTS project

Common Name	Scientific Name	Thevara	Perandoor	Chilavannoor	Edapally	Market
Kerala Dartlet	*Agriocnemis keralensis*	-	-	+	+	-
White Dartlet	*Agriocnemis pieris*	-	+		+	-
Pygmy Dartlet	*Agriocnemis pygmaea*	+	+	+	+	-
Orange Tailed Marsh Dart	*Ceriagrion cerinorubellum*	+	+	+	+	-
Coromandel Marsh Dart	*Ceriagrion coromandelianum*	+	+	+	+	-
Golden Dartlet	*Ischnura rubilio*	-	+		+	-
Blue Grass Dart	*Pseudagrion malabaricum*	+	+	+	+	+
Rufos Backed Marsh Hawk	*Brachydiplax chalybea*	+	+	+	+	+
Scarlet Marsh Hawk	*Aethriamanta brevipennis*	-	+	+	+	-
Ditch Jewel	*Brachythemis contaminata*	+	+	+	+	+
Ground Skimmer	*Diplacodes trivialis*	+	+	+	+	-
Green Marsh Hawk	*Orthetrum sabina*	-	+	+	+	-
Asiatic Bloodtail	*Lathrecista asiatica*	-	-	+	+	-
Pied Paddy Skimmer	*Neurothemis tullia*	+	+	+	+	-
Brown Backed Red Marsh Hawk	*Orthetrum chrysis*	-	-	-	+	-
Wandering Glider	*Pantala flavescens*	+	+	+	+	+
Rufos Marsh Glider	*Rhodothemis rufa*	+	+	+	+	-
Common Picture Wing	*Rhyothemis variegata*	-	+	+	+	-
Red Marsh Trotter	*Tramea basilaris*	-	-	-	+	-
Long Legged Marsh Glider	*Trithemis pallidinervis*	-	+	+	+	-
Greater Crimson Glider	*Urothemis signata*	+	+	+	+	-

Source: Bidivesity Asesment Study by Cochin University of Science & Technology (CUSAT) CUSAT during Study Period (September-November, 2020).

3.13. MANGALAVANAM BIRD SANCTUARY

Mangalavanam is a small patch of primarily mangrove species in a small tidal wetland, situated amidst Kochi, in Ernakulam district, Kerala. The mangrove serves as a shelter for birds both residents and migratory. The Mangalavanam has been declared as a bird sanctuary on 31st August 2004. It is the smallest of the protected area in the State, having an area of only 2.74 ha. The Mangalavanam Bird Sanctuary lies between latitudes 9°59'13.4" N and longitudes 76°16'26.1" E in the east of Central Marine Fisheries Research Institute (CMFRI) and National Institute of Oceanography (NIO) close to the new building complex of the High court of Kerala. A Jayson and Easa (1999) documented the vertebrate fauna of the Mangalavanam during 1998-99 and reported 72 species of birds. Azeez and Bhupathy (2006) in the month of May recorded birds belonging to 32 species. The Department of Forest, Government of Kerala has conducted survey of the birds of Mangalavanam Bird Sanctuary in November 2009. In the present study area including Mangalavanam Bird Sanctuary, common birds observed are Asian Koel (*Eudynamys scolopacea*), Common Myna (*Acridotheres tristis*), House Sparrow (*Passer domesticus*), Little Cormorant (*Phalacrocorax niger*), Grey Heron (*Ardea cinerea*), Red-wattled Lapwing (*Vanellus indicus*), Indian Robin (*Saxicoloides fulicata*), Intermediate Egret (*Mesophoyx intermedia*)House Crow (*Corvus splendens*Darter (*Anhinga melanogaster*), Black Kite (*Milvus migrans*), Brahminy Kite (*Haliastur indus*), Indian Pond-heron (*Ardeola grayii*), Indian Cormorant (*Phalacrocorax fuscicollis*), and Little Egret (*Egretta garzetta*). Birds such as Ashy Drongo (*Dicrurus leucophaeus*), Chestnut-tailed Starling (*Sturnus malabaricus*), Common Sandpiper (*Actitis hypoleucos*), Common Redshank (*Tringa totanus*), Grey Heron (*Ardea cinerea*), Marsh Sandpiper (*Tringa stagnatilis*) are seasonal visitors to the area. According to secondary sources, Greenish Warbler (*Phylloscopus trochiloides*), Blyth's Reed-Warbler (*Acrocephalus dumetorum*), Wood Sandpiper (*Tringa glareola*), Common Greenshank (*Tringa nebularia*) and Marsh Sandpiper (*Tringa stagnatilis*) are reported as the winter visitors in the area (Azeez and Bhupathy, 2006; Nameer 2010). Mangalavanam is a shallow water body and attract the waders. The Marsh sandpiper is the most commonly observed bird species followed by Spotted Sandpiper. While the presence of these two long distant migratory waders in good number is a good indicator. Apart from the sandpipers, good population of other waders such as shanks, stilts etc. is also reported. The list of the birds reported during the survey is given in Table- 3.34. The location of the Mangalavanam Bird Sanctuary with respect to project site is shown in Figure-3.13.

Table-3.34: Avi-faunal species observed in Mangalavanam Bird Sanctuary

Common Name	Scientific Name
Jungle Myna	*Acridotheres fuscus*
Common Myna	*Acridotheres tristis*

Common Name	Scientific Name
Common Sandpiper	*Actitis hypoleucos*
Crimson Sunbird	*Aethopyga siparaja*
Common Kingfisher	*Alcedo atthis*
Blue-eared Kingfisher	*Alcedo meninting*
White-breasted Waterhen	*Amaurornis phoenicurus*
Darter	*Anhinga melanogaster*
Grey Heron	*Ardea cinerea*
Purple Heron	*Ardea purpurea*
Indian Pond-heron	*Ardeola grayii*
Cattle Egret	*Bubulcus ibis*
Little Heron	*Butorides striatus*
Greater Coucal	*Centropus sinensis*
Pied Kingfisher	*Ceryle rudis*
Rock Pigeon	*Columba livia*
Oriental Magpie -Robin	*Copsychus saularis*
Large-billed Crow	*Corvus macrorhynchos*
House Crow	*Corvus splendens*
Asian Palm Swift	*Cypsiurus balasiensis*
Fulvous Whistling-duck	*Dendrocygna bicolor*
Pale-billed Flowerpecker	*Dicaeum erythrorhynchos*
Ashy Drongo	*Dicrurus leucophaeus*
Black Drongo	*Dicrurus macrocercus*
Greater racket-tailed Drongo	*Dicrurus paradiseus*
Black-rumped Flameback	*Dinopium benghalense*
Common Flameback	*Dinopium shorii*
Rufous Woodpecker	*Dryocopus hodgei*
Black Bittern	*Dupetor flavicollis*
Little Egret	*Egretta garzetta*
Asian Koel	*Eudynamys scolopacea*
Common Moorhen	*Gallinula chloropus*
Stork-billed Kingfisher	*Halcyon capensis*
White-throated Kingfisher	*Halcyon smyrnensis*
Pallas's fish- Eagle	*Haliaeetus leucoryphus*
Brahminy Kite	*Haliastur indus*
Black-winged Stilt	*Himantopus himantopus*
Cinnamon Bittern	*Ixobrychus cinnamomeus*
Black-headed Munia	*Lonchura malacca*
White-cheeked Barbet	*Megalaima viridis*
Intermediate Egret	*Mesophoyx intermedia*
Black Kite	*Milvus migrans*
Purple Sunbird	*Nectarinia asiatica*
Cotton Pygmy-goose	*Nettapus coromandelianus*
Black-crowned night Heron	*Nycticorax nycticorax*
Common Tailorbird	*Orthotomus sutorius*

Common Name	**Scientific Name**
House Sparrow	*Passer domesticus*
Indian Cormorant	*Phalacrocorax fuscicollis*
Little Cormorant	*Phalacrocorax niger*
Plain Prinia	*Prinia inornata*
Ashy Prinia	*Prinia socialis*
Rose-ringed Parakeet	*Psittacula krameri*
Indian Robin	*Saxicoloides fulicata*
Chestnut-tailed Starling	*Sturnus malabaricus*
Little Grebe	*Tachybaptus ruficollis*
Black-headed Ibis	*Threskiornis melanocephalus*
Common Redshank	*Tringa totanus*
Red-wattled Lapwing	*Vanellus indicus*

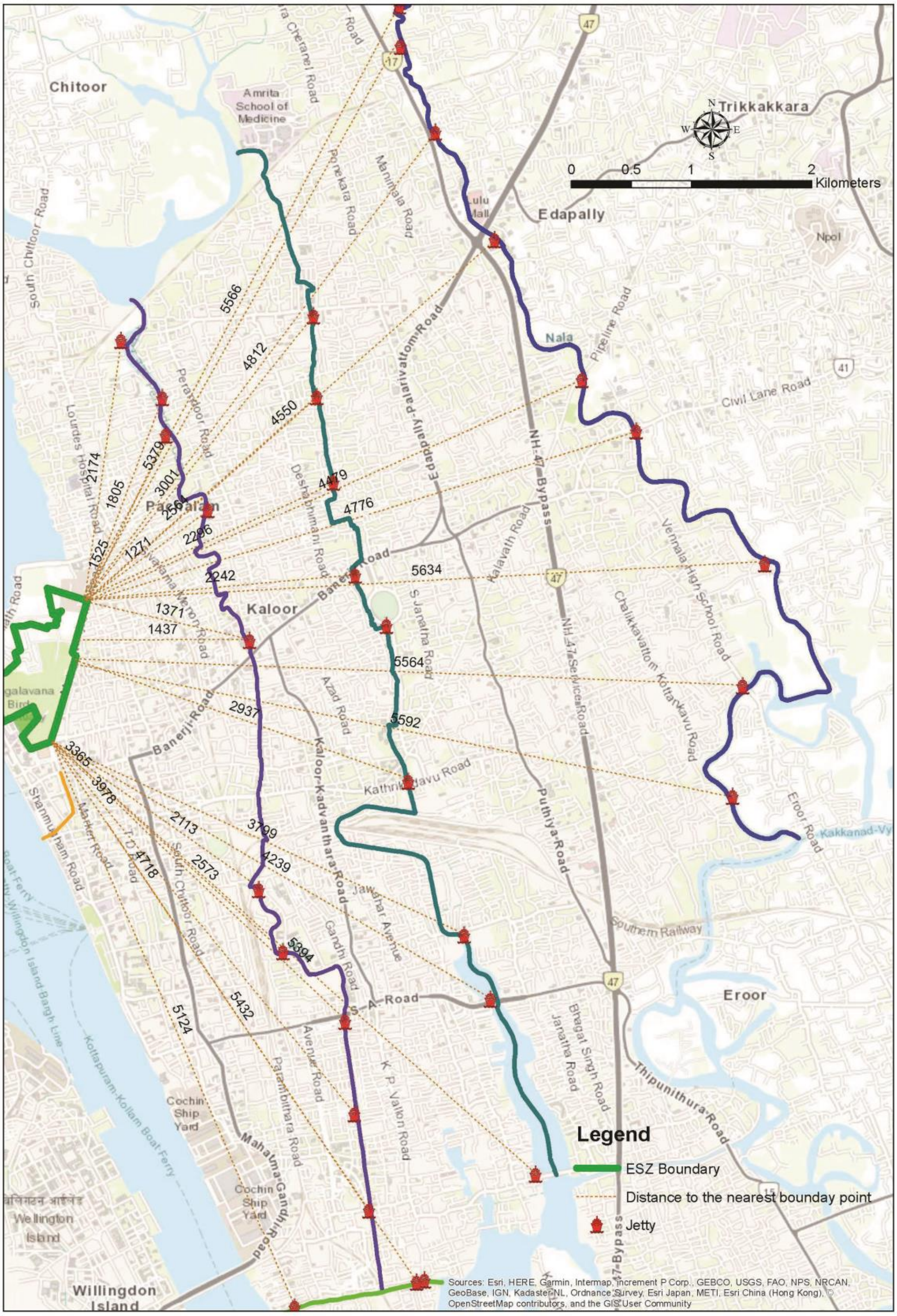


Figure-3.13: Location of Magalavanam Bird Sanctuary respect to project site

3.14. AQUATIC ECOLOGY SURVEY

The environment assessment study was carried out broadly by Department Of Marine Biology, Microbiology & Biochemistry School of Marine Sciences Cochin University of Science & Technology during September & October 2020. The analysis is carried out in the five canals and its adjoining zones and 13 study stations from the five canals were selected, based on the prevailing ecological conditions for field sampling, collection and analysis of various environmental and biological parameters. The five reference stations (blue waters) corresponding to the canal stations were also selected for field studies to understand the environmental variabilities between the two habitats. The geographic locations of the study stations were fixed based on GPS (Global Positioning System) position and the maps were redrawn using ArcGis 10.5.

The study locations selected were T1 (Market), T2 (Thechappily thodu), P1 (Panampilly Nagar), P2 (Convention Centre), P3 (Perandoor), E1 (Muttar), E2 (Marottichuvadu), E3 (Chalikkavattom), C1 (Karanakodam thodu), C2 (Kaloor Stadium), C3 (Meenchira), M1 (Market Road) and M2 (Rainbow bridge).

The reference stations selected were R1 (Thevara), corresponding to Thevara canal, R2 (Chittoor) for Perandoor canal, R3 (Thuthiyoor), for Edappally canal, R4 (Maradu), for Chilavannoor canal and R5 (Bolghatty), for Market canal (Table-3.35 and Figure-3.14)

Table-3.35: Canal and reference stations selected for marine ecology and biodiversity impact assessment study

Sl. No.	CANALS	GPS positions
	Thevara canal	
1	Market -T1	9°56'38.9"N-76°17'36.2"E
2	Thechappily Thodu -T2	9°56'46.2"N -76°18'11.7"E
	Thevara Perandoor canal	
3	Perandoor - P1	10°01'03.31"N-76°16'56.38"E
4	Convention Centre- P2	9°59'44.1"N-76°17'23.9"E
5	Panampilly Nagar - P3	9°57'05.8"N-76°17'58.8"E
	Edappally canal	
6	Muttar - E1	10°02'36.48"N-76°18'11.63"E
7	Marottichuvadu - E2	10°00' 58.53"N-76°18'56.61"E
8	Chalikkavattom - E3	9°58'56.99"N-76°19'38.13"E
	Chilavannoor canal	
9	Karanakodam thodu - C1	9°58'45.37"N-76°18'13.15"E
10	Kaloor Stadium - C2	9°59'43.89"N-76°18'00.62"E
11	Meenchira - C3	10°01'40.81"N-76°17'33.85"E
	Market canal	
12	Market Road – M1	9°98'21.65"N-76°27'77.81"E
13	Rainbow bridge – M2	9°97'98.65"N-76°27'50'E
	REFERENCE STATIONS	
14	Thevara - R1	9°55'57.7"N -76°16'12.2"E

15	Chittoor - R2	10°01'22.1"N-76°16'50.9"E
16	Thuthiyoor - R3	9°59'24.5"N-76°20'03.3"E
17	Maradu - R4	9°56'43.5"N-76°18'35.1"E
18	Bolghatty –R5	9°58'41.5"N-76°16'19.9"E

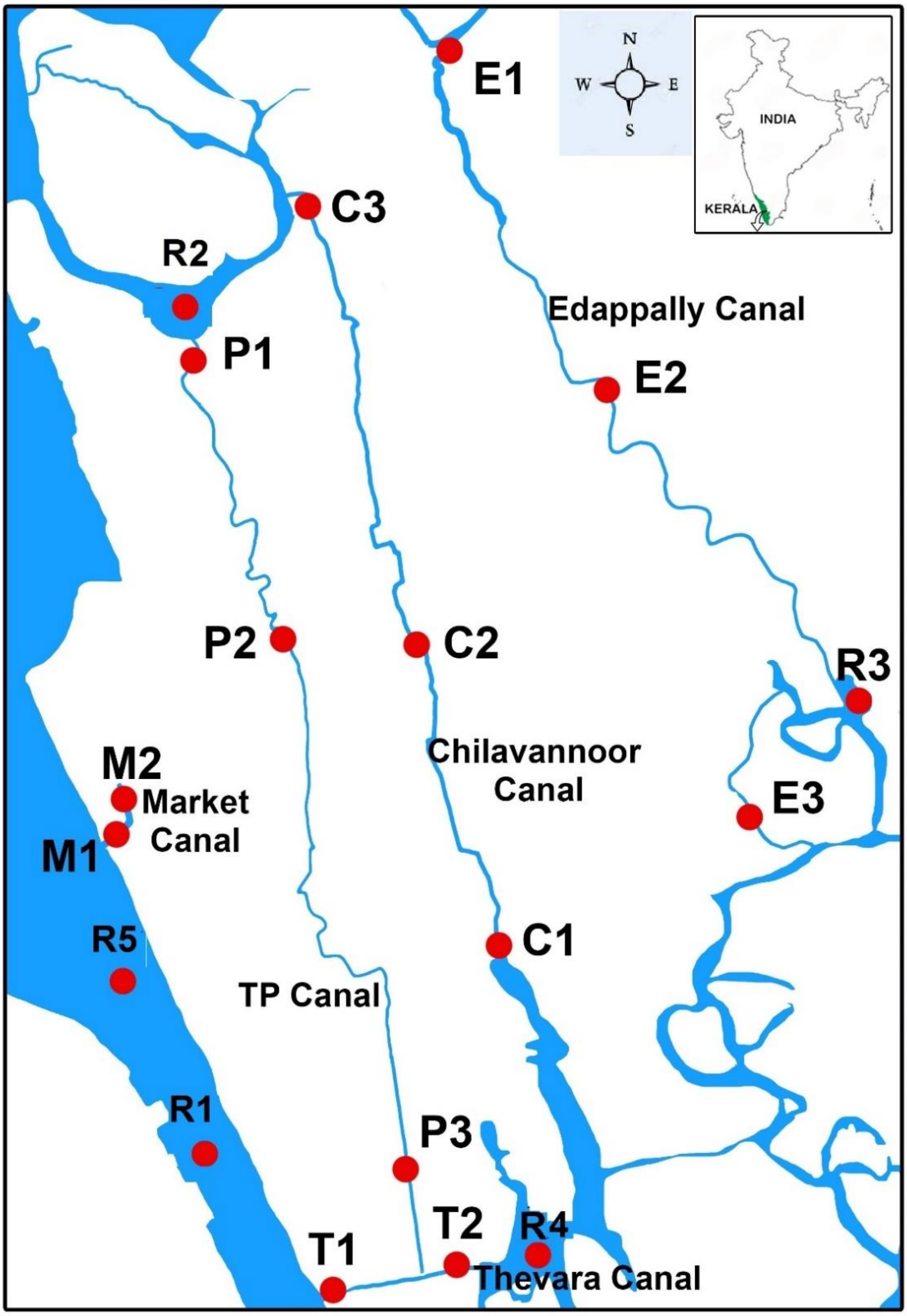


Figure-3.14: Map showing the study stations of aquatic ecology survey

3.14.1 Materials and Methods

Field sampling was invariably conducted during the early morning hours from the selected sampling stations of the five canals and corresponding reference stations during 22nd September 2020 to 1st October 2020, for the collection of water, sediment and biological parameters (Plate 3.1 and Plate 3.2). For the collection and analysis of samples from the reference stations, boats with inboard engine were employed.

Atmospheric temperature was measured using a standard degree centigrade thermometer, ranging 0° C to 50° C and 0.1° C accuracy.

WATER QUALITY

The water depth and transparency were measured onboard in field from each of the study sites. Depth was measured in the field by lowering a graduated weighted rope until it touched the bottom of the canal. Water transparency was measured with the Secchi disc (20cm in diameter) and expressed in meters (Strickland and Parsons, 1972).

The surface water and bottom water samples were collected using a standard Niskin water sampler (General Oceanics, 5L capacity). Preservation of the water samples for the analysis were based on standard methods (Grasshoff *et al*., 1999; APHA, 2005).

Physical parameters such as temperature, salinity, and chemical parameters such as pH, oxidation reduction potential (Eh), conductivity, Total Dissolved Solids (TDS) were analyzed in field using a calibrated multi-parameter waterproof meter (HI98194), HANNA INSTRUMENTS.

Total alkalinity was measured by titrimetric method using methyl orange indicator and expressed in milligrams per litre (mg L^{-1}) (APHA, 2005). Samples for the analysis of total hardness were collected in bottles of 1 litre capacity, brought to the laboratory and deep freezed at -20°C. Hardness was determined by the EDTA titration method (APHA, 2005). Ethylene diamine tetra acetic acid and its sodium salts (EDTA) form a chelated complex when added to solution containing calcium and magnesium. In the presence of dye, Erichrome Black - T at pH of 10 ± 0.1, the solution becomes wine red. On titration with EDTA, the calcium and magnesium will be complexed and when all the Ca and Mg have been complexed, the solution turns from wine red to blue.

Chloride was estimated by Argentometric method. The silver nitrate reacts with chloride to form very slightly soluble white precipitate of silver chloride. At the end point, when all the chlorides get precipitated the free silver ions reacts with potassium chromate to form silver chromate which is reddish brown in color and expressed as mg L^{-1}(APHA, 2005).

The water samples for dissolved oxygen (DO) and biological oxygen demand (BOD) were collected in standard BOD glass bottles. The samples for dissolved oxygen were fixed onboard with manganese sulphate and alkali iodide- azide reagent and estimated using the modified Winkler's method (APHA, 2005; Strickland and Parsons, 1972) and expressed in milligram/liter (mg L^{-1}). Biological oxygen demand (BOD) was measured using 3-day BOD test method (APHA, 2005; Kale and Mehotra, 2009). The dilution water was prepared using aerated distilled water (24 hrs) and adding 1 ml each of phosphate buffer, magnesium sulfate, calcium chloride and ferric chloride solution. Appropriate amount of dilution water are added to the samples before incubation and after 3 days, the DO (Dissolved oxygen) of the blank and the samples were determined and BOD is expressed in milligrams per litre (mg L^{-1}).

The Chemical Oxygen Demand (COD) test measures the oxygen required to oxidize organic matter in water and wastewater samples by the action of strong oxidizing agents under acid conditions. Organic and oxidizable inorganic substances in an aqueous sample are oxidized by potassium dichromate solution in 50% (by volume) sulphuric acid solution (Above solutions and samples are mixed in a refluxing flask). The excess dichromate is titrated with standard ferrous ammonium sulfate using orthophenanthroline ferrous complex (ferroin) as an indicator (APHA, 2005). COD was expressed in mg L^{-1}.

For the analysis of hydrogen sulphide, the water samples were fixed on board with zinc-acetate solution. Dissolved hydrogen sulphide was measured by Cline's method (Grasshoff et al., 1969). The zinc-acetate fixed samples were treated with N, N-dimethyl-p-phenylene diamine dihydrochloride and ferric chloride reagent. The blue colour developed was measured at 630nm using a spectrophotometer and the values were expressed in µmol L^{-1}.

Samples for inorganic nutrients (phosphate-phosphorus, Silicate-silicon, ammonia-nitrogen, nitrite-nitrogen and nitrate nitrogen) were collected in bottles of 1 litre capacity, brought to the laboratory and freezed at -20°C temperature. The inorganic nutrients was analysed after filtering through Whatman No: 1 filter papers, following standard procedures (Strickland and Parsons, 1972; Grasshoff et al., 1983) and using a spectrophotometer (Systronics UV-VIS spectrophotometer, Model No.117), after proper calibration. Dissolved inorganic phosphate-phosphorus was measured by ascorbic acid method (Strickland and Parsons, 1972; Grasshoff et al., 1983) and absorbance was measured at 882nm. Silicate-silicon in the water was estimated by molybdosilicate method (Grasshoff et al., 1983) at 810 nm; ammonia-nitrogen by the phenate method (Grasshoff et al., 1983); nitrite-nitrogen by diazotised method and absorbance was measured at 543 nm (Strickland and Parsons, 1968; Grasshoff et al., 1983) and nitrate nitrogen by resorcinol method (Zhang and Fischer, 2006) at 505 nm. All the results of the nutrients are expressed in the unit of micromole per litre (µmol L^{-1}).

For dissolved trace metal analysis, the samples were filtered using 0.45 µm Millipore filter paper and stored in pre-cleaned, acid washed polyethylene bottle. The sample was acidified with supra-pure nitric acid to a pH between 2-3. Samples were stored at low temperatures (-

10 to -40°C) to avoid evaporation. Four hundred milliliters of the sample was taken in a separating funnel and ammonium acetate buffer was added to adjust the pH of the sample to 4.5. Ten milliliters of 2% APDC solution was added to the sample followed by 15 ml of Methyl Isobutyl Ketone (MIBK). The funnel was shaken well using reciprocating shaker (Model: RS M1) and the 2 phases were allowed to separate, the lower aqueous layer was drained to another separating funnel. The extraction process was repeated by adding 5ml of APDC and 10 ml of MIBK 2 or 3 times. The MIBK layer was shaken well after adding 0.1ml of conc. HNO3 and 9.9ml of distilled water. The layers were separated and the aqueous layer collected in 25 ml standard flask and made up to mark with milli Q (Brooks and Presely, 1972). Following preparation, the water samples were analyzed in Inductively Coupled Plasma Atomic Emission Spectrometer (ICP-AES) (Model: Thermo Electron IRIS INTREPID II XSP DUO with detection limit of ppb level at Sophisticated Test and Instrumentation Centre (STIC) of Cochin University of Science and Technology.

Total Petroleum Hydrocarbon (TPH) in water was analysed by Liquid-liquid extraction method (IOC-UNESCO, 1984) and expressed in mg L^{-1}. The water samples were collected in 1-liter amber glass bottles with Teflon-lined screw cap and preserved adding 1-2 ml concentrated H_2SO_4 and stored at 4° C immediately after collection. Samples were then extracted with n-hexane to transfer petroleum hydrocarbon in the organic phase and the organic extract was concentrated after drying. Fluorescence of the extract was measured on a double beam Perkin–Elmer LS-3B fluorescence spectrophotometer at emission wavelength of 360 ±1 nm (excitation wavelength 310 ± 1 nm). Blanks were measured following the same procedure using petroleum hydrocarbon free water (IOCUNESCO, 1984; Law et al., 1997).

SEDIMENT QUALITY

The sediment samples were collected using a standard van Veen grab of size $0.04m^2$. Sediment temperature was determined using standard degree centigrade thermometer in the field. A separate core sample of sediment was taken for further analysis of sediment parameters. pH were measured using Systronics model 371 water analyser and Eh (oxidation reduction potential) measured using Systronics digital Eh meter (Model No; 318) (APHA, 2005) and expressed in mV.

For heavy metal analysis in sediments, the samples were oven dried to a constant weight at 80˚C and then crushed using mortar and pestle and sieved through 2 mm sieve. Nitric-Perchloric acid digestion was performed, following the procedure recommended by the AOAC (1990). Approximately 0.5 g of homogenized dry sediment samples were accurately weighed and digested using nitric acid and Perchloric acid in 5:1 ratio in KEL PLUS macro four sample (250 ml) digestion unit (model KES 04L) 180ºC for 4.5 hr and the supernatant solution was filtered in Whatmann filter paper (1µm) and made up to 25 ml for measurement

(Grasshoff et al., 1983). Following preparation, the sediment samples were analyzed in Inductively Coupled Plasma Atomic Emission Spectrometer (ICP-AES) (Model: Thermo Electron IRIS INTREPID II XSP DUO with detection limit of ppb level at Sophisticated Test and Instrumentation Centre (STIC) of Cochin University of Science and Technology.

For the analysis of sediment organic carbon, available nitrogen and available phosphorus, the sediment samples were dried in shade and a portion was powdered using mortar and pestle and then the sediment sieved through a 2 mm sieve. Organic carbon was measured by Walkley-Black method (1934) modified by Trivedy and Goel (1986) and dichromate digestion methods (Nelson and Sommers, 1982). Total carbon was analysed by using Analytik Jena TOC analyzer multi N/C 2100S. Sediment organic matter was estimated by multiplying the sediment organic carbon value with a factor 1.724 (Trask, 1939). Available nitrogen was estimated by Kjeldhal method using Nitrogen Distillation System (Model: KEL PLUS DISTYL EM (VA) (Jackson, 1973; Carter, 1993). Available phosphorus was determined by Olsen's method (Olsen et al., 1954) and expressed in mg Kg^{-1}.

PRODUCTIVITY PARAMETERS

The primary productivity (gross and net production) was estimated by *in situ* incubation method employing the Light and Dark bottle method (Strickland and Parsons, 1972). Water samples were collected and transferred to 125 ml capacity BOD bottles (light and dark bottles). The light and dark bottles were incubated for 3 hours. After the incubation period the oxygen content was determined by the modified Winkler's method and primary production was calculated as per standard protocols (APHA, 2005). The difference in oxygen concentration between the light bottle and the dark bottle (Gross primary productivity) as well as the light bottle and the control bottle (Net primary productivity) was measured and expressed in gC $m^{-3}day^{-1}$ (APHA, 2005).

BIOLOGICAL PARAMETERS

Samples for microphytoplankton were collected by filtering 50 litre of sub surface water through a plankton net of 20 µm mesh size (Tait, 1998; Santhanam, 1980) and preserved in 3% formalin. To calculate the abundance of micro phytoplankton, the concentrated sample was transferred to 15ml graduated test tube and was allowed to stand for 24 hours for settling. The settling volume was used for the calculation of biomass. Standing crop was estimated by enumeration method using Sedgewick-Rafter counting cell (Verlenkar and Desai, 2004; APHA, 2005; Santhanam et al., 1987). One ml of sample was transferred to a Sedgewick- Rafter counting cell and left for proper settling. The number of phytoplankton was counted from one corner of the counting cell to the other end and was expressed in number of individuals/m^3.

For the estimation of Chlorophyll *a* and Pheophytin, 500 ml of water samples were filtered through 47mm GF/C filters and stored in refrigerator for further analysis. Before the filtration of the water samples, 1 ml of 1% $MgCO_3$ was added on to the filter paper to form a thin bed which will serve as a precaution against the development of any acidity and subsequent degradation of pigments in refrigerator (APHA, 2005).

Zooplankton samples were collected by filtering 100 litres of water through 100/200µm plankton net and preserved in 4% buffered formalin (Goswami, 2004; Harris *et al*., 2000). Magnesium chloride (7-10%) was used as narcotizing agent (Omori and Ikeda, 1984). Biomass was volumetrically estimated after removing large detrital particles, using displacement volume method and was expressed in ml m^{-3} (Harris et al., 2000; Varghese et al., 2015). Sorting and analysis of major zooplankton taxa were done under Stereo Microscope using standard references (Omori and Ikeda, 1984; Tait 1998; Todd and Laverack,1991) and enumerated for composition, abundance, distribution and expressed as number of individuals m^{-3} (Goswami 2004; Johnson and Allen 2005; Harris *et al*., 2000).

Macrobenthos samples were collected using van Veen grab of size $0.04m^2$ and the sediment samples were sieved on-board through a 0.5 mm mesh sieve. The sieved macrobenthos with residual sediment samples were then preserved in 4 - 7 % neutral buffered formaldehyde containing Rose Bengal, which facilitate sorting of the organisms from other components of the soil in the laboratory (Holme and McIntyre, 1984; Eleftheriou and McIntyre, 2005; APHA, 2005). The sieved samples were then labeled and stored for further examination. For qualitative enumeration, each sample was examined under a binocular microscope. The organisms were separated into different taxonomic groups and then enumerated and expressed as number of individuals/m^{-2}. Organisms were identified upto lowest possible level as using standard references.

Meiofauna samples were collected from the undisturbed van Veen grab (0.04 m^2) samples using a cylindrical glass corer of 2.5cm inner diameter and 30 cm long (Eleftheriou and McIntyre, 2005). Before processing samples, it is important to check that the laboratory fresh water supply does not contain any meiofauna. For that tap water was run through a 63 µm sieve to make sure that water does not contain any meiofauna (Somerfield and Warwick, 2013). In the laboratory, core samples were extracted for meiofauna by MgCl2 decantation (Crezee, 1976) using a set of 500 µm (remove larger polychaetes and other debris) and 63 µm sieves. The sediment retained in the 63 µm sieve was decanted to extract meiofauna (Higgins and Thiel, 1988). In order to extract the meiofaunal organisms from sediment, the classical method of decantation by hand, using a 63 µm sieve was used (Somerfield and Warwick, 1996). The meiofaunal organisms were stained with Rose Bengal prior to extraction and were sorted and enumerated under a stereomicroscope. The meiofauna were identified into group level and were expressed in individual/$10cm^2$.

The water samples for bacteriological quality evaluation were collected in sterilized tarson bottles, brought and freezed for further analysis. The estimation of the total coliforms and thermo tolerant coliforms was carried out by membrane filtration technique, following the WHO protocol for water quality monitoring (WHO, 1996).

For fishery analysis, landing centre based direct data collection method and catch yield was adopted for the fish landing estimation (Per Sparre and Venema, 1992; Kurup et al., 1993; Gupta et al., 1997; Bijoy Nandan et al., 2012; Jayachandran et al., 2012). Fishes were collected by employing fishermen from each study stations.

Field survey based on various methods such as line transect, quadrant and random samplings were conducted for the data collection and analysis of terrestrial based animals, mammals, birds, butterflies and other biodiversity in the different canals and reference stations (Hyder, Dell et., al. 2010).

Collection of mangroves from each study locations were also carried out for the identification of the species. Healthy plant specimens devoid of insect- damage or diseases were collected, wrapped in wet papers and placed in polythene bags to keep them fresh until the time of identification. The collected specimens are identified using standard references and identifying keys of: Gamble, 1967 (Flora of Presidency of Madras); Tomlinson, 1986 (The botany of Mangrove); Naskar and Mandal, 1999 (Ecology and biodiversity of Indian mangroves); Spalding et al., 2010 (World atlas of mangroves).

All the physico-chemical and biological analysis were done in triplicate and the statistically suitable values were recorded. The analysis of physico-chemical and biological parameters that has been completed is incorporated in the report and detailed below (Depth, transparency, water temperature, turbidity, alkalinity, conductivity, total dissolved solids, salinity, pH, Eh, dissolved oxygen, biological oxygen demand, total petroleum hydrocarbon). The analysis of other physico-chemical and biological parameters is in progress.

3.14.2 THEVARA CANAL AND REFERENCE STATION

Water and sediment quality of the Canal

Atmospheric temperature ranged from 27°C in T1 to 28°C in T2 with an average of value of 27.5 ± 0.70 °C. Depth of the station ranged from 1m in T1 to 1.5m in T2 with an average 1.25±0.353m for two stations. The flow rate of the canal was minimum in T1 (1.38m sec^{-1}) to a maximum of 2.19 m sec^{-1} in T2. Water temperature ranged from 27.1°C in bottom water of T1 to 28.01°C in surface water of T2 with an average of 27.495 ±0.37°C; that for transparency was 0.25m in station T1 and T2; that for pH was ranged from 7.25 in surface and bottom water of T2 to 7.26 in T1 surface and bottom water with an average value of 7.25±0.01; that for Eh ranged from 122.6 mV in T1 surface water to 124 mV in bottom water of T2; that for conductivity ranged from 307µScm^{-1} in T2 surface to 445 µScm^{-1} in surface water of T1 with an average of 376±96.87; that for Total Dissolved Solids (TDS) ranged from 154 mg L^{-1} in T2 surface and bottom water to 222 mg L^{-1} in surface and bottom water of T1; that for turbidity ranged from 1.5NTU in T2 bottom water to 9.7 NTU in T1 bottom water with an average value of 4.2±3.39 NTU; that for salinity ranged from 0.14psu in T2 surface and bottom water to 0.21psu in T1 surface water with an average value of 0.17±0.05psu.

Alkalinity ranged from 70 mg L^{-1} in T1 and T2 bottom water to 170 mg L^{-1} in T1 surface water with an average value of 112.5±10.61mg L^{-1}; that for calcium was ranged from 13.6 mg L^{-1} in bottom water of T1 to 69.3 mg L^{-1} in surface water T1; that for chloride ranged from 1.2 mg L^{-1} in bottom water of T1 and T2 to 2 mg L^{-1} in surface water of T1; that for magnesium ranged from 66.1 mg L^{-1} in T2 bottom water to 129.5 mg L^{-1} in T1 bottom water ; that for total hardness ranged from 74.4 mg L^{-1} in T2 bottom water to 132.8 mg L^{-1} in bottom water of T1; that for potassium ranged from 0.3ppm in bottom water of T2 to 1.2 ppm in bottom water of T2; sodium ranged from 1.4 ppm in bottom water of T2 to 3.6 ppm in bottom water of T2; that for dissolved oxygen (D.O) ranged from 0.78 mg L^{-1} in bottom T1 to 5.51 mg L^{-1} in bottom water of T2; Biological Oxygen demand (BOD) ranged from 168 mg L^{-1} in surface water of T1 to 231 mg L^{-1} in bottom T1 with an average of 199.83±0.47 mg L^{-1}; that for Chemical Oxygen Demand (COD) ranged from 2.8 mg L^{-1} in bottom water of T1 to 38.4 mg L^{-1} in bottom water of T1; that for total sulphide was 0.0002 ppm in both stations.

Silicate-silicon ranged from 0.027µg L^{-1} in surface water of T1 to 0.03 µg L^{-1} in T2 bottom water with an average of 0.01±0.01µg L^{-1}; phosphate-phosphorus ranged from 4.5 L^{-1} in T1 bottom water to 6.7 L^{-1} in surface water of T1; nitrite-nitrogen value was 0.02 µg L^{-1}; that for nitrate-nitrogen was 0.05 µg L^{-1} in both stations; that for ammonia-nitrogen was 0.024 in surface T1 to 0.028 in T2 bottom with an average of 0.02±0.00µg L^{-1}.

Heavy metal cadmium for water ranged from 1.3 ppb in T2 surface to 3.9 ppb in surface water of T1 with an average of 2.11±0.83 ppb in the canal; that for copper ranged from 26 ppb in T1 surface water to 50 ppb in P1 bottom water with an average of 47.0±4.04 ppb in the canal; that for chromium ranged from 5 ppb in T2 surface to 11ppb in T1 surface with an average of 9.07±1.75 in the canal; that for iron ranged from 8.35ppb in T2 bottom to 28.50 ppb in T2 surface water with an average of 15.6±3.96 ppb in the canal; that for manganese ranged from 4 ppb in T2 bottom water to 8ppb in T2 surface water; that for nickel ranged from 21ppb in T2 bottom to 41 in T1 bottom with an average of 6.00±0.34 ppb in the canal; that for zinc ranged from 340ppb in T2 surface to 767ppb in T2 bottom water with an average of 566.±104.38 ppb ; that for lead ranged from 26 in T2 surface E1 to 93 in T2 bottom with an average of 58.2±17.61 ppb; that for mercury was in Below Detectable Level (BDL); that for total petroleum hydrocarbon was also at Non Detectable Level (NDL).

Sediment temperature ranged from 27.1°C in T1 to 27.2°C in T2 with an average value of 27.15±0.07°C; that for pH ranged from 6.29 in T2 to 5.88 in T1 with an average of 6.085±0.28 mV; that for Eh ranged from -443 in T2 to -446 in T1 with an average of -444.5±2.12; that for available nitrogen was ranged from 0.11% in P1 to 2.21% in P2 with an average of 1.16±1.48%.

Primary production and biological parameters

GPP values ranged from 1.476 g C m^3 day $^{-1}$ in surface and bottom water of P2 to 2.214 g C m^3 day $^{-1}$ in surface water of P1 with an average of 1.47 g C m^3 day $^{-1}$; that for NPP ranged from 0.738 in surface and bottom water of T2 to 2.214 in T1 surface with an average of 1.29±0.78 g C m^3 day $^{-1}$; that for chlorophyll *a* mg/m^3 ranged from 0.44 mg/m^3 in surface of T2 to 46.99 mg/m^3 in bottom water of T2 with an average of 12.98±16.67 mg/m^3; that for pheophytin ranged from 815.95 mg/m^3 in bottom of T1 to 18034.782 in surface water of T2. Phytoplankton biomass of the canal was 0.01(ml m^{-3}) in T1 and T2; that for Phytoplankton abundance ranged from 510 (ind m^{-3}) (T1) to 560 (ind m^{-3}) in T2 with an average of 535±35 ind m^{-3}; that for microzooplankton biomass was 0.002 (ml m^{-3}) in both stations; that for microzooplankton abundance ranged from 1040 ind m^{-3} in T1 to 13840 ind m^{-3} in T2 with an average of 7440±9050 ind m^{-3}; that for mesozooplankton biomass ranged from 0.01 ml m^{-3} (T2) to 0.002 ml m^{-3} (T1);that for mesozooplankton abundance ranged from 1040 ind m^{-3} in T1 to 13840 ind m^{-3} in T2 with an average of 7440±9050 ind m^{-3}.Macrobenthos abundance ranged from 4 ind m^{-3} to 110 ind m^{-3} with an average of 57±75 ind m^{-3}.

Water and sediment quality of R1 (Thevara)

The average atmospheric temperature of the reference station (R1-Thevara) was 27.8°C. The average depth of R1 was 4m;that for flow rate was 3.02m/sec; that for water temperature ranged from 26.45 to 28.38 °C with an average of 27.4°C ± 1.4; that for transparency was 0.5m; that for Eh ranged from 291.3mV in surface to 300mV in bottom of R1 with an average of 6.99 ± 0.2 mV; that for conductivity ranged from 1827 in surface to 1912µS/cm in bottom; that for TDS ranged from 9 to 9.13 mg L^{-1} in bottom and surface with an average of 9.065±0.1 mg L^{-1}; that for turbidity ranged from 1.5 to 9.7NTU in surface and bottom with an average of 5.6 ± 5.8 mg L^{-1};that for salinity ranged from 0.88(bottom) to 0.92 (surface) psu with an average of 60 ± 14.1psu;that for alkalinity ranged from 50-70 mg L^{-1} in surface and bottom water with an average of 60 ± 14.1 mg L^{-1}; that for calcium ranged from 82.9 to 118.1 mg L^{-1} with an average of 100.51±24.89 mg L^{-1}; that for chloride ranged from 23.1 to 28.4 mg L^{-1} in surface and bottom with an average of 25.74±3.72 mg L^{-1};that for magnesium ranged from 171.9 to 201.7 mg L^{-1} with an average of 186.78±21.1 mg L^{-1};that for total hardness ranged from 192 (surface) to 230.4 (bottom) mg L^{-1} with an average of 211.2±27.15 mg L^{-1};that for sodium ranged from 13 to 15.3 ppb in bottom and surface of R1 with an average of 14.15±1.65ppb; that for potassium ranged from 0.8 to 1.3 ppb with an average of 1.04±0.37 ppb.

DO ranged from 6.53 mg L^{-1} in surface and 8.11 mg L^{-1} in bottom with an average of 7.3 ± 1.1 mg L^{-1}; that for BOD ranged from 3.5 mg L^{-1} in surface to 4.2 mg L^{-1} in bottom with an average of 3.85 ± 0.49mg L^{-1}; that for COD ranged from 16 to 579.2 mg L^{-1} with an average of 297.6±398.24 mg L^{-1}.Total sulphide values ranged from 0.0005 to 0.0009 in bottom and surface of R1 with an average of 0.0007±0.0001ppm; that for silicate ranged from 0.030 to 0.032 ppm with an average of 0.031±0.031ppm; that for phosphate ranged from 3.5 (bottom) to 3.7 (surface) µg L^{-1} with an average of 3.56± 0.16 µg L^{-1}; that for nitrite ranged from 0.019 to 0.023 µg L^{-1} with an average of 0.021±0.003 µg L^{-1}; that for nitrate was 0.05 of surface and bottom of R1;that for ammonia ranged from 0,025 to 0.027 µg $L^{-1}$with an average of 0.026±0.001 µg L^{-1};

Heavy metal cadmium in R1 ranged from 1.8 to 4.8 ppb with an average of 3.1±1.84 ppb; that for copper ranged from 32 to 74 ppb with an average of 52.9±7432 ppb; that for chromium ranged from 6 to 10 ppb with an average of 8.3±106ppb; that for iron ranged from 8.35 to 9.19 ppb with an average of 8.8±8.359 ppb; that for manganese ranged from 4 to 8 ppb with an average of 5.9±48 ppb; that for nickel ranged from 21 (bottom) to 22 (surface) with an average of 21.4±21 ppb; that for zinc ranged from 645 (bottom) to 853 (surface) with an average of 748.9±64.58 ppb; that for lead ranged from 66 to 98 ppb with an average of 81.9±66.98 ppb; that for mercury and Total Petroleum Hydrocarbon ranged was at Below Detectable Level and Non Detectable Level respectively.

Average sediment temperature of R1 was 25.4°C; that for pH was 6.73; that for Eh was -1070; that for available nitrogen was 1.15%.

Primary production and biological parameters

GPP value ranged from 0.738 (surface) to 2.214 (bottom) g C m^3 day $^{-1}$ with an average of 1.47±0.52 g C m^3 day $^{-1}$; that for NPP ranged from 0.664 (surface) to 0.738 (bottom) g C m^3 day $^{-1}$ with an average of 0.71±0.05 g C m^3 day $^{-1}$; that for Chlorophyll *a* ranged from 12.73 to 52.99(mg/m^3) with an average of 32.86±28.46 mg/m^3; that for pheophytin ranged from 51708.822 (surface) to 13858.902 mg/m^3 (bottom) with an average of 32783.86±26763 mg/m^3. Average phytoplankton biomass of R1 was 0.002 ml m^{-3}. Phytoplankton abundance was 960 ind m^{-3} in R1 with an average of 160±181 ind m^{-3}; that for mesozooplankton biomass was 0.005 ml m^{-3} with an average of 67±23.09 ind m^{-3}; that for mesozooplankton abundance was 14240 ind m^{-3} with an average of 5696±7013 ind m^{-3}; that for macrobenthos was 12 ind m^{-3} with an average of 6±3 ind m^{-3}

Summary

When Thevara canal was compared with its reference station (Thevara- R1), it was observed that the average depth (4m) and transparency (0.5m) was comparatively higher in the reference station than the canal. The average flow rate of the canal was 1.79±0.57 m/sec with the maximum flow rate in T2 (2.19m/sec) than T1 (1.38 m/sec). The average water temperature at R1was more or less same (27.4±1.4° C). R1 was more turbid (5.6±5.8 NTU) than the canal (4.2±3.39 NTU).pH being a crucial ecological factor as the inhabitants are adapted to an optimum pH for their survival and cannot endure abrupt changes. The data from the study was compared with the quality standards of BIS, CPCB, ICMR, WHO, EPA pH of the study locations was within the desirable limits. Even though, canal was observed to be more alkaline (112.5±10.61 mg L^{-1}) than the reference station (60±14.1 mg L^{-1}), the values fell within the limit of water quality standards of BIS and WHO. Lower salinity was observed both in canal and the reference station that may be attributed to the influence of freshwater which was due to the moderate rainfall during the sampling time. Approved limit for DO and BOD is 5 mg L^{-1} according to WHO, BIS and ICMR. In this study, DO values was higher in R1 (7.3 ± 1.1mg L^{-1}) than that of the canal (3.14±2.79 mg L^{-1}). Average (COD) value was higher in the reference station (297.6±398.24 mg L-1) when compared to that of the (13.51±10.31 mg L^{-1}). However COD value of the reference station exceeded the permissible limit according to EPA which is 250 mg L^{-1}. In Thevara canal, the average concentration of heavy metals in water followed the trend Cd<Mn<Cr<Fe<Ni<Pb<Cu<Zn. According to BIS the desirable limit of nickel of drinking water is 20ppb . In the present study nickel concentration exceeded the permissible limit for both in the canal and R1 (30.7±11.19 and 21.4±2122 ppb). Mercury was at below detectable level, both in canal and R3. Total Petroleum hydrocarbon was at non detectable level, both in canal and R1. GPP (1.47 g C m^{-3} day^{-1}) and NPP (1.29±0.78 g C m^{-3} day^{-1}) was high in canal compared to R1 (1.11±0.52 g C m^{-3} day^{-1}; 0.71±0.05 g C m^{-3} day^{-1}). However, chlorophyll a (32.86±28.46 mg/m3) and pheophytin (32783.86±26763 mg/m3) was high in R1 compared to canal. Abundance of phytoplankton (233.5±19 ind m^{-3}), microzooplankton (535±35 ind m^{-3}), mesozooplankton (7440±9050 ind m^{-3}) and macrobenthos (57±75ind m^{-3}) were comparatively high in canal compared to R1.

Table-3.36: Variation in the environmental and biological parameters at Thevara canal during September, 2020

Parameters	T1			T2				Base Station		
	S	B	Mean ±SD	S	B	Mean±SD	Grand Mean	S	B	Mean ±SD
Atmospheric Temperature (°C)	27		27	28		28	27.5 ± 0.70	27.8		27.8
WATER QUALITY										
Depth(m)	1		1	1.5		1.5	1.25±0.353	4		4
Flowrate (m/sec)	1.38		1.38	2.19		2.19	1.79±0.57	3.02		3.02
Temperature (°C)	27.37	27.1	27.23±0.19	28.01	27.5	27.755±0.36	27.495 ±0.37	28.38	26.45	27.4 ± 1.4
pH	7.26	7.26	7.26±0.007	7.25	7.25	7.25±0.007	7.25±0.01	6.88	7.1	6.99 ± 0.2
Transparency (m)	0.25		0.25	0.25		0.25	0.225±0.03	0.5		0.5
Eh (mV)	122.6	124.1	123.35±1.06	123.3	123.4	123.35±0.07	123.35±0.01	291.3	300	295.65 ± 6.2
Conductivity (µS/cm)	445	444	444.5±0.70	307	308	307.5±0.70	376±96.87	1827	1912	1869.5 ± 60.1
TDS (mg L^{-1})	222	222	222	154	154	154	188±48.08	9.13	9	9.065 ± 0.1
Turbidity (NTU)	3.5	9.7	6.6±4.38	2.1	1.5	1.8±0.42	4.2±3.39	1.5	9.7	5.6 ± 5.8
Salinity (psu)	0.21	0.2	0.205±0.001	0.14	0.14	0.14	0.17±0.05	0.92	0.88	0.9 ± 0.03
Alkalinity (mg L^{-1})	170	70	120±70.71	140	70	105±49.49	112.5±10.61	50	70	60 ± 14.1
Calcium (mg Ca L^{-1})	69.3	13.6	41.45±39.35	15.3	34.1	24.7±13.25	33.07±11.84	82.9	118.1	100.51±24.89
Chloride (mg L^{-1})	2.0	1.2	1.61±0.62	0.9	1.2	1.02±0.21	1.316±0.41	23.1	28.4	25.74±3.72
Magnesium (mg L^{-1})	108.0	129.5	118.73±15.22	80.3	66.1	73.19±10.01	95.96±32.19	171.9	201.7	186.78±21.1
Total Hardness (mg L^{-1})	124.8	132.8	128.8±5.66	84.0	74.4	79.2±6.79	104±35.07	192.0	230.4	211.2±27.15
Sodium (ppm)	2.5	3.6	3.014±0.79	1.9	1.4	1.65±0.31	2.334±0.96	15.3	13.0	14.15±1.65
Pottassium (ppm)	1.1	1.2	1.176±0.04	1.1	0.3	0.71±0.60	0.944±0.33	1.3	0.8	1.04±0.37
DO (mg L^{-1})	1.57	0.78	1.175±0.55	4.72	5.51	5.115±0.55	3.14±2.79	6.53	8.11	7.3 ± 1.1
BOD (mg L^{-1})	168.0	231.0	199.50±44.53	179.8	220.50	200.16±28.75	199.83±0.47	3.5	4.2	3.85 ± 0.49
COD (mg L-1)	9.6	2.8	6.22±4.78	3.2	38.4	20.8±24.89	13.51±10.31	16.0	579.2	297.6±398.24
Total Sulphide (ppm)	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0009	0.0005	0.0007±0.0001
Silicate-silicon (µg L^{-1})	0.028	0.027	0.027±0.0007	0.0270	0.0300	0.02±0.002	0.01±0.01	0.032	0.030	0.031±0.031
Phosphate-phosphorus (µg L^{-1})	5.6	4.5	5.03±0.79	6.7	4.5	5.59±1.59	5.30±0.40	3.7	3.5	3.56± 0.16
Nitrite-nitrogen (µg L^{-1})	0.02	0.02	0.02±0.002	0.02	0.02	0.02	0.01±0.00	0.023	0.019	0.021±0.003
Nitrate-nitrogen (µg L^{-1})	0.05	0.05	0.05	0.05	0.05	0.05	0.05±0.00	0.05	0.05	0.05
Ammonia-nitrogen (µg L^{-1})	0.024	0.025	0.02±0.001	0.025	0.028	0.03±0.002	0.02±0.00	0.027	0.025	0.026±0.001

Parameters	T1			T2				Base Station		
	S	B	Mean ±SD	S	B	Mean±SD	Grand Mean	S	B	Mean ±SD
Heavy metal										
Cadmium (ppb)	3.9	1.5	2.7±1.76	1.3	1.8	1.5±0.36	2.11±0.83	4.4	1.8	3.1±1.84
Copper(ppb)	39	50	44.2±7.75	26	74	49.9±33.48	47.0±4.04	32	74	52.9±7432
Chromium (ppb)	11	10	10.3±0.72	5	10	7.8±3.67	9.07±1.75	6	10	8.3±106
Iron (ppm)	9.48	16.16	12.8±4.72	28.50	8.35	18.4±14.25	15.6±3.96	9.19	8.35	8.8±8.359
Manganese (ppb)	5	6	5.8±0.62	8	4	6.2±2.89	6.00±0.34	8	4	5.9±48
Nickel (ppb)	36	41	38.6±3.08	25	21	22.8±2.93	30.7±11.19	22	21	21.4±2122
Zinc (ppb)	514	767	640.3±179.31	340	645	492.7±215.46	566.±104.38	853	645	748.9±64.58
Lead (ppb)	48	93	70.7±31.80	26	66	45.8±28.62	58.2±17.61	98	66	81.9±66.98
Mercury (ppb)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total PetroleumHydrocarbon (mg L-1)	NDL	NDL	NDL	NDL	NDL	NDL	NDL	NDL	NDL	NDL
SEDIMENT QUALITY										
Temperature (°C)	27.1		27.1	27.2		27.2	27.15±0.07	25.4		25.4
pH	5.88		5.88	6.29		6.29	6.085±0.28	6.73		6.73
Eh (mV)	-446		-446	-443		-443	-443	-1070		-1070
Availabe nitrogen %	0.11		0.11	2.21		2.21	1.16±1.48	1.15		1.15
Productivity parameters										
GPP (g C m^3 day $^{-1}$)	2.214	0.738	1.47±1.04	1.476	1.476	1.47±0	1.47	0.738	1.476	1.11±0.52
NPP (g C m^3 day $^{-1}$)	2.214	1.476	1.84±0.52	0.738	0.738	0.74±0	1.29±0.78	0.6642	0.738	0.71±0.05
Chlorophyll-*a* (mg/m^3)	1.94	0.44	1.19±1.06	2.55	46.99	24.77±31.42	12.98±16.67	52.99	12.73	32.86±28.46
Pheophytin (mg/m^3)	1992.35	815.952	1404±831.8	18034.78	2081.5	10058±11280	5731.16±6119	51708.82	13858.902	32783.86±26763
BIOLOGICAL PARAMETERS										
Phytoplankton										
Biomass (ml m^{-3})	0.01		0.01	0.01		0.01	0.01	0.002		0.002
Abundance (ind m^{-3})	2640		220±461	4200		247±568	233.5±19	960		160±181
Microzooplankton										
Biomass (ml m^{-3})	0.002		0.002	0.002		0.002	0.002	0.001		0.001
Abundance (ind m^{-3})	510		120±123	560		187±254	535±35	200		67±23.09
Mesozooplankton										
Biomass (ml m^{-3})	0.002		0.002	0.01		0.01	0.01	0.005		0.005
Abundance (ind. m^{-3})	1040		189±89	13840		430±143	7440±9050			5696±7013

Parameters	T1			T2				Base Station		
	S	B	Mean ±SD	S	B	Mean±SD	Grand Mean	S	B	Mean ±SD
Macrobenthos										
Abundance (ind. m^{-2})	110		28±44	4		2±2	57±75	12		6±3
*NDL –Non Detectable Level; BDL- Below Detectable Level;S- Surface; B- Bottom										

3.14.3. TEVARA- PERANDOOR CANAL AND REFERENCE STATION

Water and sediment quality of canal

Atmospheric temperature ranged from 26 °C in P3 to 30 °C in P1 with an average of 28.3±2.08°C (Table 4.37). Depth of the station ranged from 0.5m in P1 and P3 to 0.6 m in P2 with an average of 0. 53 ± 0.06 m; that for water flow rate ranged from 8.33 m sec^{-1} in P1 to 1.98 m sec^{-1} in P2 with an average of 3.85± 3.91 m sec^{-1}; that for temperature ranged from 26.88 °C in surface water of P3 to 31.19 °C in both surface and bottom water of P1 with an average of 31.18± 0.02 °C; for that pH ranged from 7.02 in surface water of P2 to 7.13 in bottom water of P1 with an average of 7.08± 0.04; that for transparency ranged from 0.3 m in P3 to 0.5 m in P2 with an average of 0.4± 0.1 m; that for Eh ranged from 1.5 mV in bottom water of P2 to 217.1 mV in bottom water of P3 with an average of 73.785± 123 mV; that for conductivity 314 μS cm-1 in bottom water of P2 to 606 μS cm-1 in bottom water of P3 with an average of 485.83± 152.2 μS cm-1; that for Total Dissolved Solids (TDS) ranged from 158 mg L^{-1} in surface water of P2 to 303 mg L^{-1} in surface water of P3 with an average of 243.16± 74.6 mg L^{-1}; that for turbidity ranged from 3.3 NTU in both surface and bottom water of P1 to 6.6 NTU in surface water of P3 with an average of 4.97± 1.45 NTU; that for salinity ranged from 0.15 psu in both surface and bottom of P2 to 0.29 psu in surface water of P3 with an average of 0.23± 0.07 psu; that for calcium ranged from 30.66 mg L^{-1} in both surface and bottom water of P2 to 85.17 mg L^{-1} in bottom water of P1 with an average of 42.58± 15.14 mg L^{-1}; that for chloride ranged from 531.75 mg L^{-1} in surface water of P2 to 2304.25 mg L^{-1} in bottom water of P3 with an average of 1417.88± 725.63 mg L^{-1}; that for magnesium ranged from 78.94 mg L^{-1} in surface water of P2 to 121.32 mg L^{-1} in surface water of P1 with an average of 104.84± 18.82 mg L^{-1}; that for alkalinity ranged from 170 mg L^{-1} in bottom water of P2 to 270 mg L^{-1} in surface water of P1 with an average of 233.3± 18.92 mg L^{-1}; that for total hardness ranged from 86.4 mg L^{-1} in surface water of P2 to 129.6 mg L^{-1} in surface water of P1 with an average of 115.2± 21.99 mg L^{-1}; that for potassium ranged from 0.68 ppm in surface water of P3 to 1.21 ppm in surface water of P2 with an average of 0.93± 0.21 ppm; sodium ranged from 1.52 ppm in bottom water of P3 to 3.91 ppm in bottom water of P1 with an average of 2.31± 0.51 ppm; that for Dissolved Oxygen (D.O) ranged from 0.78 mg L^{-1} in surface water of P1 to 3.14 mg L^{-1} in both surface and bottom water of P3 with an average of 2.23± 0.99 mg L^{-1}; that for Biological Oxygen Demand (BOD) ranged from 65.67 mg L^{-1} in surface water of P1 to 189.01 mg L^{-1} in bottom water of P3 with an average of 115.97± 31.17 mg L^{-1}; that for Chemical Oxygen Demand (COD) ranged from 1.5 mg L^{-1} in surface water of P1 to 26.5 mg L^{-1} in surface water of P2 with an average of 12.46± 6.77 mg L^{-1}; that for total sulphide ranged from 2.56 ppm in bottom water of P2 to 7.24 ppm in bottom water of P3 with an average of 5.11± 1.6 ppm; that for n- silicon ranged from 0.029 μg L^{-1}in bottom water of P3 to 0.035 μg L^{-1} in bottom water of P1 with an average of 0.031± 0.001 μg

L^{-1}; that for phosphate ranged from 12.46 µg L^{-1} in surface water of P2 to 25.81 µg L^{-1} in bottom water of P1 with average of 18.04± 5.6 µg L^{-1}; that for Nitrite- nitrogen ranged from 0.01 in surface water of P1 to 0.027 µg L^{-1} in surface water of P2 with an average of 0.02± 0.005 µg L^{-1}; that for Nitrate- nitrogen recorded 0.052 µg L^{-1} for all stations; that for ammonia- nitrogen ranged from 0.02 µg L^{-1} in both bottom and surface water of P1 and P2 to 0.04 µg L^{-1} in surface water of P3.

Heavy metal cadmium ranged from 0.8 in surface water of P2 to 2.9 in surface water of P3 with an average of 1.83±0.54; that for copper ranged from 29 in surface water of P1 to 73 in surface water of P3 with an average of 46±11.3; that for chromium ranged from 4 in surface water of P1 to 7 in surface water of P2 with an average of 5.5±0.86;that for iron ranged from 5.73 in bottom water of P1 to 12.15 in surface water of P3 with an average of 10.11±1.52;that for manganese ranged from 7 in bottom water of P2 to bottom water of P3 with an average of 8.5 ±1.32;that for nickel ranged from 12 in bottom water of P1 to bottom water of P2 with an average of 17±3.46;that for zinc ranged from 332 in bottom water of P2 to 1007 in surface water of P3 with an average of 617.33±90.33; that for lead ranged from 41 in bottom water of P2 to 76 in surface water of P3 with an averge of 64.16±9.77;that for mercury was recorded in below detectable level(BDL);that for total petroleum hydrocarbon was in non-detectable level(NDL).

Sediment temperature was ranged from 26 °C in P3 to 28. 5 °C in P1 with an average of 27.5 ± 1.32 °C; that for pH ranged from 6.37 in P2 to 6.96 in P3 with an average of 6.59± 0.32; that for Eh ranged from -1370 mV in P3 to -1352 mV in P1 with an average of -1348± 22.6 mV; that for available nitrogen ranged from 0.53% in P2 to 1.88 % in P1 with an average of 1.06± 0.71 %.

Productivity and biological parameters of canal

Gross primary production (GPP) was ranged from 0.738 g C m3 day^{-1} in surface water of P3 to 2.95 g C m3 day^{-1} in surface water of P1 with an average of 1.84± 0.36 g C m3 day^{-1}; that for NPP ranged from 0.738 g C m3 day^{-1} in both surface and bottom water of P1, bottom water of P2 to 1.476 g C m3 day^{-1} in surface water of P2 and P3 with an average of 1.107± 0.36 g C m3 day^{-1}; that for chlorophyll a ranged from 3.38 mg m^{-3} in bottom water of P2 to 107.04 mg m^{-3} in bottom water of P1 with an average of 45.14± 38.3 mg m^{-3}; that for pheophytin ranged from 6429.36 mg m^{-3} in surface water of P2 to 40900.66 mg m^{-3}in surface water of P1 with an average of 25371.59± 17173.6 mg m^{-3}.

Phytoplankton biomass was ranged from 0.001 mg m^{-3} in P3 to 0.015 mg m^{-3} in P2 with an average of 0.007± 0.007 mg m^{-3}; that for phythoplankton abundance ranged from 680 ind.m^{-3} in P3 to 8560 ind.m^{-3} in P1 with an average of 2967± 2274.76 ind.m^{-3}; that for microzooplankton biomass ranged from 0.003 mg m^{-3} in P3 to 0.005 mg m^{-3} in P1 with an average of 0.004±0.001 mg m^{-3}; that for microzooplankton abundance ranged from 3440 ind.m^{-3} in P1 to 12640 ind.m^{-3} in P3 with an average of 2778.88± 3069.81 ind.m^{-3}; that for mesozooplankton biomass ranged from 0.002 mg m^{-3} in P3 to 0.01 mg m^{-3} in P2 with an average of 0.005± 0.004 mg m^{-3}; that for abundance ranged from 280 ind.m^{-3} in P2 to 5160 ind.m^{-3} in both P1 and P3 with an average of 1308.66± 1262.1 ind.m^{-3}; that for macrobenthos ranged from 10 ind.m^{-3} in P3 to 116 ind.m^{-3} in P1 with an average of 63± 74.95 ind.m^{-3} and macrobenthos was not found in P2.

Water and sediment quality of South Chittoor R2

Atmospheric temperature in reference station South Chittoor (R2) was recorded 28.12 °C during the study period. Depth of the station was 3 m; that for water flow rate was 13.31 ms^{-1}; that for water temperature ranged from 27.32 °C in bottom water to 28.17 °C in surface water with an average of 27.74± 0.06 °C; that for pH was lowest recorded in bottom water (6.74) and highest (6.86) in surface with an average of 6.8± 0.08; that for transparency recorded was 0.5 m; that for Eh was lowest in surface water (259.1mV) and highest (261.5mV) in bottom water with an average of 260.3± 1.7 mV;that for conductivity highest was in bottom water(215 µS cm^{-1}) and lowest was in surface water (210 µS cm^{-1}) with an average of 212.5± 3.54 µS cm-1; that for TDS was highest in surface water (105 mg L^{-1}) and lowest was in bottom water(102 mg L^{-1}) with an average of 103.5± 2.12 mg L^{-1};that for turbidity lowest was in surface water (2.2 NTU) and highestin (2.4 NTU) in bottom water with an averge of 2.3± 0.14NTU; that for salinity highest was in bottom water(0.12psu) and lowest in surface water (0.1psu) with an average of 0.11± 0.01psu; that for calcium highest in bottom water (10.22mg L^{-1}) and lowest in surface water (6.81 mg L^{-1}) with an average of 8.51± 2.4 mg L^{-1}; that for chloride lowest was in bottom water (531.75 mg L^{-1})and highest in surface water (1063.5 mg L^{-1}) with an average of 797±376 mg L^{-1};that for magnesium highest was in surface water(42 mg L^{-1}) and lowest was in bottom water(22 mg L^{-1}) with an average of 32±14.16 mg L^{-1}; that for alkalinity highest was in bottom water (60 mg L^{-1}) and lowest in surface water (40 mg L^{-1}) with an average of 50±14.14 mg L^{-1};that for total hardness lowest was in bottom water (24 mg L^{-1}) and highest in surface water (43.2 mg L^{-1})with an averge of 33.6±13.57 mg L^{-1}; that for potassium lowest was in bottom water (0.33 ppm) and highest in surface water (1.11 ppm) with an average of 0.72±0.55 ppm; that for sodium was lowest in bottom water (1.23 ppm) and highest in surface water (1.83 ppm) with an average of 1.53±0.42 ppm; that for DO was highest in bottom water (6.3 mg L^{-1}) and lowest in surface water (5.98 mg L^{-1}) with an average of 6.14±0.22 mg L^{-1}; that for BOD was highest in bottom water (3.5 mg L^{-1}) and lowest in surface water (2.5 mg L^{-1}) with average of 3±0.71 mg L^{-1}; that for COD was lowest in bottom water (12.8 mg L^{-1}) and highest in surface water (342.4 mg L^{-1}) with an average of 177.6±233.06 mg L^{-1}; that for total sulphide highest value in bottom water (11.08 ppm) and lowest in surface water (6.82 ppm) with an average of 8.95±3.01 ppm; that for Silicate- silicon highest was in surface water (0.028 µg L^{-1}) and lowest in bottom water (0.027 µg L^{-1}) with an average of 0.027±0.0007 µg L^{-1}; that for phosphate lowest was in surface water (0.57 µg L^{-1}) and highest in bottom water (1.14 µg L^{-1}) with an average of 0.85±0.4 µg L^{-1}; that for Nitrite- nitrogen highest was in surface water (0.0186 µg L^{-1}) and lowest in bottom water (0.0183 µg L^{-1}) with an average of 0.0184±0.0002 µg L^{-1}; that for Nitrate- nitrogen was 0.052 µg L^{-1} for both surface and bottom water of the reference station; that for ammonia- nitrogen lowest was in bottom water (0.024 µg L^{-1}) and highest in surface water (0.025 µg L^{-1}) with an average of 0.024±0.0007 µg L^{-1}.

Heavy metal cadmium was ranged from 4.4 ppb in surface water to 4.7 ppb in bottom water with an average of 4.55±0.21 ppb ;that for copper highest value was recorded from bottom water (59 ppb) and lowest was in surface water (28 ppb) with an average of 43.5±21.92 ppb; that for chromium was highest in bottom water (6 ppb) and lowest was in surface water (8 ppb) with an average of 7±1.41 ppb; that for iron highest of 6.89 ppb recorded in bottom water and lowest in surface water(3.31 ppb) with an average of 5.1±2.53 ppb; that for manganese was highest in surface water (9 ppb) lowest was in bottom water (7 ppb) with an average of 8±1.41;that for nickel lowest water in bottom water(14 ppb) and highest in surface water(16 ppb) with an average of 15±1.41 ppb; that for zinc highest value of 1005 ppb recorded in bottom water and lowest was in surface water(778 ppb) with an average of 891.5±1060.51 ppb; that for lead lowest was in surface water 31 ppb and highest was in bottom water (37 ppb) with an average of 34±4.24 ppb; that for mercury was recorded in below detectable level(BDL);that for total petroleum hydrocarbon was in nondetectable level(NDL).

Sediment temperature recorded was 27.32 °C during the study period; that for pH was 5.82; that for Eh was -95mV whereas available nitrogen recorded was 0.48%.

GPP was recorded recorded 0.738 g C m3 day^{-1} in both surfacea and bottom water of the reference station where NPP was lowest in bottom (0.6642 g C m3 day^{-1}) and highest in surface water (0.738 g C m3 day-^{1}) with an average value of 0.701±0.05 g C m3 day^{-1}; that for chlorophyll a was highest in surface water (66.98 mg m^{-3}) and lowest in (18.96 mg m^{-3}) with an average of 42.94± 33.91 mg m^{-3}; that for pheophytin was highest in surface water (44140.97 mg m^{-3}) and lowest in bottom water (23375.31 mg m^{-3}) with an average of 33758.14±14683.54 mg m^{-3}.

Productivity and biological parameters of South Chittoor

Phytoplankton biomass was 0.003 mg m^{-3} whereas abundance was 6920 ind.m^{-3} with average of 768.88± 2037.03 ind.m^{-3}; that for microzooplankton biomass was 0.002 mg m^{-3} and abundance was 520 ind.m^{-3} with an average of 130±82.46 ind.m^{-3}; that for mesozooplankton biomass was 0.005 mg m^{-3} and abundance was 320 ind.m^{-3} with an average of 80±32.65 ind.m^{-3}; that for macrobenthos abundance was 12 ind.m^{-3} during the study period.

Summary

The quality and quantity of the canal directly supports to the biodiversity, but anthropogenic activities leading the gradual degradation of water quality. During the present study, P1 has high flow rate compared with other two stations, and the BOD value in all canal stations (115.97±31.17 mg L^{-1}) was beyond with the EPA standards (30 mg L^{-1}) but in reference station value within the limit (3 ± 0.71 mg L^{-1}). Low DO and high BOD value revealing the extremely polluted condition of the canal. COD value of the canal stations and reference stations within the EPA standards. Plankton diversity in P1 is slightly good when compared with other two stations. Plankton are non-motile or too small or weak to swim against the current, exist in drifting state, so if the water quality is degraded plankton communities will destroy faster, and the trophic structure endure more. Dumping of plastic wastes and other non-degradable things to the canal also increasing the pollution load and decreasing the flowrate and depth. Heavy metal Cadmiun in canal stations and reference station was within the limit of BIS (3ppb), WHO (3ppb) and EPA (5ppb) standards .Iron was considerably high in all canal stations (10.11± 1.52 ppm) and reference stations (5.1± 2.53 ppm) when compared with BIS (O.3ppm), EPA (O.3ppm), WHO (O.3ppm) standards. In the present study Zinc in canal (64.16± 9.77 ppb) exceeded the permissible limit of BIS (50 ppb) EPA (50 ppb) but within the WHO standards (100 ppb).

Table-3.37: Variation in the environmental and biological parameters at Thevara Perandoor canal during September, 2020

	PERANDOOR CANAL										R3(- SOUTH CHITTOOR)		
Parameters	**P1**			**P2**			**P3**						
	Surface	**Bottom**	**Mean ±SD**	**Surface**	**Bottom**	**Mean±SD**	**Surface**	**Bottom**	**Mean±SD**	**Grand Mean**	**Surface**	**Bottom**	**Mean ±SD**
Atmospheric Temperature (°C)	30			29			26			28.3 ± 2.08	28.12		
WATER QUALITY													
Depth (m)	0.5			0.6			0.5			0.53 ± 0.06	3		
Flowrate (ms-1)	8.33			1.98			1.22			3.85 ± 3.91	13.31		
Temperature (°C)	31.19	31.19	31.185 ± 0.01	28.03	28.02	28.025 ± 0.007	26.88	26.89	26.885 ± 0.007	28.69 ± 2.22	28.17	27.32	27.74 ± 0.60
pH	7.12	7.13	7.125 ± 0.01	7.02	7.05	7.035 ± 0.021	7.07	7.09	7.08 ± 0.014	7.08 ± 0.04	6.86	6.74	6.8 ± 0.08
Transparency (m)	0.4			0.5			0.3			0.40 ±0.1	0.5		
Eh (mV)	2.81	2.9	2.855 ± 0.06	1.9	1.5	1.7 ± 0.283	216.5	217.1	216.8 ± 0.424	73.785 ± 123.	259.1	261.5	260.3 ± 1.70
Conductivity (µS cm^{-1})	537	538	537.5 ± 0.71	315	314	314.5 ± 0.707	605	606	605.5 ± 0.707	485.83 ± 152.22	210	215	212.5 ± 3.54
TDS (mg L^{-1})	269	269	269	158	160	159 ± 1.41	303	300	301.5 ± 2.121	243.16 ± 74.6	105	102	103.5 ± 2.12
Turbidity (NTU)	3.3	3.3	3.3	5.5	6.4	5.95 ± 0.636	6.6	4.7	5.65 ± 1.34	4.97 ± 1.45	2.2	2.4	2.3 ± 0.14
Salinity (psu)	0.26	0.27	0.265 ± 0.01	0.15	0.15	0.15	0.29	0.29	0.29	0.235 ± 0.07	0.1	0.12	0.11 ± 0.01
Calcium (mg L-1)	34.06	85.17	59.61± 36.13	30.66	30.66	30.66	37.47	37.47	37.47	42.58 ± 15.14	6.8136	10.2204	8.51 ± 2.4
Chloride (mg L-1)	1418	1772.5	1595.25 ± 250.66	531.75	709	620 ± 125.33	1772.5	2304.25	2038.38 ± 376.004	1417.88 ± 725.63	1063.5	531.75	797.62 ± 376.004
Magnesium (mg L-1)	121.32	118.5	119.91 ± 1.99	78.94	88.54	83.74 ± 6.78	106.09	115.69	110.89 ± 6.78	104.84 ± 18.82	42	22	32 ± 14.16
Alkalinity (mg L^{-1})	270	240	255 ± 21.21	270	170	220 ± 7.71	240	210	225 ± 21.21	233.3 ± 18.92	40	60	50 ± 14.14
Total Hardness (mg L-1)	129.6	139.2	134.4 ± 6.7	86.4	96	91.2 ± 6.78	115.2	124.8	120 ± 6.78	115.2 ± 21.99	43.2	24	33.6 ± 13.57
Potassium (ppm)	1.09	0.75	0.92 ± 0.24	1.21	1.02	1.11 ± 0.13	0.68	0.69	0.68 ± 0.007	0.903 ± 0.21	1.11	0.33	0.72 ± 0.55
Sodium (ppm)	1.9	3.91	2.9 ± 1.42	1.87	2.4	2.13 ± 0.37	2.33	1.52	1.92 ± 0.57	2.31 ± 0.51	1.83	1.23	1.53 ± 0.42
DO (mg L^{-1})	0.78	1.57	1.18 ± 0.56	2.36	2.36	2.36	3.14	3.14	3.14	2.2304 ± 0.99	5.98	6.3	6.14 ± 0.22
BOD (mg L^{-1})	65.67	94.54	80.11±20.42	84.05	136	9	73.55	189.01	131.28±81.64	115.97±31.17	2.5	3.5	3 ± 0.71
COD (mg L^{-1})	1.5	19.2	10.35 ± 12.51	26.5	13.6	20.05 ± 9.12	6.3	7.7	7 ± 0.98	12.46 ± 6.77	342.4	12.8	177.6 ± 233.06

Parameters	PERANDOOR CANAL										R3(- SOUTH CHITTOOR)		
	P1			P2			P3						
	Surface	Bottom	Mean ±SD	Surface	Bottom	Mean±SD	Surface	Bottom	Mean±SD	Grand Mean	Surface	Bottom	Mean ±SD
Total Sulphide (ppm)	6.39	6.82	6.6 ± 0.3	4.26	2.56	3.41 ± 1.2	3.41	7.24	5.32 ± 2.7	5.11 ± 1.6	6.82	11.08	8.95 ± 3.01
Silicate- silicon (µg L^{-1})	0.033	0.035	0.034 ± 0.001	0.0301	0.0306	0.03 ± 0.0003	0.033	0.029	0.031 ± 0.002	0.031 ± 0.001	0.028	0.027	0.027 ± 0.0007
Phosphate -phosphorus (µg L^{-1})	23.39	25.81	24.6 ± 1.7	12.46	14.94	13.7 ± 1.7	16.97	16.85	16.91 ± 0.08	18.04 ± 5.6	0.57	1.14	0.85 ± 0.4
Nitrite- nitrogen (µg L^{-1})	0.01	0.02	0.015 ± 0.007	0.027	0.024	0.025 ± 0.002	0.022	0.021	0.021 ± 0.0007	0.02 ± 0.005	0.0186	0.0183	0.0184 ± 0.0002
Nitrate-nitrogen (µg L^{-1})	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052
Ammonia (µg L^{-1})	0.03	0.02	0.025 ± 0.007	0.02	0.03	0.025 ± 0.007	0.04	0.03	0.035 ± 0.007	0.02 ± 0.005	0.025	0.024	0.024 ± 0.0007
Heavy metal													
Cadmium (ppb)	1.50	1.3	1.4 ± 0.14	0.8	2.5	1.65 ± 1.2	2.9	2	2.45 ± 0.6	1.83 ± 0.54	4.4	4.7	4.55 ± 0.21
Copper (ppb)	29	69	49 ± 28.28	39	28	33.5 ± 7.7	73	38	55.5 ± 24.7	46 ± 11.3	28	59	43.5 ± 21.92
Chromium (ppb)	4	5	4.5 ± 0.7	7	5	6 ± 1.4	6	6	6	5.5 ± 0.86	8	6	7 ± 1.41
Iron (ppm)	12.13	5.73	8.93 ± 4.52	10.55	8.59	9.57 ± 1.3	12.15	11.5	11.83 ± 0.4	10.11 ± 1.52	3.31	6.89	5.1 ± 2.53
Manganese(ppb)	8	8	8	8	7	7.5 ± 0.7	8	12	10 ± 2.8	8.5 ± 1.32	9	7	8 ± 1.41
Nickel(ppb)	14	12	13 ± 1.41	18	20	19 ± 1.4	19	19	19	17 ± 3.46	16	14	15 ± 1.41
Zinc(ppb)	655	485	570 ± 120.2	789	332	560.5 ± 323.15	1007	436	721.5 ± 403.76	617.33 ± 90.33	778	1005	891.5 ± 160.51
Lead(ppb)	75	55	65 ± 14.14	67	41	54 ± 18.3	76	71	73.5 ± 3.5	64.16 ± 9.77	31	37	34 ± 4.24
Mercury(ppb)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total Petroleum Hydrocarbon (mg L^{-1})	NDL	NDL	NDL	NDL	NDL	NDL	NDL	NDL	NDL	NDL	NDL	NDL	NDL
Productivity parameters													
GPP(g C m3 day-1)	2.952	1.476	2.21 ± 1.04	2.214	1.476	1.84 ± 0.52	0.738	2.214	1.47 ± 1.04	1.84 ± 0.36	0.738	0.738	0.738
NPP (g C m3 day-1)	0.738	0.738	0.738	1.476	0.738	1.107 ± 0.52	1.476	1.476	1.476	1.107 ± 0.36	0.738	0.6642	0.701 ± 0.05
Chlorophyll-*a* (mg m-3)	55.75	107.04	81.39 ± 36.26	6.75	3.38	5.06 ± 2.38	50.14	47.8	48.97 ± 1.65	45.14 ± 38.3	66.92	18.96	42.94 ± 33.91
Pheophytin (mg m-3)	40900.7	33333.4	37117.01 ± 5350.89	6429.36	4894.11	5661.73 ± 1085.58	34467.56	32204.47	33336.02 ± 1600.24	25371.59 ± 17173.6	44140.97	23375.31	33758.14 ± 14683.54
SEDIMENT QUALITY													
Temperature (°C)	28.5			28			26			27.5 ± 1.32	27.32		

PERANDOOR CANAL											R3(- SOUTH CHITTOOR)		
Parameters	**P1**			**P2**			**P3**						
	Surface	**Bottom**	**Mean ±SD**	**Surface**	**Bottom**	**Mean±SD**	**Surface**	**Bottom**	**Mean±SD**	**Grand Mean**	**Surface**	**Bottom**	**Mean ±SD**
pH	6.45			6.37			6.96			6.59 ± 0.32	5.82		
Eh (mV)	-1351			-1325			-1370			-1348 ± 22.6	-95		
Availabe nitrogen (%)	188			0.53			0.78			1.06 ± 0.71	0.48		
BIOLOGICAL PARAMETERS													
Phytoplankton													
Biomass (mg m-3)	0.005			0.015			0.001			0.007 ± 0.007	0.003		
Abundance (ind.m-3)	8560		4280 ± 4638.62	2360		295 ± 360.91	680		340 ±424.26	2966.667 ± 2274.76	6920		768.88 ± 2037.03
Micro zooplankton													
Biomass (mg m-3)	0.005			0.004			0.003			0.004 ± 0.001	0.002		
Abundance (ind.m-3)	3440		1146.667 ± 1640.16	3480		870 ± 1660	12640		6320 ± 7693.32	2778.88 ± 3069.81	520		130 ± 82.46
Meso Zooplankton													
Biomass (mg m-3)	0.005			0.01			0.002			0.005 ± 0.004	0.005		
Abundance(ind.m-3)	5160		1290 ± 2473.4	280		56 ± 21.9	5160		2580 ± 2687.006	1308.66 ± 1262.1	320		80 ± 32.65
Macrobenthos													
Abundance(ind.m-3)	116			0			10			63 ± 74.95	12		
*NDL –Non Detectable Level													
BDL- Below Detectable Level													

3.14.4 EDAPPALLY CANAL AND REFERENCE STATION

Water and sediment quality of Canal

Atmospheric temperature ranged from 26.5ºC in E1 to 28.8ºC in E3 with an average of value of 27.77±1.18ºC. Depth of the station ranged from 0.7 m in E2 to 1.2m in E3 with an average of 0.93±0.25m for three stations. The water flow rate was lowest in E1 (1.38m sec^{-1}) and a maximum of 6.61 m sec^{-1} recorded in E3. Water temperature ranged from 25.3ºC in bottom water of E1 to 28.83ºC in surface water of E3 with an average of 27.18ºC; that for transparency was 0.5m in station E1 and E3 and 0.7m in E2 with an average of 0.57±0.12m; that for pH was ranged from 6.35 in surface and bottom water of E1 and E3 to 6.79 in E2 surface water with an average value of 6.49±0.19; that for Eh was ranged from 223.1 mV in E2 surface water to 324 mV in bottom water of E2; that for conductivity was ranged from 69 µScm^{-1} in E1 bottom water to 274 µScm^{-1} in bottom water of E2 with an average of 196.6±96.60 µScm^{-1} ; that for Total Dissolved Solids (TDS) was ranged from 35 mg L^{-1} in E1 surface water to 139 mg L^{-1} in bottom water of E2; that for turbidity was ranged from 1.7 NTU in E1 surface water to 6.2 NTU in bottom water of E1 with an average value of 3.03±1.67 NTU; that for salinity ranged from 0.02psu in bottom water of E1 to 0.15psu in bottom water of E2 with an average value of 0.09±0.05psu.

Alkalinity was ranged from 40 mg L^{-1} in E3 surface water to 200.2 mg L^{-1} in both surface water of E1 and E2 with an average value of 108.42±72.86 mg L^{-1}; that for calcium was ranged from 3.41 mg L^{-1} in surface and bottom water of E1 to 27.25 mg L^{-1} in surface water of E2; that for chloride was ranged from 177.3 mg L^{-1} in surface and bottom water of E1 to 513.8 mg L^{-1} in surface and bottom water of E3 and E2; that for magnesium was ranged from 30.37 mg L^{-1} in surface water of E1 to 119.01 mg L^{-1} in bottom water of E2; that for total hardness ranged from 31.2 mg L^{-1} in E1 surface water to 124.8 mg L^{-1} in bottom water of E2; that for potassium was ranged from 0.65 ppm in bottom water of E2 to 1.99 ppm in bottom water of E3; sodium was ranged from 0.41ppm in surface water of E3 to 2.47ppm in bottom water of E1; that for dissolved oxygen (D.O) was ranged from 2.36 mg L^{-1} in surface water of E1 and bottom water of E2 to 5.1 mg L^{-1} in bottom water of E1; Biological Oxygen demand (BOD) was ranged from 73.55 mg L^{-1} in surface water of E3 to 272.98 mg L^{-1} in bottom of E3; that for Chemical Oxygen Demand (COD) was ranged from 3.2 mg L^{-1} in bottom water of E2 to 64 mg L^{-1} in bottom water of E1; that for total sulphide was ranged from 0.426 ppm in bottom water of E1 to 15.33ppm in bottom water of E3. Silicate was ranged from 0.027µg L^{-1} in surface water of E2 to 0.032 µg L^{-1} in bottom water of E2 with an average of 0.029±0002 µg L^{-1}; phosphate was ranged from 0.18 L^{-1} in surface water of E1 to 92.18 L^{-1} in surface water of E3; nitrite was ranged from 0 in surface water of E1 to 0.03 in bottom water of E2; that for nitrate was ranged from 0.05 µg L^{-1} in bottom water of E1 to 0.053 µg L^{-1} in other stations; that for ammonia ranged from 0.003 in bottom water of E3 to 0.031 in bottom water of E2 with an average of 0.027±0.003 µg L^{-1}.

Heavy metal cadmium was ranged from 1.31ppb in bottom water of E1 to 11.58 ppb in surface water of E3; that for copper ranged from 34.32 ppb in surface water of E3 to 60.57 ppb in bottom water of E2; that for chromium was ranged from 2.36 ppb in bottom water of E2 to 6.77 ppb in bottom water of E3; that for iron ranged from 2.17ppm in surface water of E1 to 14.31 in bottom water of E2; that for manganese ranged from 9.41ppb in surface water of E1 to 85.45ppb in surface water of E3; that for nickel ranged from 19.83ppb in surface water of E1 to 69.99 in bottom water of E3; that for zinc ranged from 274.57ppb in surface water of E1 to 583.3 in bottom water of E2; that for lead ranged from 14.92ppb in surface water E1 to 159.9ppb in bottom water of E2; that for mercury was recorded in below detectable level (BDL); that for total petroleum hydrocarbon was in non-detectable level (NDL).

Sediment temperature was ranged from 26.1°C in E2 to 27.2°C in E1 with an average value of 26.6±0.56°C; that for pH ranged from 6.41 in E1 to 6.8 in E3 with an average of 6.57±0.2; that for Eh was ranged from -525 mV in E2 to -315 mV in E3 with an average of -388±118.7 mV; that for available nitrogen was ranged from 1.4 mV in E2 to 2.66 mV in E3 with an average of 2.07±0.63 mV.

Productivity and biological parameters

Gross Primary Production (GPP) was ranged from 0.74 gC m^{-3} day^{-1} in surface and bottom water of E2 to 5.17 gC m^{-3} day^{-1} in surface water of E1; that for Net Primary Production ranged from 0.44 gC m^{-3} day^{-1} in bottom water of E2 to 4.43 gC m^{-3} day^{-1} in surface water of E1; that for chlorophyll *a* ranged from 1.019 gC m^{-3} day^{-1} in surface water of E2 to 11.454 gC m^{-3} day^{-1} in bottom water of E1; that for pheophytin ranged from 1356 gC m^{-3} day^{-1} in bottom water of E2 to 5597.3 gC m^{-3} day^{-1} in bottom water of E1. Phytoplankton biomass was ranged from 0.003 ml m^{-3} in E1 to 0.005 ml m^{-3} in E3 with an average of 0.004±0.001 ml m^{-3}; that for phytoplankton abundance ranged from 40 ind m^{-3} in E2 to 1640 ind m^{-3} in E1 with an average of 60±23.09 ind m^{-3}; that for microzooplankton biomass ranged from 0.001 ml m^{-3} in E1 to 0.005 ml m^{-3} in E3; that for microzooplankton abundance ranged from 80 ind m^{-3} in E1 to 1480 ind m^{-3} in E2; that for mesozooplankton biomass ranged from 0.001 ml m^{-3} in E1 to 0.01 ml m^{-3} in E3 with an average of 0.005±0.004 ml m^{-3}; that for mesozooplankton abundance ranged from 240 ind m^{-3} in E1 and E3 to 2080 ind m^{-3} in E2 with an average of 60±23.09 ind m^{-3}; that for macrobenthos ranged from 4 ind m^{-3} in E1 to 88 ind m^{-3} in E2 with an average of 47.3±42.1 ind m^{-3}.

Water and sediment quality of Thuthiyoor (R3)

Atmospheric temperature in reference station Thuthiyoor (R3) was recorded 28°C during the study period. Depth of the station was 3.5 m; that for water flow rate was 6.11 ms^{-1}; that for water temperature ranged from 28.14 °C in bottom water to 29.1°C in surface water with an average of 28.64± 0.70°C; that for pH was lowest recorded in bottom water (6.35) and highest (6.47) in surface with an average of 6.41± 0.08; that for transparency recorded was 0.6 m; that for Eh was lowest in bottom water (1011mV) and highest (1018mV) in bottom water with an average of 1014.5±4.94 mV; that for conductivity highest was in bottom water(215 µS cm^{-1}) and lowest was in surface water (215 µS cm^{-1}) with an average of 222.5± 10.61 µS cm-1; that for TDS was highest in surface water (107 mg L^{-1}) and lowest was in bottom water(102 mg L^{-1}) with an average of 104.5± 3.54 mg L^{-1};that for turbidity lowest was in surface water (2.8 NTU) and highest in (10.1 NTU) in bottom water with an average of 6.45± 3.54 NTU; that for salinity highest was in bottom water (0.2psu) and lowest in surface water (0.1psu) with an average of 0.15± 0.07psu; that for calcium highest in surface water (21.58mg L^{-1}) and lowest in bottom water (10.22 mg L^{-1}) with an average of 15.89±8.03 mg L^{-1}; that for chloride lowest was in surface water (709mg L^{-1}) and highest in bottom water (1063.5 mg L^{-1}) with an average of 886.25±250.7 mg L^{-1};that for magnesium highest was in bottom water (59.92 mg L^{-1}) and lowest was in surface water (40.36 mg L^{-1}) with an average of 50.14±13.83 mg L^{-1}; that for alkalinity highest was in bottom water (80 mg L^{-1}) and lowest in surface water (60 mg L^{-1}) with an average of 70±14.14 mg L^{-1};that for total hardness lowest was in surface water (45.6 mg L^{-1}) and highest in bottom water (62.4 mg L^{-1}) with an average of 54±11.9 mg L^{-1}; that for potassium lowest was in surface water (1.17 ppm) and highest in bottom water (1.76 ppm) with an average of 0.79±0.53 ppm; that for sodium was lowest in surface water (0.41 ppm) and highest in bottom water (0.66 ppm) with an average of 1.21±0.77 ppm; that for DO was highest in bottom water (5.51 mg L^{-1}) and lowest in surface water (3.38 mg L^{-1}) with an average of 4.45±1.50 mg L^{-1}; that for BOD was highest in bottom water (5.51 mg L^{-1}) and lowest in surface water (3.8 mg L^{-1}) with average of 4.45±1.50 mg L^{-1}; that for COD was lowest in bottom water (6.4 mg L^{-1}) and highest in surface water (12.8 mg L^{-1}) with an average of 9.6±4.5 mg L^{-1}; that for total sulphide highest value in surface water (8.95 ppm) and lowest in bottom water (5.11ppm) with an average of 7.03±2.7 ppm; that for Silicate- silicon highest was in surface water (0.032 µg L^{-1}) and lowest in bottom water (0.03 µg L^{-1}) with an average of 0.031±0.001 µg L^{-1}; that for phosphate lowest was in surface water (45.75 µg L^{-1}) and highest in bottom water (54.54 µg L^{-1}) with an average of 50.15±6.22µg L^{-1}; that for nitrite- nitrogen highest was in surface water (0.023 µg L^{-1}) and lowest in bottom water (0.02 µg L^{-1}) with an average of 0.021±0.002 µg L^{-1}; that for nitrate- nitrogen was 0.052 µg L^{-1} for both surface and bottom water of the reference station;

that for ammonia- nitrogen lowest was in surface water (0.025 µg L^{-1}) and highest in bottom water (0.026 µg L^{-1}) with an average of 0.025±0.0005 µg L^{-1}.

Heavy metal cadmium was ranged from 4.38 ppb in surface water to 6.7 ppb in bottom water with an average of 5.55±1.6 ppb; that for copper highest value was recorded from bottom water (70.8 ppb) and lowest was in surface water (35.3 ppb) with an average of 53±25.1 ppb; that for chromium was 7.3 for both surface and bottom water; that for iron highest of 11.3 ppb recorded in bottom water and lowest in surface water(5.9 ppb) with an average of 8.58±3.8 ppb; that for manganese was highest in surface water (15.1ppb) and lowest was in bottom water (8.2 ppb) with an average of 12±4.9;that for nickel lowest water in surface water(24.8 ppb) and highest in bottom water(39.5 ppb) with an average of 32±10.3 ppb; that for zinc highest value of 804.8 ppb recorded in bottom water and lowest was in surface water (766.5 ppb) with an average of 786±27.1 ppb; that for lead lowest was in surface water 40.9 ppb and highest was in bottom water (75.2 ppb) with an average of 58±27.1 ppb; that for mercury was recorded in below detectable level (BDL);that for total petroleum hydrocarbon was in nondetectable level (NDL). Sediment temperature recorded was 29 °C during the study period; that for pH was 6.27; that for Eh was -1018 mV whereas available nitrogen recorded was 0.98%.

Productivity and biological parameters of Thuthiyoor (R3)

GPP was recorded 0.74 g C m3 day^{-1} in surface water and 1.48 g C m3 day^{-1} in bottom water of the reference station where NPP was recorded 0.74 g C m3 day^{-1} in both surface and bottom water; that for chlorophyll *a* was highest in bottom water (71.44 mg m^{-3}) and lowest in surface water (52.9 mg m^{-3}) with an average of 62.2± 13.1 mg m^{-3}; that for pheophytin was lowest in surface water (33280.4 mg m^{-3}) and highest in bottom water (34870.2 mg m^{-3}) with an average of 34075±1124.1 mg m^{-3}. Phytoplankton biomass was 0.005 mg m^{-3} whereas abundance was 1960 $ind.m^{-3}$ with average of 115.3±111.2 $ind.m^{-3}$; that for microzooplankton biomass was 0.002 mg m^{-3} and abundance was 1120 $ind.m^{-3}$ with an average of 186.7±130.6 $ind.m^{-3}$; that for mesozooplankton biomass was 0.101 mg m^{-3} and abundance was 1360 $ind.m^{-3}$ with an average of 194±254 $ind.m^{-3}$; that for macrobenthos abundance was 102 $ind.m^{-3}$ during the study period.

Summary

In the present study observation of water quality status of the Edappally canal revealed that the depth was maximum in E3 (1.2m) and minimum in E2 (0.7m). When compared with its reference station (Thuthiyoor-R3) it was observed that the depth (3.5m) was comparatively high in the reference station than canal whereas transparency was recorded high in E2 (0.7m). Water flow rate was recorded maximum in E3 (6.61 m sec^{-1}) compared to its reference station (6.11 m sec^{-1}). pH is considered as an important ecological factor whose variation in any aquatic system affects the inhabitants as they are adapted to an optimum pH and cannot endure abrupt changes. The data was compared with the water quality standards of BIS, CPCB, ICMR, WHO, EPA. Compared to reference station (70±14.14 mg L^{-1}) high alkalinity was recorded in E1 (125.12±106.1 mg L^{-1}) and E2 (140.1±84.94 mg L^{-1}) which was within the limit of water quality standards of BIS and WHO. Permissible limit of DO and BOD was 5 mg L^{-1} according to WHO, BIS and ICMR. In this study, DO values was higher in R3 (4.45±1.50 mg L^{-1}) that of the canal (3.02±0.81 mg L^{-1}). BOD values were considerably high in the canal (218.74±34.94 mg L^{-1}) than that of the reference station (4 ±0.71 mg L^{-1}). According to EPA permissible limit of COD is 250 mg L^{-1}. The range of COD values were high in the canal (23.47±21.5 mg L^{-1}) when compared to R3 (9.6±4.5 mg L^{-1}) which was within the limit of EPA standards. In Edappally canal, the average concentration of heavy metals in water followed the trend Cr<Cd<Fe<Mn<Cu<Pb<Mn<Zn. Zinc was considerably high in the reference station (786±27.1ppb) compared to the canal (489±81.62ppb) however, according to BIS (5000ppb), the range of zinc was within the limit during the study period. Whereas manganese (24.33±24.59ppb) and nickel (357.51±295.5ppb) recorded higher concentration in canals compared to R3 (12±4.9ppb; 32±10.3ppb). According to BIS the desirable limit of nickel of drinking water is 20ppb, and 100ppb from EPA, but in the present study nickel exceeded the permissible limit. Mercury was at below detectable level, both in canal and R3. Total Petroleum hydrocarbon was at non detectable level, both in canal and R3. GPP (2.21±1.69 mgc L^{-1} day) and NPP (1.77) was high in canal compared to R3 (1.77±1.43 mgc L^{-1} day; 0.74 mgc L^{-1} day), The increasing organic load from houseboat and eutrophication might be the reason for lower GPP and NPP values in R3. However, chlorophyll *a* (62.2±13.1 gC m^{-3} day^{-1}) and pheophytin (34075±1124.1 gC m^{-3} day^{-1}) was high in R3 compared to canal. Abundance of phytoplankton (1960 ind m^{-3}), microzooplankton (1120 ind m^{-3}), mesozooplankton (1360 ind m^{-3}) and macrobenthos (120 ind m-3) were recorded high in reference station compared to canal during the study period.

Table-3.38: Variation in the environmental and biological parameters at Edapally canal during September, 2020

EDAPPALLY CANAL										
Parameters	**E1**			**E2**			**E3**			
	S	**B**	**Mean ±SD**	**S**	**B**	**Mean±SD**	**S**	**B**	**Mean±SD**	**Grand Mean**
Atmospheric Temperature (°C)	26.5		26.5	28		28	28.8		28.8	27.77±1.18
WATER QUALITY										
Depth (m)	0.9		0.9	0.7		0.7	1.2			0.93±0.25
Flowrate (m sec^{-1})	1.38		1.38	2.59		2.59	6.61		6.61	3.53±0.85
Temperature (°C)	26.45	25.29	25.87±0.82	27.62	26.12	26.87±1.06	28.83	28.75	28.79±0.06	27.18±1.46
pH	6.35	6.41	6.38±0. 04	6.79	6.66	6.725 ±0.09	6.38	6.35	6.365 ±0.02	6.49±0.19
Transparency (m)	0.5		0.5	0.7		0.7	0.5			0.57±0.12
Eh (mV)	320. 1	324	322.05 ±2.76	223.1	223.2	223.15 ±0.07	300	311	305.5±7.78	283.56±47.53
Conductivity (µS cm^{-1})	71	69	70±1.4 1	273	274	273.5 ±0.71	234	235	234.5 ±0.71	192.6±96.60
TDS (mg L^{-1})	35	36	35.5±0. 71	137	139	138 ±1.41	117	120	118.5 ±2.12	97.3±48.7
Turbidity (NTU)	1.9	2.1	2±0.14	1.7	6.2	3.95 ±3.18	3.2	3.1	3.15 ±0.07	3.03±1.67
Salinity (psu)	0.03	0.02	0.025± 0.01	0.13	0.15	0.14 ±0.01	0.1	0.11	0.105 ±0.01	0.09±0.05
Alkalinity (mg L^{-1})	200. 2	50.05	125.12 5±106.17	200.2	80.08	140.14 ±84.94	40	80	60 ±28.28	108.42±72.86
Calcium (mg L^{-1})	3.41	3.41	3.14	27.25	23.85	25.55±2.41	17.03	13.63	15.33±2.41	14.76±10.03
Chloride (mg L^{-1})	177.3	177.3	177.3	354.5	531.8	443.13±125.3	531.8	531.8	531.8	384.04±174.3
Magnesium (mg L^{-1})	30.3721	32.7721	31.57±1.70	96.58	119.01	107.79±15.86	48.66	92.69	70.7±31.1	70.1±37.51
Total Hardness (mg L^{-1})	31.2	33.6	32.4±1.70	103.2	124.8	114±15.27	52.8	96	74.4±30.5	73.6±39.6
Potassium (ppm)	1.02	1.14	1.08±0.08	0.92	0.65	0.79±0.19	0.68	1.99	1.38±1	1.08±0.53
Sodium (ppm)	1.38	2.47	1.92 ±0.77	1.89	2.00	1.95±0.08	2.09	3.29	2.64±0.92	2.17±0.65
DO (mg L^{-1})	2.36	5.51	3.935± 2.23	2.4	2.36	2.38 ±0.03	2.4	3.1	2.71 ±0.49	3.02±0.81
BOD (mg L^{-1})	262.48	220.5	241.49 ±29.69	346.45	126.03	236.24 ±155.86	73.55	272.98	178.51 ±141	218.74±34.94
COD (mg L^{-1})	16	64	40± 33.9	12.8	3.2	8±6.79	16	28.8	22.4±9.05	23.47±21.5
Total Sulphide (ppm)	1.704	0.426	1.07±0.90	6.816	5.964	6.39 ±0.61	0.852	15.336	8.10 ±10.25	5.18±5.66
Silicate-silicon (µg L^{-1})	0.029	0.03	0.030±0.001	0.029	0.032	0.031±0.002	0.027	0.028	0.028±0.001	0.029±0.002
Phosphate-phosphorus (µg L^{-1})	0.18	0.3	0.24±0.08	3.39	4.63	4.01±0.88	92.18	66.66	79.42±18.05	27.9±40.8
Nitrite-nitrogen (µg L^{-1})	0.019	0.019	0	0.019	0.03	0.024±0.008	0.025	0.021	0.026±0.003	0.005
Nitrate-nitrogen (µg L^{-1})	0.053	0.052	0.052±0.001	0.053	0.053	0.053	0.053	0.053	0.053	0.052±0.000

EDAPPALLY CANAL										
Parameters	**E1**			**E2**			**E3**			
	S	**B**	**Mean ±SD**	**S**	**B**	**Mean±SD**	**S**	**B**	**Mean±SD**	**Grand Mean**
										1
Ammonia-nitrogen (µg L^{-1})	0.024	0.025	0.025±0.001	0.029	0.031	0.030±0.001	0.027	0.003	0.015±0.017	0.027±0.003
Heavy metal										
Cadmium (ppb)	8.46	1.31	4.88±5.06	3.77	2.13	2.95±1.16	11.58	7.84	9.71±2.64	5.67±3.18
Copper (ppb)	34.45	37.65	36.05±2.26	39.82	60.57	50.2±14.68	34.32	39.64	36.98±3.76	36.98±41.08
Chromium (ppb)	4.16	5.95	5.05±1.27	6.58	2.36	4.47±2.98	4.74	6.77	5.76±1.43	5.09±0.65
Iron (ppm)	2.17	5.89	4.03±2.63	7.01	14.31	10.66±5.16	8.7	10.7	9.70±1.41	8.13±3.58
Manganese (ppb)	9.41	10.65	10.03±0.87	9.79	10.7	10.23±0.63	85.45	19.98	52.72±46.30	24.33±24.59
Nickel (ppb)	19.83	23.52	21.68±2.61	38.99	23.8	31.38±10.76	26.28	69.99	48.13±30.91	357.51±295.5
Zinc (ppb)	274.57	559.36	416.96±201.38	572.31	583.3	577.78±7.74	448.77	497.39	473.08±34.38	489±81.62
Lead (ppb)	14.92	21.34	18.13±4.53	45.6	159.9	102.75±80.82	17.68	32.85	25.27±10.73	48.72±46.9
Mercury (ppb)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total Petroleum Hydrocarbon (mg L^{-1})	NDL	NDL	NDL	NDL	NDL	NDL	NDL	NDL	NDL	NDL
SEDIMENT QUALITY										
Temperature (°C)	27.2			26.1		26.1	26.5		26.5	26.6±0.56
pH	6.41			6.5		6.5	6.8		6.8	6.57±0.2
Eh (mV)	-324			-525		-525	-315		-315	- 388±118.7
Availabe nitrogen (%)	2.16		2.16	1.4		1.4	2.66		2.66	2.07±0.63
PRODUCTIVITY PARAMETERS										
GPP (gC m^{-3} day^{-1})	5.17	2.95	4.06±1.57	0.74	0.74	0.74	1.48	2.21	1.85±0.52	2.21±1.69
NPP (gC m^{-3} day^{-1})	4.43	2.21	3.32±1.57	0.59	0.44	0.52±0.10	1.48	1.48	1.48	1.77±1.43
Chlorophyll-*a* (mg m^{-3})	1.192	11.454	6.32±7.3	1.019	2.23	1.62±0.86	1.77	2.64	2.2±0.62	3.38±2.56
Pheophytin (mg m^{-3})	1812.3	5597.3	3704.8±2676.3	1359.03	1356	1357.5±2.14	3082.2	1718.4	2400.33±964.3	2487.5±1176.1
BIOLOGICAL PARAMETERS										
Phytoplankton										
Biomass (ml m^{-3})	0.003			0.004		0.004	0.005		0.005	0.004±0.001
Abundance (ind m^{-3})	1640		137±137.9	40		40	240		240	60±23.09
Micro zooplankton										
Biomass (ml m^{-3})	0.001			0.004		0.004	0.005		0.005	0.005±0.003
Abundance (ind m^{-3})	80		40	1480		370±633.6	680		680	136±140.3

EDAPPALLY CANAL										
Parameters	**E1**			**E2**			**E3**			
	S	**B**	**Mean ±SD**	**S**	**B**	**Mean±SD**	**S**	**B**	**Mean±SD**	**Grand Mean**
Meso Zooplankton										
Biomass (ml m^{-3})	0.001			0.005		0.005	0.01		0.01	0.005±0.004
Abundance (ind m^{-3})	240		120±56.75	2080		297±493	240		240	60±23.09
Macrobenthos										
Abundance (ind m^{-2})	4			88		88	50	50	50	47.3±42.1
*NDL –Non Detectable Level; BDL- Below Detectable Level;S- Surface; B- Bottom										

3.14.5 CHILAVANNOOR CANAL AND REFERENCE STATION

Water and sediment quality of canal

During the present study, three stations of Chilavannoor canal were selected. They are represented as C1 (Karanakodam thodu), C2 (Kaloor stadium) and C3 (Meenchira). The variations in environmental parameters recorded in Chilavannoor canal during September 2020 were detailed below. The atmospheric temperature ranged from 25.5 °C (C1) to 29.5 °C (C2) with an average of 28 ± 2.17 °C. The water quality parameters obtained as depth ranged from 0.5 m (C1 & C2) to 0.75 m (C3) with an average of 0.58 ± 0.14 m. The flow rate was lowest value of 0.13 m s^{-1} in C1 to maximum of 2.44 m s^{-1} in C2 with an average of 0.99 ± 1.3 m s^{-1}. The temperature ranged from 25.12 °C in bottom water of C1 to 28.53 °C in surface water of C3 with an average of 27.09 ± 1.04 °C; that for pH values ranged from 6.01 of bottom water of C3 to 6.98 of bottom water of C2 with an average of 27.09 ± 1.04 ;that for transparency ranged from 0.4 m in C1 to 0.75 m in C3, with an average of 0.5 ± 0.18 m; that for average oxidation reduction potential (Eh) was -8.61 ± 0.57 mV and ranged from -46.4 mV in surface water of C1 to 15 mV in bottom water of C2; that for electrical conductivity of the canal with lowest value of 329 µS cm^{-1} in bottom water of C2 and highest value of 382 µS cm^{-1} in bottom water of C3 ,with an average value of 378 ± 5.65 µS cm^{-1} ; that for total dissolved solids (TDS) values ranged from 166 mg L^{-1} in surface water of C2 to 187 mg L^{-1} surface water of C3 with an average value of 185 ± 2.82 mg L^{-1} ; that for the mean turbidity obtained was 3.88 ± 0.72 NTU with minimum value of 2 NTU from the surface water of C2 and the maximum value of 6.5 NTU from the bottom water of C2; that for salinity ranged from 0.16 psu in surface water of C2 to 0.32 psu in bottom water of C1 with an average of 0.22 ± 0.06 psu; that for the mean alkalinity value was 206.83 ± 59.25 mg L^{-1} while the minimum alkalinity value of 137 mg L^{-1} was in the surface water of C3 and highest value of 270 mg L^{-1} was in the surface water of C1; that for calcium ranged from 13.6 mg L^{-1} in the bottom water of C1 to 97.7 mg L^{-1} in the bottom water of C3 with an average of 46.7 ± 33.7 mg L^{-1}; that for chloride ranged from 354.5 mg L^{-1} in the surface water of C2 and C3 to 1063.5 mg L^{-1} in the surface water of C1 with an average of 620.4 ± 291.3 mg L^{-1} ; that for magnesium ranged from 61 mg L^{-1} in the bottom water of C1 to 120 mg L^{-1} in the bottom waters of C2 with an average of 93 ± 24.4 mg L^{-1}; that for average hardness was 104.7 ± 29.6 mg L^{-1} and ranged from 63.84 mg L^{-1} in the bottom water of C1 to 134.4 mg L^{-1} in the bottom water of C3; that for potassium ranged from 0.57 ppm in the surface water of C3 to 1.24 ppm in the bottom water of C3, with an average of 0.92 ± 0.26 ppm ; that for mean value of sodium was 1.7 ± 0.4 ppm and ranged from 1.09 ppm in the bottom water of C3 to 2.13 ppm in the surface water of C2; that for dissolved oxygen (DO) ranged from 0.78 mg L^{-1} in the surface water of C3 to 4.72 mg L^{-1} in the surface water of C2, with an average of 2.75 ± 1.36 mg L^{-1}; that for mean BOD value of 194.25 ± 22.87 mg L^{-1}

and ranged from 168.02 mg L^{-1} in the bottom water of C2 to 220.5 mg L^{-1} in both surface and bottom water of C1; that for COD ranged from 3.2 mg L^{-1} in the surface water of C1 to 16 mg L^{-1} the bottom water of C1 with an average of 10.13 ± 4.71 mg L^{-1}; that for total sulphide ranged from 0.43 ppm in the surface water of C3 to 6.82 ppm in the bottom water of C2 with an average of 2.70 ± 2.51 ppm; that for silicate-silicon ranged from 0.028 µg L-1 in the bottom water of C1 and C3 to 0.041 µg L^{-1} in the bottom water of C2 with an average of 0.033 ± 0.005 µg L^{-1}; that for phosphate-phosphorus ranged from 1.70 µg L^{-1} in the bottom water of C1 and surface water of C2 to 5.87 µg L^{-1} with an average of 3.99 ± 2.24 µg L^{-1}; that for mean nitrite- nitrogen was 0.025 ± 0.007 µg L^{-1} and ranged from 0.018 µg L-1 in the bottom of C1 to 0.036 µg L^{-1} in the bottom water of C2; that for nitrate-nitrogen ranged from 0.052 µg L^{-1} in the surface and bottom water of C1 and 0.053 µg L^{-1} in the surface and bottom water of C2 and C3with an average of 0.053 µg L^{-1} ; that for ammonia- nitrogen ranged from 0.025 µg L^{-1} in the bottom water of C1 to 0.034 µg L^{-1} in the surface water of C1 and in the bottom water of C3.

The heavy metal cadmium content ranged from 0.5 ppb in the surface water of C3 to 1.2 ppb in the C1 with an average of 0.72 ± 0.26 ppb; that for copper ranged from 19 ppb in the surface water of C1 to 216 ppb in the surface water of C3 with an average of 65.7 ± 75.52 ppb; that for chromium ranged from 5 ppb in the surface water of C2 and C3 to 70 ppb in the surface water of C1 with an average of 16.8 ± 26.1 ppb; that for iron ranged from 11.4 ppm in the bottom water of C3 to 22.75 ppm in the surface water of C1 with an average of 16.8 ± 4.1 ppm; that for manganese ranged from 5 ppb in both surface and bottom water of C1 to 14 ppb in the bottom water of C3 with an average of 9 ± 4.5 ppm ; that for nickel ranged from 8 ppb in the surface water of C3 to 34 ppb in the surface water of C3 with an average of 22 ± 10.7 ppb; that for zinc ranged from 247.2 ppb in the surface water of C2 to 791 ppb in the surface water of C3 with an average of 481 ± 196.3ppb; that for lead ranged from 12 ppb in the surface water of C2 to 36 ppb in the surface water of C3 with an average of 20.9 ± 9.6 ppb; that for mercury was in below detectable level (BDL) and that for total petroleum hydrocarbon was Non detectable level (NDL).

The sediment temperature ranged from 27.2 °C in C1 to 29.8 °C in the C2 with an average of 28.66 ± 1.33 °C ; that for pH ranged from 5.95 in C1 to 6.13 in C3 with an average of 6.023 ± 0.09; that for oxidation reduction potential (Eh) ranged from -208 mV in C2 to -217 mV with an average of 213 ± 4.93 mV; that for available nitrogen ranged from 0.56 % in C2 to 2.32 % in C3 with an average of 1.61 ± 0.9%.

Productivity and biological parameters of canal

In the present study, the productivity parameters were as given below. The gross primary product (GPP) ranged from 0.738 g C m^{-3} day^{-1} in the bottom water of C3 to 2.214 g C m^{-3} day^{-1} in the surface water of C1 with an average of 1.3 ± 0.5 g C m^{-3} day^{-1}; that for net primary productivity (NPP) ranged from 0.738 g C m^{-3} day^{-1} in the surface water of C2 and bottom water of C3 to 2.952 g C m^{-3} day^{-1} in the surface water of C1 with an average of 1.54 ± 0.98 g C m^{-3} day^{-1}; that for chlorophyll a ranged from 1.0214 mg m^{-3} in the bottom water of C2 to 14.27 mg m^{-3} in the bottom water of C3 with an average of 3.81 ± 5.16 mg m^{-3}; that for pheophytin ranged from 358.8 mg m^{-3} in the bottom water of C1 to 27105.3 mg m^{-3} in the bottom water of C3 with an average of 5709.17 ± 10521.12 mg m^{-3}.

The phytoplankton biomass ranged from 0.001 ml m^{-3} in C3 to 0.01 ml m^{-3} in C1 with an average of 0.006 ± 0.005 ml m^{-3}; that for abundance ranged from 80 ind.m^{-3} in C3 to 560 ind.m^{-3} in C2 with an average of 320 ± 240 ind.m^{-3}; that for microzooplankton biomass ranged from 0.002 ml m^{-3} in C1 to 0.008 ml m^{-3} in C2 with an average of 0.005 ± 0.003 ml m^{-3}; that for abundance ranged from 720 ind.m^{-3} in C2 to 2760 ind.m^{-3} in C3 with an average of 1650 ± 1034.6 ind.m^{-3} ; that for Mesozooplankton biomass ranged from 0.005 ml m^{-3} in C1 and C2 to 0.01 ml m^{-3} in C3 with an average of 0.007 ± 0.003 ml m^{-3}; that for abundance ranged from 1280 ind.m^{-3} in C3 to 8920 ind.m^{-3} in C1 with an average of 3973 ± 4289.6 ind.m-3; that of Macrobenthos abundance ranged from 0 ind.m-3 in C1 to 76 ind. m^{-3} in C2 with an average of 27.3 ± 42.2 ind. m^{-3}.

Water and sediment quality of Maradu (R4)

The reference station for Chilavannoor canal was Maradu. During the study period, the atmospheric temperature recorded was 28 °C. The Depth recorded was 0.8 m; that for flowrate was 5.09 m s-1; that for water temperature ranged from 28.12 °C in bottom water to 29.06 °C with an average of 28.59 ± 0.66 °C; that for pH was lowest in bottom water (6.68) and highest was in the surface water (6.74 °C) with an average of 6.71 ± 0.04; that for transparency was 0.4 m; that for oxidation reduction potential (Eh) ranged from 435 mV in the surface water to 454 mV in the bottom water with an average of 444.5 ± 13.43 mV; that for electrical conductivity was highest in surface water (448 µS cm^{-1}) and lowest in bottom water (447 µS cm^{-1}) with an average of 447.5 ± 0.71 µS cm^{-1}; that for TDS highest value 232 mg L^{-1} in bottom water and lowest value 224 mg L^{-1} in surface water with an average of 228 ± 5.65 mg L^{-1}; that of turbidity ranged from 4.8 NTU in surface water to 5.1 NTU in bottom water with an average of 4.95 ± 0.21 NTU; that for salinity was highest in bottom water (0.3 psu) and lowest in surface water (0.21 psu) with an average of 0.255 ± 0.06 psu; that for alkalinity ranged from 70 mg L^{-1} in bottom water to 80 mg L^{-1} with an average of 75 ± 7.07 mg L^{-1}; that for calcium was highest in surface water (57.9 mg L^{-1}) and lowest in bottom water (47.7 mg L^{-1}) with an average of 52.8 ± 7.23 mg L^{-1}; that of chloride highest of 2658.75 mg L^{-1} recorded in bottom water and lowest of 2304.25 mg L^{-1} in surface water with an average of 2481.5 ± 250.7 mg L^{-1}; that for magnesium was recorded highest in surface water (65 mg L^{-1}) and lowest in bottom water (5 mg L^{-1}) with an average of 35 ± 42.4 mg L^{-1}; that of Hardness was minimum in surface water (19.2 mg L^{-1}) and maximum in bottom water (76.8 mg L^{-1}) with an average of 48 ± 40.7 mg L^{-1}; that for potassium highest of 0.38 ppm in surface water and lowest of 0.37 ppm in bottom water with an average of 0.37 ± 0.01 ppm ; that for sodium was lowest in bottom water (1.67 ppm) and highest in surface water (3.63 ppm)with an average of 2.65 ± 1.4 ppm; that for DO value ranged from 3.62 mg L^{-1} in bottom water to 4.96 mg L^{-1} in the surface water, with an average of 4.29 ± 0.94 mg L^{-1} ; that for BOD values was highest in the bottom water (6.2 mg L^{-1}) and lowest in surface water (4.8 mg L^{-1}) with an average of 5.5 ± 0.99 mg L^{-1}; that for COD ranged from 6.4 mg L^{-1} in bottom water to 12.8 mg L^{-1} in the surface water with an average of 9.6 ± 4.53 mg L^{-1}; that for total sulphide was 4.26 ppm in both surface and bottom water; that for silicate-silicon was highest in surface water (0.031 µg L^{-1}) and lowest in bottom water (0.029 µg L^{-1}) with an average of 0.030 ± 0.0015 µg L^{-1}; that for phosphate-phosphorus ranged from 23.62 µg L^{-1} in the bottom water to 24.46 µg L^{-1} in the surface water with an average of 24.04 ± 0.60 µg L^{-1}; that for nitrite-nitrogen highest value of 0.022 µg L^{-1} was recorded from bottom water and lowest value of 0.021 µg L^{-1} was recorded from surface water with an average of 0.022 ± 0.0005 µg L^{-1}; that for nitrate-nitrogen was 0.053 µg L^{-1} in both surface and bottom water; that for ammonia-nitrogen was 0.027 µg L^{-1} in both surface and bottom water.

The heavy metal cadmium content ranged from 1.8 ppb in bottom water to 3.1 ppb in surface water with an average 2.5 ± 0.9 ppb; that for copper was lowest in bottom water (27 ppb) and highest in surface water (32 ppb) with an average of 29.5 ± 3.5 ppb; that for average chromium was 9.3 ± 4.2 ppb with highest value of 10 ppb in bottom water and lowest value of 4 ppb in surface water; that for iron maximum value of 10.72 ppm in surface water and minimum value of 8.05 ppm in bottom water with an average of 9.4 ± 1.9 ppm; that for manganese ranged from 7 ppb in surface water to 32 ppb in bottom water with an average of 19.5 ± 17.7 ppb; that for nickel was highest in bottom water (17 ppb) and lowest in surface water (14 ppb) with an average of 16 ± 2.3 ppb ; that for zinc ranged from 400 ppb in the bottom water to 289 ppb in the surface water with an average of 345 ± 78.6 ppb; that for lead maximum value was recorded from bottom water (67 ppb) and minimum value from surface water (56 ppb) with an average of 62 ± 7.9 ppb; that for mercury was in below detectable level (BDL) and that for total petroleum hydrocarbon was Non detectable level (NDL).

The sediment temperature was recorded as 28.12 °C; that for pH was 6.55; that for oxidation reduction potential (Eh) was -543 mV; that for available nitrogen was 2.35%.

Productivity and biological parameters of Maradu (R4)

In the present study, the productivity parameters were as given below. The gross primary product (GPP) ranged from 0.81 g C m^{-3} day-1 in surface water to 0.738 g C m^{-3} day-1 in the bottom water with an average of 0.77 ± 0.05 g C m^{-3} day-1 ; that for net primary productivity (NPP) 0.738 g C m^{-3} day^{-1} both in surface and bottom water; that for Chlorophyll a ranged from 106.56 mg m^{-3} in bottom water and 60.44 mg m^{-3} in the surface water with an average of 83.50 ± 32.61 mg m^{-3}; that for pheophytin highest value recorded was 69886.7 mg m^{-3} in the bottom water and lowest value 55957.326 mg m^{-3} in the surface water with an average of 62922.021 ± 9849.57 mg m^{-3}.

During the present study, the phytoplankton biomass was recorded as 0.005 ml m^{-3} and abundance was 3600 ind.m^{-3} with an average of 164 ± 195.9 ind.m^{-3}; that for microzooplankton biomass was 0.001 ml m^{-3} and abundance was 960 ind. m^{-3} with an average of 320 ± 144.2 ind.m^{-3}; that for mesozooplankton biomass was 0.005 ml m-3 and abundance was 320 ind.m^{-3} with an average of 107 ± 23.1 ind.m^{-3}; that of macrobenthos was not found during the study period.

Summary

When Chilavannoor canal was compared with its reference station (Maradu -R4), it was observed that the average depth (0.8 m) was comparatively higher in the reference station than in the canal. The water flowrate was higher (5.09 m s^{-1}) in reference station compared to canal (0.99 ± 1.3 m s^{-1}). The average alkalinity value of C1 (265 ± 7.07 mg L^{-1}) was above the limit of water quality standards of BIS. The chloride and magnesium values in both the reference station and canal were beyond the limits of BIS and ICMR . The dissolved oxygen (DO) was low in C3 when compared to other locations. The mean BOD value was comparatively low in reference station where as BOD values were beyond the EPA standard due to extreme pollution. The iron content in water samples was beyond the limits of BIS and EPA standards in both reference station and canal. The nickel in the canal (22 ± 10.7 ppb) was above the limits of BIS standard. The GPP and NPP was less in R4 when compared to canal; chlorophyll a and pheophytin was high in reference station than the canal. The biomass of phytoplankton (0.008 ml m^{-3}), and microplankton (0.008 ml m^{-3})was high in canal water than in reference station while mesozooplankton was recorded almost similar trend in C1, C2 and reference station.

Table-3.39: Variation in the environmental and biological parameters at Chilavanoor canal during September, 2020

Parameters	CHILAVANOOR CANAL										R4 (MARADU)		
	C1			C2			C3						
	S	B	Mean ±SD	S	B	Mean±SD	S	B	Mean±SD	Grand Mean	S	B	Mean ±SD
Atmospheric Temperature (°C)	25.5		25.5	29.5		29.5	29		29	28 ± 2.17	28		28
WATER													
Depth(m)	0.5		0.5	0.5		0.5	0.75		0.75	0.58 ± 0.14	0.8		0.8
Flowrate (m s^{-1})	0.13		0.13	2.44		2.44	0.40		0.40	0.99 ± 1.3	5.09		5.09
Temperature (°C)	26.68	25.1	25.9 ± 1.10	27.75	27.3	27.5 ± 0.35	28.53	27.22	27.87 ± 0.92	27.09 ± 1.04	29.06	28.12	28.59 ± 0.66
pH	6.87	6.22	6.545 ± 0.45	6.95	6.98	6.965 ± 0.02	6.82	6.01	6.415 ± 0.57	6.64 ± 0.28	6.74	6.68	6.71 ± 0.04
Transparency (m)	0.4		0.4	0.5		0.5	0.75		0.75	0.5 ± 0.18	0.4		0.4
Eh (mV)	-46.4	-48	- 47.3 ± 1.27	14	15	14.5 ± 0.70		-9.020	-8.61 ± 0.57	-8.61 ± 0.57	454	435	444.5 ± 13.43
Conductivity (µS cm^{-1})	364	370	367 ± 4.24	331	329	330 ± 1.41	374	382.000	378 ± 5.65	358.33 ± 25.14	448	447	447.5 ± 0.71
TDS (mg L^{-1})	180	179	179.5 ± 0.70	166	167	166.5 ± 0.70	187	183.000	185 ± 2.82	177 ± 9.5	224	232	228 ± 5.65
Turbidity (NTU)	2.5	3.6	3.05 ± 0.77	2	6.5	4.25 ± 3.18	4.4	4.300	4.3 ± 0.07	3.88 ± 0.72	4.8	5.1	4.95 ± 0.21
Salinity (psu)	0.26	0.32	0.29 ± 0.04	0.16	0.18	0.17 ± 0.01	0.18	0.220	0.2 ± 0.02	0.22 ± 0.06	0.21	0.3	0.255 ± 0.06
Alkalinity (mg L^{-1})	270	260	265 ± 7.07	160	255	207.5 ± 67.1	137	146.000	141 ± 6.36	206.83 ± 59.25	80	70	75 ± 7.07
Calcium (mg L^{-1})	63.6	13.6	38.6 ± 35.3	64.7	20.4	42.6 ± 31.3	20.4	97.7	59.1 ± 54.6	46.7 ± 33.7	57.9	47.7	52.8 ± 7.23
Chloride (mg L^{-1})	1063.5	532	797.6 ± 376	354.5	532	443.1 ± 125.3	354.5	886.250	620.4 ± 376	620.4 ± 291.3	2304.25	2659	2481.5 ± 250.7
Magnesium (mg L^{-1})	107	61	84 ± 33.2	95	120	107 ± 17.8	67	111.0	89 ± 31.1	93 ± 24.4	5	65	35 ± 42.4
Total Hardness (mg L^{-1})	122.88	63.8	93.36 ± 41.75	110.4	125	117.6 ± 10.18	72	134.400	103.2 ± 44.12	104.7 ± 29.6	19.2	76.8	48 ± 40.7

CHILAVANOOR CANAL											R4 (MARADU)		
Parameters	**C1**			**C2**			C3						
	S	**B**	**Mean ±SD**	**S**	**B**	**Mean±SD**	**S**	**B**	**Mean±SD**	**Grand Mean**	**S**	**B**	**Mean ±SD**
Potassium (ppm)	1.04	1.24	1.14 ± 0.14	1.02	0.61	0.81± 0.29	0.57	1.04	0.8 ± .033	0.92 ± 0.26	0.38	0.37	0.37 ± 0.01
Sodium (ppm)	1.5	2.0	1.76 ± 0.34	2.13	1.42	1.7 ± 0.5	1.8	1.09	1.45 ± 0.50	1.7 ± 0.4	3.63	1.67	2,65 ± 1.4
DO (mg L^{-1})	3.93	3.14	3.535 ± 0.55	4.72	2.36	3.54 ± 1.66	0.78	1.570	1.175 ± 0.55	2.75 ± 1.36	3.62	4.96	4.29 ± 0.94
BOD (mg L^{-1})	220.5	221	220.5	189	168	178.51 ±14.84	189	178.510	183.76 ± 7.42	194.25 ± 22.87	4.8	6.2	5.5 ± 0.99
COD (mg L^{-1})	3.2	16	9.6 ± 9.05	12.8	6.4	9.6 ± 4.53	9.6	12.800	11.2 ± 2.26	10.13 ± 4.71	12.8	6.4	9.6 ± 4.53
Total Sulphide (ppm)	4.26	2.98	3.62 ± 0.90	0.85	6.82	3.83 ± 4.21	0.43	0.852	0.64 ± 0.30	2.70 ± 2.51	4.26	4.26	4.26
Silicate-silicon (µg L^{-1})	0.034	0.028	0.031 ± 0.004	0.034	0.041	0.038 ± 0.005	0.033	0.028	0.03 ± 0.004	0.033 ± 0.005	0.031	0.029	0.030 ± 0.0015
Phosphate-phosphorus (µg L^{-1})	5.31	1.70	3.51 ± 2.55	1.70	5.87	3.79 ± 2.95	6.72	2.62	4.6 ± 2.90	3.99 ± 2.24	24.46	23.62	24.04 ± 0.60
Nitrite-nitrogen(µg L^{-1})	0.021	0.018	0.020 ± 0.0014	0.022	0.036	0.029 ± 0.0099	0.022	0.028	0.025 ± 0.004	0.025 ± 0.007	0.021	0.022	0.022 ± 0.0005
Nitrate-nitrogen (µg L^{-1})	0.052	0.052	0.052	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053
Ammonia-nitrogen (µg L^{-1})	0.034	0.025	0.030 ± 0.006	0.026	0.028	0.027 ± 0.002	0.029	0.034	0.032 ± 0.004	0.029 ± 0.004	0.027	0.027	0.027
Heavy metal													
Cadmium (ppb)	0.6	1.2	0.9 ± 0.42	0.8	0.6	0.7 ± 0.14	0.5	0.6	0.55 ± 0.07	0.72 ± 0.26	3.1	1.8	2.5 ± 0.9
Copper (ppb)	19	37	28 ± 12.73	20	37	28.5 ± 12.02	216	62	139 ± 108.89	65.7 ± 75.52	32	27	29.5 ± 3.5
Chromium (ppb)	70	8	39 ± 43.8	5	7	6 ± 1.41	5	6	5.5 ± 0.71	16.8 ± 26.1	4	10	9.3 ± 4.2
Iron (ppm)	22.75	20.11	21.43 ± 1.87	17.38	15.07	16.23 ± 1.64	14.18	11.4	12.8 ± 2	16.8 ± 4.1	10.72	8.05	9.4 ± 1.9
Manganese (ppb)	5	5	5	13	9	11 ± 3.21	8	14	10.50 ± 4.95	9 ± 4.5	7	32	19.5 ± 17.7
Nickel (ppb)	22	33	28 ± 7.9	34	23	28 ± 5.7	12	8	10 ± 2.8	22 ± 10.7	14	17	16 ± 2.3
Zinc (ppb)	390	623	507 ± 165	247	467	357 ± 156	791	366	578 ± 300.5	481 ± 196.3	289	400	345 ± 78.6

Parameters	CHILAVANOOR CANAL										R4 (MARADU)		
	C1			C2			C3						
	S	B	Mean ±SD	S	B	Mean±SD	S	B	Mean±SD	Grand Mean	S	B	Mean ±SD
				.2	.8								
Lead (ppb)	13	21	17 ± 5.57	12	29	20 ± 12.35	36	15	25 ± 14.5	20.9 ± 9.6	56	67	62 ± 7.9
Mercury (ppb)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total Petroleum Hydrocarbon (mg L^{-1})	NDL	NDL	NDL	NDL	NDL	NDL	NDL	NDL	NDL	NDL	NDL	NDL	NDL
SEDIMENT													
Temperature (°C)	27.2		27.2	29.8		29.8	29		29	28.66 ± 1.33	28.12		28.12
pH	5.95		5.95	5.99		5.99	6.13		6.13	6.023 ± 0.09	6.55		6.55
Eh (mV)	-217		-217	-208		-208	-216		-216	213 ± 4.93	-543		-543
Available nitrogen (%)	1.96		1.96	0.56		0.56	2.32		2.32	al	2.35		2.35
Productivity parameters													
GPP (g C m^{-3} day $^{-1}$)	2.214	1.11	1.7 ± 0.8	1.476	1.25	1.4 ± 0.2	1.033	0.738	0.9 ± 0.2	1.3 ± 0.5	0.738	0.812	0.77 ± 0.05
NPP (g C m^{-3} day $^{-1}$)	2.952	2.58	2.8 ± 0.3	0.738	1.18	1.0 ± 0.3	1.033	0.738	0.9 ± 0.2	1.54 ± 0.98	0.738	0.738	0.738
Chlorophyll-*a* *(mg m^{-3})*	2.5902	1.06	1.82 ± 1.09	1.732	1.02	1.38 ± O.50	2.208	14.276	8.24± 8.53	3.81 ± 5.16	60.4422	106.6	83.50 ± 32.61
Pheophytin (mg m^{-3})	2988.8	724	1856.18 ± 1601.76	358.8	1450	904.33 ± 771.43	1629	27105	14367 ± 18014. 68	5709.17 ± 10521.12	55957.3	69887	62922.021 ± 9849.57
BIOLOGICAL PARAMETERS													
Phytoplankton													
Biomass (ml m^{-3})	0.01		0.01	0.008		0.008	0.001		0.001	0.006 ± 0.005	0.005		0.005
Abundance (ind.m^{-3})	320		160 ± 56.5	560		93 ± 70.05	80		53.3	320 ± 240	3600		164 ± 195.9
Microzooplankton													
Biomass (ml m^{-3})	0.002		0.002	0.008		0.008	0.006		0.006	0.005 ± 0.003	0.001		0.001

CHILAVANOOR CANAL											R4 (MARADU)		
Parameters	**C1**			**C2**			C3						
	S	**B**	**Mean ±SD**	**S**	**B**	**Mean±SD**	**S**	**B**	**Mean±SD**	**Grand Mean**	**S**	**B**	**Mean ±SD**
Abundance (ind.m^{-3})	1440		360 ± 535.7	720		120 ± 126.5	2760		460 ± 951.5	1650 ± 1034.6	960		320 ± 144.2
Mesozooplankton													
Biomass (ml m^{-3})	0.005		0.005	0.005		0.005	0.01		0.01	0.007 ± 0.003	0.005		0.005
Abundance (ind.m^{-3})	8920		1487 ± 3058	1720		430 ± 675	1280		256 ± 176	3973 ± 4289.6	320		107 ± 23.1
Macrobenthos													
Abundance (ind.m^{-3})	0		0	76		76	6		6	27.3 ± 42.2	0		0
*NDL - Non detectable level; * BDL- Below **detectable level; *S- Surface ; *B-Bottom**													

3.14.6 MARKET CANAL AND REFERENCE STATION

Water and sediment quality of canal

During the present study, two stations of Market canal were selected. They are represented as M1 (Market road) and M2 (Rainbow bridge). The variations in environmental parameters recorded in Market canal during September 2020 were detailed below. The atmospheric temperature ranged from 24.5 °C in M1 to 26.5 °C in M2 with an average of 25.5 ± 1.41 °C. The water quality parameters obtained as depth was 0.5 m in both M1 and M2. The flow rate ranged from 0.12 m s^{-1} in M1 to 3.45 m s^{-1} in M2 with an average of 1.78 ± 2.35 m s^{-1}; that for water temperature ranged from 26.11 °C in the bottom waters of M2 to 27.39 °C in surface water of M1 with an average of 26.89 ± 0.56 °C; that for pH values ranged from 7.02 in the surface water of M2 to 7.15 in the bottom water of M2 with an average of 7.1 ± 0.05; that for transparency ranged from 0.20 in M2 to 0.22 in M1 with an average of 0.21 ± 0.01; that for average oxidation reduction potential (Eh) was 81.8 ± 51.49 mV and ranged from 35.6 mV in surface water of M2 to 130 mV in bottom water of M1; that for electrical conductivity of the canal with lowest value 0f 417 µS cm^{-1} in the surface water of M2 and highest value of 546 µS cm^{-1} ,with an average value of 481 ± 73.33 µS cm^{-1}; that for total dissolved solids (TDS) values ranged from 209 mg L^{-1} in surface water of M2 to 271 mg L^{-1}in the surface water of M1 with an average value of 234.5 ± 28.82 mg L^{-1}; that for the mean turbidity obtained was 3.3 ± 2.78 NTU with minimum value of 1.0 NTU in the bottom water of M1 and maximum value of 7.3 NTU in the surface water of M1; that for salinity ranged from 0.20 psu in the surface water of M2 to 0.28 psu in the bottom water of M1, with an average of 0.24 ± 0.03 psu; that for the mean alkalinity value was 165.16 ± 80.7 mg L^{-1} while the minimum alkalinity value of 80.08 mg L^{-1} in the surface water of M1 and highest value of 260 mg L^{-1} in the surface water of M2; that for calcium ranged from 10.22 mg L^{-1} in the bottom water of M1 to 54.50 mg L^{-1} in the surface water of M2, with an average of 30.1 ± 19 mg L^{-1}; that for chloride ranged from 709 mg L^{-1} in the bottom water of M2 to 2836 mg L^{-1} in the surface water of M1 with an average of 1373.7 ± 985.6 mg L^{-1}; that for magnesium ranged from 67 mg L^{-1} in the bottom water of M1 to 186 mg L^{-1} in the surface water of M2 with an average of 130 ± 62.3 mg L^{-1}; that for mean total hardness was 137.4 ± 66.5 mg L^{-1} and ranged from 69.6 mg L^{-1} in the bottom water of M1 to 199.2 mg L^{-1} in the surface water of M2; that for potassium ranged from 1.2 ppm in the bottom water of M1 to 9.16 ppm in the surface water of M2 with an average of 4.5 ± 3.4 ppm; that for mean value of sodium was 9.06 ± 4.22 ppm and ranged from 3.2 ppm in the bottom water of M2 to 12.83 ppm in the surface water of M2; that for dissolved oxygen (DO) ranged from 0.79 mg L^{-1} in the bottom water of M2 to 4.7 mg L^{-1} in the bottom water of M1 with an average of 2.76 ± 2.23 mg L^{-1}; that for mean BOD value of 246.73 ± 22.26 mg L^{-1} and ranged from 189.01 mg L^{-1} in the bottom water of M1 to 293.97 mg L^{-1} in the bottom water of M2; that for COD ranged from

6.4 mg L^{-1} in the surface water of M1 to 300.8 mg L^{-1} in the bottom water of M2 with an average of 91.2 ± 141 mg L^{-1} ; that for total sulphide ranged from 0.0002 ppm in the bottom water of M1 to 0.0004 ppm in the surface water of M1 with an average of 0.0003 ± 0.0001 ppm; that for silicate-silicon ranged from 0.028 µg L^{-1} in bottom water of both M1 and M2 to 0.030 µg L^{-1} in the surface water of both M1 and M2 with an average of 0.029 ± 0.002 µg L^{-1} ; that for phosphate-phosphorus ranged from 3.62 µg L^{-1} in the surface water of M1 to 17.4 µg L^{-1} in the surface water of M2 with an average of 10.65 ± 7.60 µg L^{-1}; that for mean nitrite- nitrogen was 0.025 ± 0.004 µg L^{-1} and ranged from 0.020 µg L^{-1} in the bottom water of M1 to 0.031 µg L^{-1} to surface water of M2; that for nitrate-nitrogen was 0.05 µg L^{-1} in all stations; that for ammonia- nitrogen ranged from 0.024 µg L^{-1} in both surface and bottom water of M1 to 0.030 µg L^{-1} in the bottom water of M2 with an average of 0.027 ± 0.003 µg L^{-1}.

The heavy metal cadmium content ranged from 1.07 ppb in the bottom water of M2 to 2.8 ppb in the surface water of M1 with an average of 2.01 ± 0.76 ppb; that for copper ranged from 10 ppb in the surface water of M2 to 236 ppb in the bottom water of M2 with an average of 89.9 ± 100 ppb; that for chromium ranged from 2 ppb in the surface water of M2 to 12.1 ppb in the bottom water of M2 with an average of 6.7 ± 4.7 ppb ; that for iron ranged from 2.7 ppm in the surface water of M1 to 143 ppm in the bottom water of M2 with an average of 8.6 ± 4.8 ppm; that for manganese ranged from 27.2 ppb in the surface water of M1 to 143 ppb in the bottom water of M2, with an average of 5.2 ± 62.3 ppb ; that for nickel ranged from 11 ppb in the surface water of M1 to 125 ppb in the bottom water of M2 with an average of 52.4 ± 50.9 ppb; that for zinc ranged from 423 ppb in the bottom water of M2 to 846 ppb to 846 ppb in the bottom water of M1 with an average of 502 ± 242.4 ppb; that for lead ranged from 8 ppb in the surface water of M2 to 33 ppb in the surface water of M1 with an average of 28.7 ± 21.3 ppb; that for mercury was in below detectable level (BDL); that for total petroleum hydrocarbon ranged from 0.325 mg L^{-1} in M2 to 4.305 mg L^{-1} with an average of 2.31±2.81 mg L^{-1}.

The sediment temperature ranged from 25.1 °C in M1 to 28.8 °C in M2 with an average of 26.95 ± 2.62 °C; that for pH ranged from 5.82 in M1 to 5.88 in M2 with an average of 5.85 ± 0.04; that for oxidation reduction potential (Eh) ranged from -435 mV in M2 to -485 mV with an average of -460 ± 35.36 mV ; that for available nitrogen ranged from 0.67% in M2 to 1.65% in M2.

Productivity and biological parameters of canal

In the present study, the productivity parameters were as given below. The gross primary product (GPP) ranged from 0.738 g C m^{-3} day^{-1} in the surface water M2 to 1.476 g C m^{-3} day^{-1} in the bottom water of M1 & M2 and in surface water of M1 with an average of 1.3 ± 0.4 g C m^{-3} day^{-1} ; that for net primary productivity (NPP) ranged from 0.738 g C m^{-3} day^{-1} in the surface and bottom water of M2 to 1.476 in the surface water of M1 with an average of 1.01

± 0.35 g C m^{-3} day^{-1} ; that for chlorophyll a ranged from 0.4 mg m^{-3} in the surface water of M1 to 9.5 mg m^{-3} in the surface water M2 with an average of 3.47 ± 4.12 mg m^{-3}; that for pheophytin ranged from 904.1 mg m^{-3} in the bottom water of M2 to 3699.0 mg m^{-3} with an average of 1829.62 ± 1284.3 mg m^{-3}.

The phytoplankton biomass ranged from 0.004 ml m^{-3} in M2 to 0.01 ml m^{-3} in M1 with an average of 0.007 ± 0.004 ml m^{-3} ; that for abundance ranged from 327 ind.m^{-3} in M2 to 2600 ind.m^{-3} in M1 with an average of 1960 ± 334.1 ind.m^{-3}; that for microzooplankton biomass ranged from 0.002 ml m^{-3} in M1 to 0.006 ml m^{-3} in M2 with an average of 0.004 ± 0.002 ml m^{-3} ; that for abundance ranged from 400 ind.m^{-3} in M1 to 8680 ind.m^{-3} in M2 with an average of 4340 ± 6024.5 ind.m^{-3}; that for Mesozooplankton biomass ranged from 0.005 ml m^{-3} in M2 to 0.05 ml m^{-3} in M1 with an average of 0.027 ± 0.03 ml m^{-3} ; that for abundance ranged from 1080 ind.m^{-3} in M1 to 3800 ind.m^{-3} in M2 with an average of 1900 ± 2517 ind.m^{-3}; that of macrobenthos was not found in both stations during the study period.

Water and sediment quality of Bolgatty R5

Atmospheric temperature in reference station Bolgatty R5 was recorded 27.89°C during the study period. Depth of the station was 2 m; that for water flow rate was 0.65 ms^{-1}; that for water temperature ranged from 28.55°C in bottom water to 28.65°C in surface water with an average of 28.6± 0.07 °C; that for pH was lowest recorded in surface water (6.25) and highest (6.26) in surface with an average of 6.25± 0.007; that for transparency recorded was 0.4 m; that for Eh was lowest in bottom water (299.3 mV) and highest (300.7mV) in surface water with an average of 300± 0.98 mV; that for conductivity highest was in surface water(288.5 µS cm^{-1}) and lowest was in bottom water (287 µS cm^{-1}) with an average of 287.75± 1.06 µS cm-1; that for TDS was highest in surface water (1442 mg L^{-1}) and lowest was in bottom water(1422 mg L^{-1}) with an average of 1435± 14.14 mg L^{-1}; that for turbidity lowest was in surface water (3 NTU) and highest in (8.9 NTU) in bottom water with an averge of 5.95± 4.17 NTU; that for salinity highest was in bottom water(1.5 psu) and lowest in surface water (1.49 psu) with an average of 1.5± 0.007 psu; that for calcium highest in surface water (132.9 mg L^{-1}) and lowest in bottom water (94.3 mg L^{-1}) with an average of 113.6± 27.3 mg L^{-1}; that for chloride lowest was in surface water (21979 mg L^{-1})and highest in bottom water (25524 mg L^{-1}) with an average of 23751± 2506.7 mg L^{-1};that for magnesium highest was in surface water(160 mg L^{-1}) and lowest was in bottom water(55 mg L^{-1}) with an average of 107.5± 74.2 mg L^{-1}; that for alkalinity was 60 mg L^{-1} in both surface and bottom water; that for total hardness lowest was in bottom water (15 mg L^{-1}) and highest in surface water (160 mg L^{-1})with an averge of 87.7± 102.2 mg L^{-1}; that for potassium lowest was in bottom water (1.19 ppm) and highest in surface water (1.54 ppm) with an average of 1.4± 0.3 ppm; that for sodium was lowest in bottom water (5.97 ppm) and highest in surface water (18.67 ppm) with an average of 12.3± 8.98 ppm; that for DO was highest in surface water

(6.77 mg L^{-1}) and lowest in bottom water (6.53 mg L^{-1}) with an average of 6.65± 0.16 mg L^{-1}; that for BOD was highest in bottom water (4 mg L^{-1}) and lowest in surface water (2.5 mg L^{-1}) with average of 3.25± 1.06 mg L^{-1}; that for COD was lowest in bottom water (9.8 mg L^{-1}) and highest in surface water (300.8 mg L^{-1}) with an average of 155.2± 205.9 mg L^{-1}; that for total sulphide highest value in bottom water (0.0009 ppm) and lowest in surface water (0.0007 ppm) with an average of 0.0008± 0.0002 ppm; that for Silicate- silicon highest was in bottom water (0.030 µg L^{-1}) and lowest in surface water (0.029 µg L^{-1}) with an average of 0.03±0.0008 µg L^{-1}; that for phosphate lowest was in bottom water (3.11 µg L^{-1}) and highest in surface water (4.13 µg L^{-1}) with an average of 3.62± 0.72 µg L^{-1}; that for Nitrite- nitrogen highest was in bottom water (0.0198 µg L^{-1}) and lowest in surface water (0.0195 µg L^{-1}) with an average of 0.0197±0.002 µg L^{-1}; that for Nitrate- nitrogen was 0.053 µg L^{-1} for both surface and bottom water of the reference station; that for ammonia- nitrogen lowest was in bottom water (0.025 µg L^{-1}) and highest in surface water (0.027 µg L^{-1}) with an average of 0.026± 0.002 µg L^{-1}.

Heavy metal cadmium was ranged from 2.4 ppb in surface water to 1.3 ppb in bottom water with an average of 1.85± 0.72 ppb ;that for copper highest value was recorded from bottom water (21.1 ppb) and lowest was in surface water (18.2 ppb) with an average of 19.6± 2.04 ppb; that for chromium was highest in surface water (7.9 ppb) and lowest was in bottom water (4.9 ppb) with an average of 6.4± 2.1 ppb; that for iron highest of 5.58 ppb recorded in surface water and lowest in bottom water (2.95 ppb) with an average of 4.26± 1.8 ppb; that for manganese was highest in surface water (18 ppb) lowest was in bottom water (4 ppb) with an average of 11± 9.5 ppb; that for nickel was recorded 16 ppb in both surface and bottom water of the reference atation; that for zinc highest value of 441 ppb recorded in bottom water and lowest was in surface water(286 ppb) with an average of 363± 109.9 ppb; that for lead lowest was in bottom water 20 ppb and highest was in surface water (23 ppb) with an average of 21.3± 2.2 ppb; that for mercury was recorded in below detectable level(BDL);that for total petroleum hydrocarbon was in non-detectable level(NDL).

Sediment temperature recorded was 28°C during the study period; that for pH was 5.82; that for Eh was -95mV whereas available nitrogen recorded was 1.26%.

GPP was recorded highest in surface water(2.2 g C m3 day^{-1}) and lowest in bottom water (1.5 mg L^{-1}) with an average of 1.8± 0.5 g C m3 day-1 ; that for NPP was lowest in bottom (0.66 g C m3 day^{-1}) and highest in surface water (2.14 g C m3 day-^{1}) with an average value of 1.4± 1.04 g C m3 day^{-1}; that for chlorophyll a was highest in bottom water (41.36 mg m^{-3}) and lowest in (20.64 mg m^{-3}) with an average of 31± 14.6mg m^{-3}; that for pheophytin was highest in bottom water (17150.47mg m^{-3}) and lowest in surface water (16018.93 mg m^{3})with an average of 16584.7± 800.1 mg m^{-3}.

Productivity and biological parameters of Bolgatty

Phytoplankton biomass was 0.001 mg m^{-3} whereas abundance was 360 ind.m^{-3} with average of 51± 19.5 ind.m^{-3}; that for microzooplankton biomass was 0.001 mg m^{-3} and abundance was 320 ind.m^{-3} with an average of 53± 32.6 ind.m^{-3}; that for mesozooplankton biomass was 0.015 mg m^{-3} and abundance was 120 ind.m^{-3} with an average of 40 ind.m^{-3}; that for macrobenthos abundance was 10 ind.m^{-3} with an average of 5± 4.2 ind.m^{-3} during the study period.

Summary

A comparison of Market canal with its reference station Bolghatty (R5), depicted that the depth (0.5 m) was high in canal than R5 (2m) and transparency (0.4m) was comparatively lower than that of canal (0.21 ±0.01 m). The average flow rate of the canal was 1.79±0.57 m/sec with the maximum flow rate in T2 (2.19m/sec) than T1 (1.38 m/sec). R5 was more turbid (5.95 ±4.17 NTU) than the canal (3.3 ± 2.78 NTU) which was above the permissible limit as per WHO water quality standards. The canal was observed to be more alkaline (165.16 ± 80.7 mg L^{-1}) than the reference station (60 mg L^{-1}). However, the values were within the limit of water quality standards of BIS and WHO . Approved limit for DO and BOD is 5 mg L^{-1} according to WHO, BIS and ICMR. In the present study, DO values was higher in R5 (6.65±0.16 mg L^{-1}) than that of canal (2.76±2.23 mg L^{-1}). BOD values of the canal (246.73±22.26 mg L^{-1}) exceeded the permissible limit that and was higher than that of the reference station (3.25 ±1.06 mg L^{-1}). Average (COD) value was higher in the reference station (155.2 ±205.9 mg L^{-1}) than that of canal (91.2±141mg L^{-1}). However COD values was within the permissible limit according to EPA which is 250 mg L^{-1}. In Market canal, the average concentration of heavy metals in water followed the trend Cd<Fe<Cr<Mn<Pb<Ni<Cu<Zn. According to BIS the desirable limit of nickel of drinking water is 20ppb and Cu is 50ppb. The present study nickel concentration exceeded the permissible limit for both in the canal and R5 (52.4 ± 50.9 and 16 ppb). Total Petroleum hydrocarbon was at non detectable level in the reference station while that of in canal was 2.31±2.81 mg L^{-1}. GPP (1.3 ± 0.4 g C m-3 day-1) and NPP (1.01 ± 0.35g C m-3 day-1) was slightly high in R5 than that in canal .However, chlorophyll *a* (31±14.6mg/m^3) and pheophytin (16584.7±800.1mg/m^3) was high in R5 compared to canal. Abundance of phytoplankton (228±310.4ind m^{-3}), microzooplankton (1311 ± 3214.3 ind m^{-3}), mesozooplankton (976± 1528.8ind m^{-3}) and macrobenthos (5 ± 4.2ind m^{-}3) were comparatively high in canal compared to R5.

Table-3.40: Variation in the environmental and biological parameters at Market canal during September, 2020

MARKET CANAL								R5 (BOLGATTY)		
Parameters	**M1**			**M2**						
	S	**B**	**Mean ±SD**	**S**	**B**	**Mean±SD**	**Grand Mean**	**S**	**B**	**Mean±SD**
Atmospheric Temperature (°C)	24.5		24.5	26.5		26.5	25.5±1.41	27.89		
WATER QUALITY										
Depth (m)	0.5		0.5	0.5		0.5	0.5	2		2
Flowrate (m s^{-1})	0.12		0.12	3.45		3.45	1.78 ± 2.35	0.65		0.65
Temperature (°C)	27.39	27.2	27.39 ± 0.13	26.89	26.11	26.89 ± 0.55	26.89 ± 0.56	28.65	28.55	28.6±0.07
pH	7.12	7.14	7.13±0.01	7.02	7.15	7.08±0.09	7.1 ± 0.05	6.25	6.26	6.25±0.007
Transparency (m)	0.22		0.22	0.20		0.20	0.21 ± 0.01	0.40		0.40
Eh (mV)	122.6	130	126.3 ± 5.2	35.6	39	37.3 ± 2.4	81.8 ± 51.49	300.7	299.3	300±0.98
Conductivity (µS cm^{-1})	543	546	544.5 ± 2.1	417	418	417.5 ± 0.71	481 ± 73.33	288.5	287	287.75±1.06
TDS (mg L^{-1})	271	244	257.5 ± 19.1	209	214	211.5 ± 3.54	234.5 ± 28.82	1442	1422	1435±14.14
Turbidity (NTU)	7.3	1	4.15 ± 4.5	3.2	1.9	2.55 ± 0.92	3.3 ± 2.78	3	8.9	5.95±4.17
Salinity (psu)	0.26	0.28	0.27 ± 0.01	0.2	0.25	0.22 ± 0.04	0.24 ± 0.03	1.49	1.5	1.5±0.007
Alkalinity (mg L^{-1})	80.08	120.12	100.1 ± 28.3	260	200	230 ± 42.47	165.16 ± 80.7	60	60	60
Calcium (mg L^{-1})	21.5764	10.2204	15.9 ± 8	54.5088	34.068	44.3 ± 14.5	30.1 ± 19	132.9	94.3	113.6 ± 27.3
Chloride (mg L^{-1})	2836	1063.5	1949.8 ± 1253.3	886.25	709	797.6 ± 125.3	1373.7 ± 985.6	21979	25524	23751 ± 2506.7
Magnesium (mg L^{-1})	86	67	76.5 ± 13.4	186	181	183 ± 3.5	130 ± 62.3	160	55	107.5 ± 74.2
Total Hardness	91.2	69.6	80.4 ± 15.3	199.2	189.6	194.4 ± 6.8	137.4 ± 66.5	160	15	87.7 ± 102.2
Potassium (ppm)	2.9	1.2	2.1 ± 1.2	9.16	4.76	6.96 ± 3.1	4.5 ± 3.4	1.54	1.19	1.4 ± 0.3
Sodium (ppm)	9.1	3.2	6.1 ± 4.15	12.83	11.19	12.01 ± 1.2	9.06 ± 4.22	18.67	5.97	12.3 ± 8.98
DO (mg L^{-1})	3.9	4.7	4.3 ± 0.56	1.57	0.79	1.18 ± 0.56	2.76 ± 2.23	6.77	6.53	6.65±0.16
BOD (mg L^{-1})	272.9	189.0	230.99 ±	230.9	293.	262.48 ±	246.73 ±	2.5	4	3.25 ± 1.06

MARKET CANAL								R5 (BOLGATTY)		
Parameters	**M1**			**M2**						
	S	**B**	**Mean ±SD**	**S**	**B**	**Mean±SD**	**Grand Mean**	**S**	**B**	**Mean±SD**
	8	1	59.37	9	97	44.53	22.26			
COD (mg L^{-1})	6.4	48	27.2 ± 2.9.41	9.6	300.8	155.2 ± 205.9	91.2 ± 141	300.8	9.6	155.2 ±205.9
Sulphide (ppm)	0.0004	0.0002	0.0003± 0.0002	0.0003	0.0003	0.0003	0.0003 ± 0.0001	0.0007	0.0009	0.0008 ± 0.0002
Silicate (µg L^{-1})	0.030	0.028	0.029 ± 0.002	0.030	0.028	0.029 ± 0.002	0.029 ± 0.002	0.029	0.030	0.03 ± 0.0008
Phosphate (µg L^{-1})	3.62	4.52	4.07 ± 0.64	17.4	17.1	17.22 ± 0.2	10.65 ± 7.60	4.13	3.11	3.62 ± 0.72
Nitrite (µg L^{-1})	0.025	0.020	0.023 ± 0.003	0.031	0.024	0.027 ± 0.004	0.025 ± 0.004	0.0195	0.0198	0.0197 ± 0.002
Nitrate (µg L^{-1})	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.053	0.053	0.053
Ammonia (µg L^{-1})	0.024	0.024	0.024	0.029	0.030	0.029 ± 0.001	0.027 ± 0.003	0.027	0.025	0.026 ± 0.002
Heavy metal										
Cadmium (ppb)	2.8	2.5	**2.62 ± 0.20**	1.72	1.07	1.4 ± 0.5	2.01 ± 0.76	2.4	1.3	1.85 ± 0.72
Copper (ppb)	51.82	61.20	56.5 ± 6.6	10	236	123.2 ± 159.6	89.9 ± 100	18.2	21.1	19.6 ± 2.04
Chromium (ppb)	9	4	6 ± 3.8	2	12.1	7.0 ± 7	6.7 ± 4.7	7.9	4.9	6.4 ± 2.1
Iron (ppm)	9.5	14.3	11.9 ± 3.37	2.7	8.0	5.4 ± 3.72	8.6 ± 4.8	5.58	2.95	4.26 ± 1.8
Manganese (ppb)	27.2	4.3	16 ± 16.2	31	143	87 ± 555.9	5.2 ± 62.3	18	4	11 ± 9.5
Nickel (ppb)	49	25	37 ± 16.89	11	125	68 ± 80.53	52.4 ± 50.9	16	16	16
Zinc (ppb)	463	846	654 ± 271.1	278	423	350 ± 102.4	502 ± 242.4	286	441	363 ± 109.9
Lead (ppb)	33	57	44.7 ± 17.15	8	17	13 ± 6	28.7 ± 21.3	23	20	21.3 ± 2.2
Mercury (ppb)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total Petroleum Hydrocarbon (mg L^{-1})	4.305		4.305	0.325		0.325	2.31±2.81	NDL	NDL	NDL
SEDIMENT QUALITY										
Temperature (°C)	25.1		25.1	28.8		28.8	26.95 ± 2.62	28		28
pH	5.82		5.82	5.88		5.88	5.85 ± 0.04	5.82		5.82
Eh (mV)	-485		-485	-435		-435	-460 ± 35.36	-95		-95
Availabe nitrogen	1.65		1.65	0.67		0.67	1.16 ± 0.69	1.26		1.26

	MARKET CANAL							R5 (BOLGATTY)		
Parameters	**M1**			**M2**						
	S	**B**	**Mean ±SD**	**S**	**B**	**Mean±SD**	**Grand Mean**	**S**	**B**	**Mean±SD**
Productivity parameters										
GPP (g C m^{-3} day $^{-1}$)	1.476	1.476	1.476	0.738	1.476	1.1 ± 0.5	1.3 ± 0.4	2.2	1.5	1,8 ± 0.5
NPP (g C m-3 day -1)	1.476	1.107	1.3 ± 0.3	0.738	0.738	0.738	1.01 ± 0.35	2.14	0.66	1.40 ± 1.04
Chlorophyll-*a* (mg m^{-3})	0.4	2.5	1.48 ± 1.47	9.5	1.4	5.46 ± 5.74	3.47 ± 4.12	20.6456	41.3618	31 ± 14.6
Pheophytin (mg m^{-3})	1633.0	1082.4	1357.7 ± 389.3	3699.0	904.1	2301.5 ± 1976.3	1829.62 ± 1284.3	16018.932	17150.478	16584.7 ± 800.1
BIOLOGICAL PARAMETERS										
Phytoplankton										
Biomass (ml m^{-3})	0.004		0.004	0.01		0.01	0.007 ± 0.004	0.001		0.001
Abundance (ind.m^{-3})	2600		186 ± 302	327		1960 ± 334.1	228 ± 310.4	360		51 ± 19.5
Micro zooplankton										
Biomass (ml m^{-3})	0.002		0.002	0.006		0.006	0.004 ± 0.002	0.001		0.001
Abundance (ind.m^{-3})	400		100 ± 69.2	8680		4340 ± 6024.5	1311 ± 3214.3	320		53 ± 32.6
Meso Zooplankton										
Biomass(ml m^{-3})	0.05		0.05	0.005		0.005	0.027 ± 0.03	0.015		0.015
Abundance (ind.m^{-3})	1080		360 ± 288	3800		1900 ± 2517	976 ± 1528.8	120		40
Macrobenthos										
Abundance (ind.m^{-3})	0		0	0		0	0	10		5 ± 4.2

Table -3.41: Water quality standards and their permissible limits prescribed in various agencies

WATER QUALITY STANDARDS					
PARAMETERS	**BIS (2012)**	**CPCB (2016)**	**ICMR**	**WHO (2009)**	**US EPA (2003)**
pH	6.5- 8.5	6.5-8.5	6.5- 8.5	7-8.5	6.3-9.0
Alkalinity (mg L^{-1})	200	-	120	300	-
Conductivity (μS cm^{-1})	750	-	300	750	-
TDS (mg L^{-1})	500	-	-	600	-
Turbidity (NTU)	5	-	-	1	-
Salinity (psu)	100	-	-	100	-
Calcium (mg L^{-1})	75	-	-	100	-
Chloride (mg L^{-1})	250	-	250	200-300	-
Magnesium (mg L^{-1})	30	-	-	30	-
Total Hardness (mg L^{-1})	300	-	300	-	-
Potassium (ppm)	-	-	-	10	-
Sodium (ppm)	200	-	-	50	-
DO (mg L^{-1})	5	>4	5	NA	-
BOD (mg L^{-1})	-	-	5	-	30
COD (mg L^{-1})	-	-	-	-	250
Nitrate (μg L^{-1})	45	-	-	-	10000

Table-3.42: Water quality standards status of canals in relation to the various stations

	WATER QUALITY STANDARDS				
	Canals				
PARAMETERS	**Thevara**	**Perandoor**	**Edappally**	**Chilavannur**	**Market**
pH	Fair	Fair	Fair	Fair	Fair
Alkalinity (mg L^{-1})	Fair	Fair	Fair	Poor	Poor
Conductivity (μS cm^{-1})	Fair	Fair	Fair	Fair	Fair
TDS (mg L^{-1})	Fair	Fair	Fair	Fair	Fair
Turbidity (NTU)	Fair	Fair	Fair	Fair	Fair
Salinity (psu)	Fair	Fair	Fair	Fair	Fair
Calcium (mg L^{-1})	Fair	Fair	Fair	Fair	Fair
Chloride (mg L^{-1})	Fair	Poor	Poor	Poor	Poor
Magnesium (mg L^{-1})	Poor	Poor	Poor	Poor	Poor
Total Hardness (mg L^{-1})	Fair	Fair	Fair	Fair	Fair
Potassium (ppm)	Fair	Fair	Fair	Fair	Fair
Sodium (ppm)	Fair	Fair	Fair	Fair	Fair
DO (mg L^{-1})	Poor	Poor	Poor	Poor	Poor
BOD (mg L^{-1})	Poor	Poor	Poor	Poor	Poor
COD (mg L^{-1})	Fair	Fair	Fair	Fair	Moderate
Nitrate (μg L^{-1})	Fair	Fair	Fair	Fair	Fair

*0-3: Poor; 3-6: Moderate; 6-8: Fair; <8: Good

Table-3.43: Heavy metal standards and their permissible limits prescribed in various agencies

Heavy metal			
PARAMETERS	BIS	WHO	US EPA
Cadmium (ppb)	3	3	5
Copper (ppb)	50	2000	3000
Chromium (ppb)	-	50	10
Iron (ppm)	0.3	0.3	0.3
Manganese(ppb)	-	50	50
Nickel(ppb)	20	-	100
Zinc(ppb)	5000	-	5000
Lead(ppb)	50	50	100
Mercury(ppb)	-	-	10

Table-3.44: Water quality status of the canals corresponding to the various standards prescribed for heavy metal

Heavy Metals					
	Canals				
Parameters	**Thevara**	**Perandoor**	**Edappally**	**Chilavannoor**	**Market**
Cadmium (ppb)	Moderate	Moderate	Poor	Fair	Moderate
Copper (ppb)	Fair	Fair	Fair	Poor	Poor
Chromium (ppb)	Fair	Poor	Fair	Poor	Fair
Iron (ppm)	Poor	Fair	Poor	Poor	Poor
Manganese (ppb)	Fair	Fair	Moderate	Fair	Fair
Nickel (ppb)	Poor	Poor	Poor	Poor	Poor
Zinc (ppb)	Moderate	Moderate	Moderate	Moderate	Moderate
Lead (ppb)	Poor	Poor	Moderate	Moderate	Moderate
Cadmium (ppb)	Moderate	Moderate	Poor	Fair	Moderate
Copper (ppb)	Fair	Fair	Fair	Poor	Poor

*0-3: Poor; 3-6: Moderate; 6-8: Fair; <8: Good

3.15 BACTERIOLOGICAL ANALYSIS OF WATER AND SEDIMENT SAMPLES

3.15.1 Methodology

Water and sediment samples were collected from the study stations, transported in iceboxes, and processed immediately for the bacteriological analyses. Estimation of the heterotrophic bacterial count was carried out with serially diluted samples, according to the American Public Health Association (APHA) protocol in plate count agar (APHA, 2016). Estimation of the total coliforms and thermotolerant coliforms (faecal coliforms) was carried out by the membrane filtration technique, following the WHO protocol for water quality monitoring (WHO, 1996). Guideline values for verification of the microbial quality of water for different purposes are given in Table-3.45.

3.15.2 Results and Discussion

Heterotrophs are broadly defined as microorganisms that require organic carbon for growth. They include bacteria, yeasts and moulds. Simple culture-based tests that are intended to recover a wide range of microorganisms from water are referred to as heterotrophic plate count (HPC). Only a small proportion of the metabolically active microorganisms present in a water sample may grow on agar plates and be detected under any given set of HPC test conditions, and the population recovered will differ significantly according to the test method used. The actual organisms recovered in HPC testing can also vary widely between locations, between seasons and between consecutive samples at a single location. Microorganisms recovered through HPC tests generally include those that are part of the natural microbiota of water; in some instances, they may also include organisms derived from diverse pollutant sources (WHO, 2003).

The heterotrophic plate count (HPC) in the water and sediment samples from the study stations are provided in Table-3.46. The values ranged between 6×10^5-2.8×10^8 CFU/mL in water samples and 3×10^5-2.7×10^9 CFU/mL in sediment samples. The high values of the HPC can be attributed to the high organic load in the water and sediment samples. The heterotrophic bacteria in the samples are not generally considered as a health concern to the general public. However, some genera such as *Acinetobacter*, *Aeromonas*, *Chryseobacterium*, *Klebsiella*, *Legionella*, *Moraxella*, *Mycobacterium*, *Serratia*, *Pseudomonas*, and *Xanthomonas* which are often present in a heterotrophic population are opportunistic pathogens that could infect individuals with weakened immune systems, if they are exposed to these waters (WHO, 2003). Reducing the organic load is the possible strategy to minimise the levels of HPC in the water bodies.

Total coliforms represent a group of Gram-negative, facultatively anaerobic, rod-shaped bacteria that ferment lactose to produce acid and gas within 48 h at 35 °C (Feng et al., 2002), and are naturally found in environmental samples. Faecal coliforms are a subset of total coliforms which are present in high numbers in the faeces of warm-blooded animals, hence are considered as an indicator of faecal contamination in environmental samples. Faecal coliforms grow and ferment lactose at elevated incubation temperatures, and also referred to as thermotolerant coliforms (Feng et al., 2002).

The total coliform and thermotolerant (faecal) coliform counts obtained from the water samples collected from the study stations are provided in Table-3.47. The Total Coliform (TC) level in the water samples tested was found to be between 5×10^{2}-2.9×10^{4} CFU/100 mL and Thermotolerant Coliform (Faecal Coliform, FC) level between 3×10^{2}-2.4×10^{4} CFU/100 mL. The coliform levels in all the samples are well beyond the permissible limits, and it is unfit for drinking purpose at any cause and even not suitable for bathing, contact water sports, and commercial fishing or agricultural uses. The range of coliform levels from 72% of the samples analysed are in agreement with the values that reported by the Kerala State Pollution Control Board from other locations in the Kochi city (Irumpanam, Brahmapuram, Manackakadavu, Pathalam, and Manjummal) (KSPCB, 2020). The high Total Coliform values can be correlated to the HPC values of the study stations. The thermotolerant coliform levels typically show the faecal contamination of the water bodies. The domestic and market sewages that enter into the water bodies are the prime factors that contribute to the faecal contamination of the aquatic system. The faecal matter from cattle and other domesticated animals are also a rich source of thermotolerant coliforms (Geldreich, 1978). Therefore, cattle grazing near the canals and poultry wastes and wastes originated from other domestic pets also may be an important factor contributing to the high faecal coliform levels.

Table-3.45: Guideline values for verification of microbial quality

Purpose	Guideline value	Source	Reference
Potable water	Heterotrophic plate count (HPC) < 500 CFU/mL	Centers for Disease Control and Prevention, USA	CDC, 2003
Potable water	No *E. coli* or thermotolerant coliform/100 mL	WHO	WHO, 2008
Treated water entering the distribution system	No *E. coli* or thermotolerant coliform/100 mL	WHO	WHO, 2008
Irrigation of crops likely to be eaten uncooked, sports fields and public	1,000 CFU/ 100 mL	WHO	WHO, 2000

Purpose	Guideline value	Source	Reference
parks			
Urban reuse	No faecal coliform/100 mL	Environment Protection Agency, United States (USEPA)	USEPA, 2017
Agricultural reuse	Faecal coliform <200 CFU /100 mL;	USEPA	USEPA, 2017
Ground water recharge	No faecal coliform/100 mL;	USEPA	USEPA, 2017
Recreational use	Total Coliforms <200 CFU /100 mL	USEPA	USEPA, 2017
For Industrial cooling, Recreation (non-contact) and Aesthetics	Fecal Coliform ≤500 CFU /100 mL	CPCB, India	CPCB, 2000
For Bathing, Contact Water Sports and Commercial Fishing	Fecal Coliform ≤100 CFU /100 mL	CPCB, India	CPCB, 2000
For Harbour Waters, Navigation and Controlled Waste Disposal	Fecal Coliform ≤500 CFU /100 mL	CPCB, India	CPCB, 2000

Table-3.46: Mean values of bacterial counts in water and sediment samples

Sl No	Station	Heterotrophic Plate Count (HPC)	
		Water (CFU/mL)	Sediment (CFU/g)
1	Bolgatty	2.8×10^{6}	1.5×10^{6}
2	Maradu	2×10^{7}	8×10^{6}
3	Thuthiyoor	1×10^{7}	7×10^{7}
4	South Chittoor	6×10^{6}	3×10^{5}
5	Thevara	1.2×10^{7}	6×10^{7}
6	T1	6×10^{5}	2×10^{8}
7	T2	2.7×10^{7}	7×10^{6}
8	M1	2.1×10^{6}	1.8×10^{7}
9	M2	1.65×10^{7}	2×10^{7}
10	C1	2.1×10^{7}	2.7×10^{9}
11	C2	2.6×10^{7}	1.3×10^{9}

12	C3	2.8×10^7	2.4×10^9
13	E1	8×10^6	8×10^7
14	E2	1.6×10^7	1.2×10^8
15	E3	1.3×10^8	1.8×10^8
16	P1	1.5×10^7	1.2×10^9
17	P2	2.8×10^8	9×10^8
18	P3	1.2×10^7	1.05×10^9

Table-3.47:Mean values of coliform counts in water samples

Sl No	Station	Coliforms (CFU/100 mL)	
		Total Coliforms	Thermotolerant Coliforms
1	Bolgatty-Surface	2.3×10^3	1.6×10^3
2	Bolgatty-Bottom	3.3×10^3	2.8×10^3
3	Maradu-Surface	3.9×10^3	2.2×10^3
4	Maradu-Bottom	4.7×10^3	4×10^3
5	Thuthiyoor-Surface	3.9×10^3	3.4×10^3
6	Thuthiyoor-Bottom	3.3×10^3	2.7×10^3
7	South Chittoor-Surface	4.1×10^3	1.8×10^3
8	South Chittoor-Bottom	4.4×10^3	6×10^2
9	Thevara-Surface	3.4×10^3	1.4×10^3
10	Thevara-Bottom	4.8×10^3	3.1×10^3
11	T1-Surface	2.5×10^3	1.6×10^3
12	T1-Bottom	1.7×10^4	1.3×10^4
13	T2-Surface	5×10^2	4×10^2
14	T2-Bottom	3.5×10^3	2.6×10^3
15	M1-Surface	1.7×10^3	6×10^2
16	M1-Bottom	8.1×10^3	5.2×10^3
17	M2-Surface	3.7×10^3	2.4×10^3
18	M2-Bottom	1.3×10^3	8×10^2
19	C1-Surface	1.3×10^4	1×10^4
20	C1-Bottom	1.9×10^4	1.7×10^4
21	C2-Surface	2×10^4	1.5×10^4
22	C2-Bottom	2.9×10^4	2.4×10^4
23	C3-Surface	1.7×10^3	6×10^2
24	C3-Bottom	2.3×10^3	1.8×10^3
25	E1-Surface	7×10^2	3×10^2
26	E1-Bottom	1.1×10^3	8×10^2
27	E2-Surface	5.3×10^3	3.6×10^3
28	E2-Bottom	4.3×10^3	3.4×10^3
29	E3-Surface	8.9×10^3	7.6×10^3
30	E3-Bottom	1.5×10^3	1×10^3
31	P1-Surface	1.2×10^4	9.2×10^3
32	P1-Bottom	2.7×10^4	1.6×10^4
33	P2-Surface	2.4×10^4	1.8×10^4
34	P2-Bottom	2.5×10^4	1.9×10^4
35	P3-Surface	2.2×10^4	1.6×10^4
36	P3-Bottom	9.8×10^3	5.6×10^3

3.15.3 Pytoplankton, Zooplankton and macrobenthos

From the five canals 32 groups of phytoplankton, 11 groups of microzooplankton, 14 groups of mesozooplankton and four groups of macrofauna were identified (Table-3.48 to 3.50). Compared to zooplankton and macrobenthos, phytoplankton were the dominant fauna during the study period. Bdelloids rotifer were the most dominant zooplankton reported from all the stations. Polychaete larvae, chironomid larvae were the second dominant groups whereas fish larvae reported only from market canal. Clam, mussel, barnacle and gastropod were the macrofauna recorded from the canal and diversity and abundance were very low compared to the reference stations.

Table-3.48: List of phytoplankton in Kochi canals

Phytoplankton					
Organism	**Thevara**	**Market**	**Edapally**	**Chilavannur**	**Perandoor**
Navicula	+	+	-	-	-
Thalassiosira	+	-	+	-	+
Oscillatoria	+	+	+	+	+
Pennate diatom	-	+	+	+	-
Nitzchia	+	+	+	-	-
Trichodesmium	-	+	+	-	-
Gyrosygma	-	+	-	-	-
Peridinium	+	+	+	+	+
Planktothrix	+	-	-	+	+
Aphanothece	-	-	-	+	-
Synedra	-	-	+	+	-
Triceratium	-	-	+	-	-
Leptocylindrum	+	+	+	-	-
Pediastrum	+	-	-	-	+
Spirulina	+	-	-	-	+
Pleurosigma	+	+	-	-	-
Achnathes	+	-	-	-	-
Coscinodiscus	+	+	+	-	-
Phacus	+	-	-	-	-
Volvox	+	-	-	-	-
Euglina	+	-	-	-	-
Pseudonitzchia	+	+	-	-	-
Cyclotella	+	+	-	-	+
Plagiotropis	-	+	-	-	-
Amphora	-	+	-	-	-
Coleastrum	+	-	-	-	-
Ceratulina	+	-	-	-	-
Odontella	+	-	-	-	+
Anomoeonoeis	-	-	-	-	+
Aphanizomenon	-	-	+	-	-
Spirogyra	-	-	+	-	-
Cryptomonas	-	-	+	-	-
* +Present -Absent					

Table-3.49:List of zooplankton in Kochi canals

Mesozooplankton					
Organism	**Thevara**	**Market**	**Edapally**	**Chilavannur**	**Perandoor**
Rotifers (Bdelloids)	+	+	+	+	+
Cladocera	+	-	+	+	+
Crustacean nauplii	-	+	-	+	+
Cyclopoid copeod	-	-	+	-	-
oligochaete	-	-	-	+	-
polychaete larvae	-	-	-	+	+
water insect	-	-	-	+	-
Chironomid larvae	-	-	+	+	+
Gastropod larvae	-	-	+	-	+
Zoea	-	-	+	-	-
Water bug (insect)	-	-	+	+	-
Calanoid copepod	-	+	+	-	+
Ostracod	-	-	-	-	+
Fish larvae	-	+	-	-	-
Microzooplankton					
Organism	**Thevara**	**Market**	**Edapally**	**Chilavannur**	**Perandoor**
Copepod	-	+	+	+	-
Rotifers (Bdelloids)	+	+	+	+	+
cladocera	+	-	-	+	+
Nematode	-	-	-	+	-
ostracod	-	-	+	+	-
polychaete larvae	+	-	-	+	-
crustacean nauplius	-	-	-	+	-
cladocera	-	-	-	+	-
chironomid larvae	-	-	+	+	+
Cyclopoid	-	-	-	-	+
cyphonatius larvae	-	-	-	+	-
* +Present -Absent					

Table-3.50: List of macrobenthos in Kochi canals

Macrobenthos					
Organism	**Thevara**	**Market**	**Edapally**	**Chilavannur**	**Perandoor**
Clam	+	-	-	-	-
Mussel	+	-	-	+	-
Barnacle	+	-	-	-	-
Gastropod	+	-	+	+	+
* +Present -Absent					

3.15.4 Mangroves

Structural analysis of mangroves of the study area

Altogether seven true mangrove species were observed in Thevara canal region, coming under six genera belonging to four families – as classified by Tomlinson (1986) and Spalding et al. (2010). The species identified were *Rhizophora apiculata* Bl., *R. mucronata* Poir., *Avicennia officinalis* L., *Kandelia candel* (L.) Druce, *B. gymnorhiza* (L.) Lamk, *S. caseolaris* (L). Engler, and *Acrostichum aureum* L. In T1 station, the density of true mangrove species ranged from 133-6800/ha whereas basal area ranged from 8.6-2021m^2/ha. *Avicennia* *officinalis* was found to be the densest species whereas *Rhizophora mucronata* contributed to maximum basal area. Unlike T1, a *Rhizophora mucronata* (density 2267/ha, basal area 7262 m^2/ha) dominated mangrove forest was observed in T2 station. The dominance of *Acrostichum aureum* (mangrove fern) was observed in all the other study sites. In the other canals- Perandoor, Edapally, Chilavannoor and Market canal, mangrove vegetation were almost scarce.

Zonation pattern

The species zonation pattern differs clearly from site to site. In general, a seaward assemblage of *Avicennia*, *Sonneratia*, *Kandelia* and *Rhizophora* species and landward assemblage of *Bruguiera* were observed along the entire coast. *B. gymnorhiza*, and *Acrostichum aureum* were limited to the landward zone in all the sites.

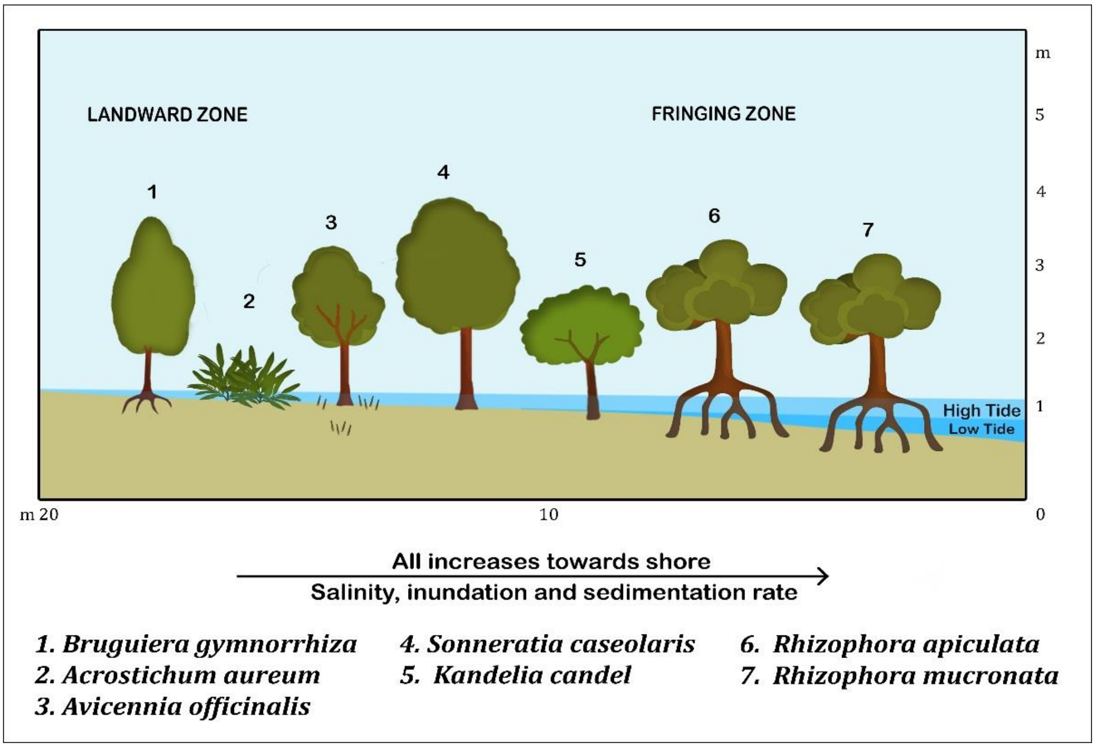


Figure-3.15: Image showing Zonation pattern of mangroves in Thevara canal

3.16. ARCHEOLOGICALLY IMPORTANT AREA

Mattancherry palace and St. Francis Church are the notified archeological important area as per archeological survey of India (ASI), coming in the 10 km radius of project area.

Mattancherry Palace Museum, Kochi

The palace was built around 1545 AD by the Portuguese and presented to Veera Kerala Varma as a generous gift by them. It underwent major repairs and renovations by the Dutch and hence the palace is also known as "Dutch Palace." The palace represents the blending of the European and Indian styles of architecture.

The present museum was established in May 1985 housing a variety of exhibits such as portraits of the Cochin Kings, palanquins, dresses, weapons, three royal umbrellas, canopy, dolis, swords, stamps and coins etc. The life-size portraits of the kings of Cochin from 1864 onwards are displayed in a long hall originally served as coronation hall. The weapons on display are sheathed swords, daggers and axes besides ceremonial spears decorated with feathers.

There are two temples dedicated to Lord Krishna and Shiva respectively. The upper story of the palace where the present museum is housed consists of a coronation hall, bed chamber, ladies chamber, dining hall and other rooms.

The glory of the palace lies in its mural paintings covering an area of nearly 300 sq.m executed in three phases. The themes depict scenes from Ramayana.

St. Francis Church, Kochi

St. Francis Church is one of the earliest European churches in India well known for its beautiful architecture and ambience. The church's history dates back to 1503 A.D when the Portuguese erected a wooden church dedicated to St. Bartholomew within the temporary fort made with mud and bamboo at Kochi.

The church is also known for its architectural style with old world charm and magnificence being very visible on every element of the church – the pulpit made of wood decorated with carvings, baptism platform, the offering etc. There is also a cenotaph in the middle of the lawn and it was built in 1920 in remembrance of the Kochiites who laid down their lives in World War I.

The famous explorer Vasco Da Gama, the first Portuguese sailor to reach the shores of Kerala, died here in 1524 during his third visit to Kochi. He was buried in this Church. After 14 years, his body was taken back to Portugal. His burial spot inside the church is clearly marked out and has drawn visitors ever since.

There are also several inscriptions on leaves, depicting the life and times of the Portuguese and the Dutch.

3.17. SOCIO-ECONOMIC ASPECTS

3.17.1 Socio Economic Profile of the Influence Area

The project command of the proposed IURWTS project falls in a rapidly urbanized coastal and estuarine region, which delimits within the Kochi corporation and three municipalities, viz., Kalamassery, Thrikkakkara, maradu of Kochi city

Kochi Corporation Wards: There are 41 Corporation wards of Kochi Corporation are coming under the influence of the project. As per the 2011 censes total population of Kochi corporation is 6,33,553 and density of population 5,914/km2.The average literacy rate is 96.29%(Male:97.64 and Female:94.99). Sex ratio shows that 1000 Males having 1030 female and it is just below the state average. 3.85% of population are belongs to scheduled cast (socially vulnerable).Only 2,344 people are schedule tribe (Indigenous). As per the 2011 censes 58% of population is unemployed.

Maradu Municippality: Five wards of Maradu Municipplality coming under the project influence. Total population recorded in 2011 censes is 44,704. Religious distribution says that 49.23% are Hindus, 35.67% are Christians and 14.87% are muslims. Cast wise 8.81 % are scheduled cast and 0.58% are Sheduled tribes. Literacy rate is 85.5%. Sex ratio shows that 1000 male having 1016 female and it is below the state average.

Thrikkakkara Municipality: Seven wards of Thrikkakkara Municipality coming under the influence of the project. As per the 2011 censes the total population of the municipality is 77,319 and density of population is 2800/km2.Religious distribution says that 49.42% are Hindus, 27.01% are Christians and 21.92% are Muslims. The Cast distribution shows that 15.71 % are Scheduled cast and 0.44% are scheduled tribes. Literacy rate is 93.75 and sex ratio is 1000: 1002.

Kalamassery Municipality: Three wards of Kalamasserry Municipality coming under the project influence. As per the 2011 cense the total population of the municipality is 70776 having literacy rate of 95.87%. Sex ratio is 1000:1011. Religious distribution says that 41.77% are Hindus, followed by 34.53% Muslims and23.42% Christians. Cast distribution shows that 7.93% are scheduled cast and 0.54% is scheduled tribe.

3.17.2 Details of project affected families

Project implementation agency appointed M/s. Kerala Voluntary Health Services (KVHS), Kottayam for conducting the social impact assessment study. As per the study 1641 families are affected by the project. The

Caste & Religion Profile

The distribution of population among project affected people on the basis of caste is summarized in Table-3.51 and Figure-3.16.The General Caste is the dominant caste in the study area accounting for about 57 % of the total PAFs. The cast distribution shows that 8% Title holders belongs to Scheduled Cast and 1% are Scheduled Tribe. But 35% of title holders are belongs to Other Backward Community. Religious distribution shows that 36% are Hindus and 13% are Muslims and 51% are Christians. The details are given in Table-3.52 & Figure-3.17.

Table-3.51: Caste profile of affected families

Name of Canal	Social Category					
	Scheduled Cast (SC)	Scheduled Tribe (ST)	Other Back Ward Class (OBC)	General	Other	Total
Thevara	19	0	30	52	0	101
Thevara-Perandoor	77	6	216	338	0	637

Name of Canal	Social Category					
	Scheduled Cast (SC)	Scheduled Tribe (ST)	Other Back Ward Class (OBC)	General	Other	Total
Edappally	22	4	118	254	0	398
Chellavannur	14	2	169	258	0	443
Market	1	1	33	27	0	62
Total	**133**	**13**	**566**	**929**	**0**	**1641**

Source: Social Impact Assessment Study by KVHS.

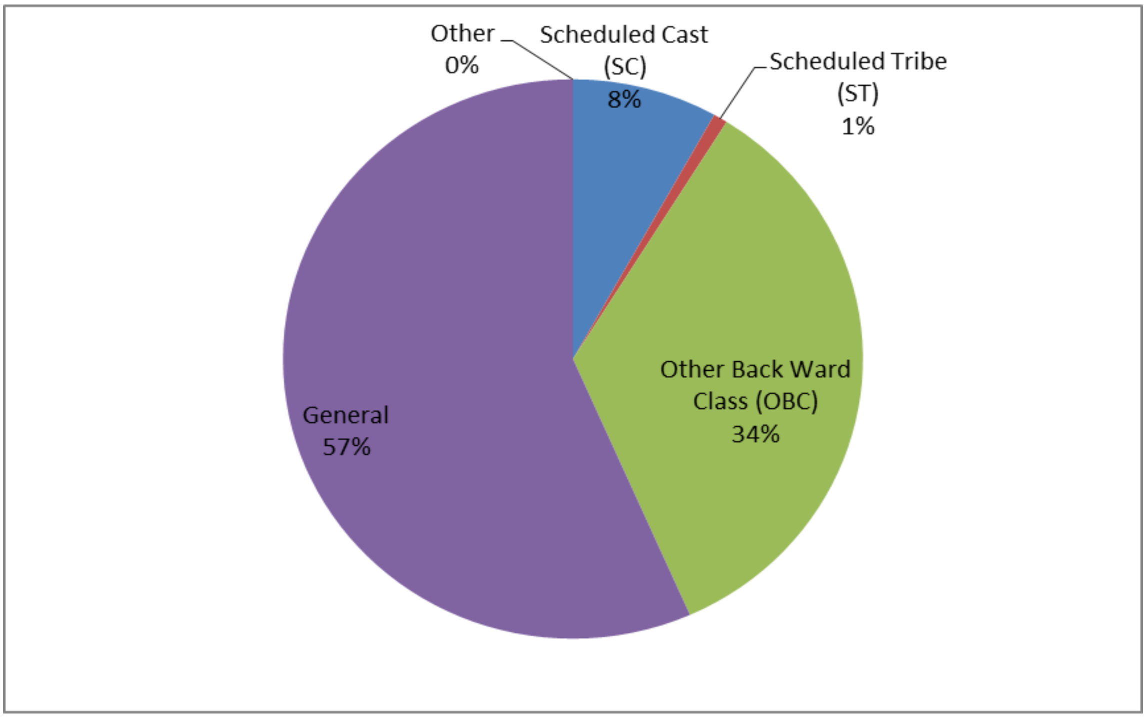


Figure-3.16: Caste profile of project affected families

Table-3.52: Religious wise distribution of AffectedFamilies

Name of Canal	Religious Category				
	Hindus	Muslims	Christians	Other	Total
Thevara	45	4	52	0	101
Thevara-Perandoor	219	34	384	0	637
Edappally	161	77	159	1	398
Chillavanoor	143	84	216	0	443
Market	18	13	31	0	62
Total	**586**	**211**	**842**	**1**	**1640**

Source: Social Impact Assessment Study by KVHS.

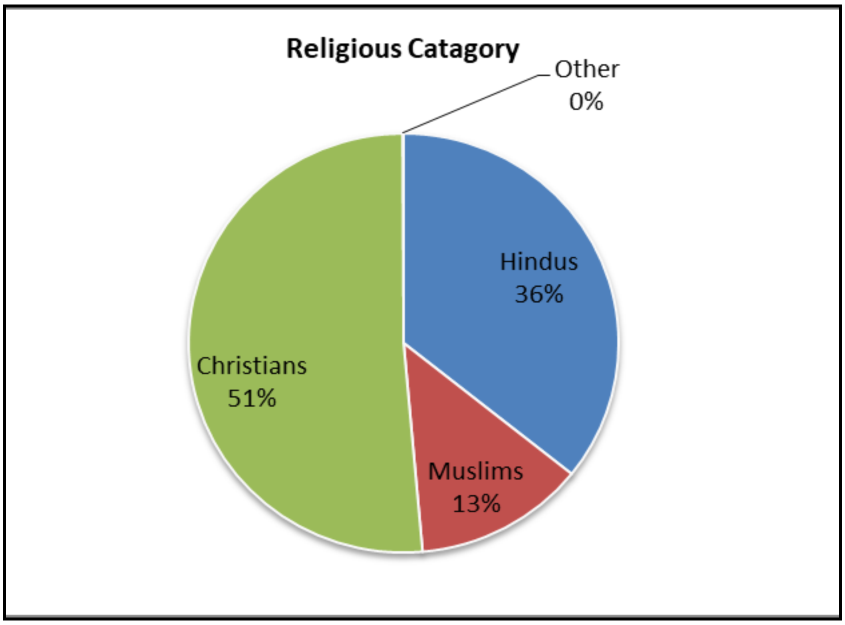


Figure-3.17: Religious profile of project affected families

Literacy Levels

The details of literate and illiterate population amongst the tota project affected families are shown in Table-3.53. It is observed that about 100 % of the PAFs are literate and 82 % are having SSLC and above qualifications.

Table-3.53: Distribution of literate in affected families

Name of Canal	Literacy Level							
	Illiterate	Below 10th	SSLC	11th & 12th	Degree	PG/ professional	Other	Total
Thevara	0	13	44	16	7	4	17	101
Thevara-Perandoor	0	133	245	143	42	24	50	637
Edappally	0	62	144	89	51	25	27	398
Chilavanoor	0	71	195	69	39	34	35	443
Market	0	19	15	12	6	7	3	62
Total	**0**	**298**	**643**	**329**	**145**	**94**	**132**	**1641**

Source: Social Impact Assessment Study by KVHS.

Occupational profile

The details on occupational profile in the project affected families are given in Table-3.54 and in Figure-3.18. It is observed that 45% of the total population is working in private companies. On the other hand, Non-workers or persons who are dependent on the population, which is engaged in economically productive work accounts for about 3 % of the total population. Among the population that is working about 5 % has been designated as government employees.

Table-3.54: Occupational profile in the project affected families

Name of Canal	Employment Status							
	Government	**Private**	**Self-Employed**	**Business**	**Coolie**	**Unemployed**	**Others**	**Total**
Thevara	4	10	20	32	19	7	9	101
Thevara-Perandoor	39	301	32	190	48	20	7	637
Edappally	19	196	23	104	38	9	9	398
Chilavanoor	16	217	26	131	33	7	13	443
Market	0	19	3	31	4	1	4	62
Total	**78**	**743**	**104**	**488**	**142**	**44**	**42**	**1641**

Source: Social Impact Assessment Study by KVHS.

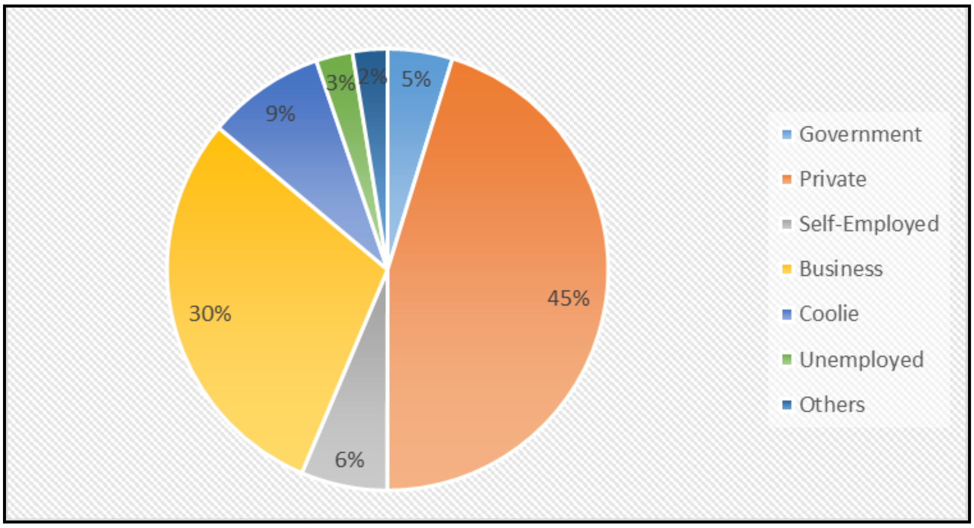


Figure-3.18: Occupational profile in the project affected families

CHAPTER – 4

ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

4.1 INTRODUCTION

Based on the project details and the baseline environmental status, potential impacts that are expected to accrue as a result of the proposed project have been identified. The assessment for quite a few disciplines is subjective in nature and cannot be quantified. Wherever possible, the impacts have been quantified. However, for non-tangible impacts, a qualitative assessment has been done so as to formulate appropriate management measures for them as well. This Chapter deals with anticipated positive as well as negative impacts due to the construction and operation of the proposed project and strategies to mitigate them.

The proposed project envisages the Integrated urban regeneration and Inland water studies for a catchment encompassing of 5 canals covering one third of Kochi corporation and part of 3 municipalities (Kalamassery, Thrikkakara, and Thripunithura adjoining the eastern side of Kochi corporation. The Urban regeneration part is addressed by

1) Covering the entire catchment with sewer house hold connectivity, sanitation facilities in areas not approachable by sewer network, solid waste management collection measures and integrating the conveyance and treatment in association with the existing enhanced corporation facilities of Waste to Energy plant at Brahmapuram plant.

2) By addressing the catchment with a Canal Oriented development (COD) by providing beautification measures to enhance the tourist potential proposed in the catchment.

The rejuvenation of the existing 5 canals in IURWTS catchment to its original width as per the FMB village records and providing adequate depth (limiting the depth to the moorum layer) for movement of small vessels is designed to improve the inter modal connectivity with Rail metro and canal metro to serve passenger traffic.

The following section describes the various impacts and mitigation measures suggested to minimize the impacts due to the proposed project.

4.2 IMPACTS DURING CONSTRUCTION PHASE

The impacts during construction phase will be localized and short-term and primarily related to civil works and erection of equipment. The duration of impact will be limited to the construction phase of 24 months only. The following activities may cause environmental impacts during construction of the proposed project:

- Site preparation
- Excavation and backfilling
- Hauling of earth materials
- Piling, cutting and drilling
- Dredging (deepening and widening activities) activities
- Erection of concrete and steel structures
- Noise from heavy equipment operation

- Road construction
- Painting and finishing
- Clean up operations
- Landscaping and Green belt development

The details of activities and probable impacts during construction phase are depicted in Table 4.1.

Table 4.1: Identification of Activities & Probable Impacts during Construction Phase

Activities	Sector	Anticipated Impacts
Site clearing and levelling (cutting, stripping excavation, earth movement, compaction)	Air	Fugitive dust emission
		Air emission from construction equipments and machinery
	Water	Run off from grass stripped area.
	Land	Loss of fertile top soil
		Change in drainage pattern
	Ecology	Loss of vegetation
Transportation and storage of construction material/ equipment	Air	Air emission from vehicles
		Fugitive dust emission due to traffic movement
	Water	Spilling of construction material and flow into streams.
		Run–off from storage areas of construction material
	Soil	Deposition of spilled construction material and flow into streams
	Public utilities	Increased flow of traffic and congestion
Civil construction activities	Air	Fugitive dust emission from construction
	Water	Run–off from erection areas containing oils, paints
	Socio-economic	Increase in employment
Influx of labours	Socio-economic	Stress on infrastructure
		Stress on social relation

4.2.1 Impact on Land Environment

a) Impacts due to pre-construction activities

Pre-construction activities include the Clearing, stripping and levelling the sites, earth filling, excavation for foundations and construction activities would result in generation of debris and construction wastes. Since, the proposed development is taking place near to the road side and some area is accessible to the boats, the existing routes would be utilised for gaining access for construction. Thus, impacts on land environment during pre-construction phase are not expected to be significant.

b) Impacts due to the acquisition of land

The proposed project envisages construction of 30 small jetties, 4 STPS, 56 road bridges, 31 foot bridges, Sewerage networks and canal oriented developmental activities. The total land requirement for the jetties, STPs, road and footover bridges has been estimated as 41 ha of which 13.68 ha is govt. land, 9.65 ha is government land in private possession and 17.37 ha is private land. Canal shall be developed to the original width as per the FMB village records.

Mitigation measures: The project is proposed along Edappally, Thevara, Thevara-Peranoor, Chilavanoor and Market canals and land is to be acquired along periphery of the canal as per the FMB village records. As private land is proposed to be acquired, appropriate compensation shall be paid to the PAFs.

c) Impacts due to quarrying and reclamation

The proposed jetties are proposed on the bank of canals, and envisages the construction of passenger Boat Jetty and the STPs as major construction work. Various construction materials shall be used for the construction work shall be used from the existing quarry. The proposed site needs to be levelled for construction activities. Reclamation is proposed in the STP sites and low lying canals banks.

The quantity that will be required for developing the low lying areas as part of canal beautification proposed is estimated as 90,000m^3 and embankment using soil bio-engineering measures is proposed at suitable low lying areas on either side of canals, with a base width 1 m , top width .7 m and height of .7 m. Total quantity that assessed is 36650 m^3. The total quantity estimated from deepening is 4,54,013m^3 and from widening is 241401 m^3 totalling to 6,95,414m^3 . Out of the total quantity estimated 20 percent is proposed to be used for canal embankment, landscape works and remaining conveyed to land filling sites. Based on analysis of the samples, it can be concluded that the sediments are not toxic in-situ, and will not become so even after the disposal. The analysis report by KEIL is attached as **Appendix-5** The cutting material to be used for reclamation is non-toxic and uncontaminated. Hence, adverse impacts on water quality on account of the use of dredged material for reclamation are not anticipated.

Mitigation measures: The levelling and reclamation is proposed to be undertaken using the earth obtained from deepening and widening of the proposed canals. No exclusive quarries are proposed for these projects and construction material will be procured from the existing quarries or from other available sources in the vicinity of the project area.

d) Impacts due to construction activities

The major components envisaged as a part of the proposed project includes construction of Jetty, Terminal and various foot over bridges and road bridges and STPs, etc. The construction material required for the project is proposed to be brought from nearest market/quarry and, which is about 10-100 km from the project site.

Mitigation measures: There is only small vegetation on the land to be acquired for the proposed sites and no major wildlife has been reported in the area. The following measures shall be implemented:

- Awareness programmes shall be undertaken to sensitize workers so as to avoid the loss of vegetation and disturbance to the faunal species in the area.
- No exclusive quarries are proposed for these projects.
- During transportation of the material care shall be taken to avoid damages to the Air and Noise environment.
- On completion of construction activities, surplus materials, debris, discarded boxes, containers, drums etc; will be removed from the site and disposed in designated disposal site.

e) Impact due to disposal of solid waste

During construction phase, the domestic solid waste generated will contain mainly vegetable matter followed by paper, cardboard, packaging materials, wood boards, polythene, etc. Proper solid waste management shall be based on the principle of reduce, reuse and recycle and adequate facilities for collection and conveyance of municipal wastes generated at each post shall be developed. Garbage bins will be kept for collection of solid waste at appropriate locations construction site. Solid waste will be disposed off at designated landfill sites to be identified in consultation with local administration under contractors scope

These wastes are generally classified in to bio-de- gradable and recyclable. The solid waste will be collected and disposed as per the Solid Waste management Rule 2006. The estimated daily generation rate, collection mode and disposal of solid waste generated during construction phase is presented in **Table-4.2**.

Table-4.2: Quantification of Solid Waste Generated during Construction Period

Type of waste	Assumption	Quantity of waste generated (kg/day)	Storage & disposal
Organic waste – food waste	Generation rate of organic waste is 0.18kg/day. Average number of workers per day assumed is 2500	450	Collected in closed green colored bins and send to the biogas plant under scope of contractor.
Recyclable waste - paper , plastic , pack- ages , and other inert	Generation rate of recyclable waste is 0.02 kg/day. Average number of workers per day assumed is 2500	50	Collected in closed white colored bins for subsequent transfer for recycling under contractor's scope.
Other wastes	Lump sum		Collected in closed black colored bins for subsequent authorized disposal under scope of contractor.

Mitigation measures: The solid waste management shall be based on the principle of reduce, reuse and recycle and adequate facilities for collection and conveyance of municipal wastes generated at each post shall be developed. Garbage bins will be kept for collection of solid waste at appropriate locations at each construction site. Solid waste will be disposed off at designated landfill sites to be identified in consultation with local administration.

4.2.2 Impact on Water Environment

a) Impacts due to effluents from labour camps

During construction phase, about 2400 workers are likely to be engaged in the project. The details are given in Table-4.3.

Table-4.3: Details of manpower involved

Components	Number of labour in each facility	Number of facilities	Total
Jetties	20	30	600
STPs	50	4	200
Road Bridges	20	56	1120
Foot over Bridges	15	31	465
Total			**2385 say 2400**

The labour involved in construction phase will be mainly would from the nearby villages and migrant workers. However, technical manpower is likely to be deployed from outside and will stay near the site during construction phase. It is assumed that about 25% of the total labourers and technical staff will come from outside.

About 100 technical manpower is required for the project. The total increase in population during the construction phase will be of the order of 2500 during construction phase. Considering 25% of labour population to come from outside, about 625 persons would be staying in various labour camps as the site is distributed in the vast area.

The total water requirement for the technical manpower @ 135 lpcd and workers during construction phase has been estimated as 27 m^3/day. The details are given in Table-4.4.

Table-4.4: Details of Water requirement during construction phase

Description	Water Requirement (m^3/day)
Technical Manpower @ 135 lpcd	13.50
Labour population involved in construction work @ 45 lpcd for 2400 persons	108.00
Labour population staying at construction site @ 70 lpcd for 625 persons	43.75
Total	**165.25**

The sewage generated is normally taken as 80% of the total water requirement. Thus, the sewage generated would be of the order of 132.2 m^3/day. The disposal of sewage without treatment could lead to significant problems related to water pollution and public health. The disposal of sewage without treatment can cause problems of odour and water pollution. The typical composition of untreated sewage is given in Table-4.5.

Table-4.5: Typical composition of untreated sewage

Parameters	Value
Total Solids, mg/l	720
Total Dissolved Solids, mg/l	500
Total Suspended Solids, mg/l	220
BOD mg/l	220
Oil and grease, mg/l	100
Alkalinity (as $CaCO_3$), mg/l	100
Total Phosphorus, mg/l	80
Total Nitrates, mg/l	40
Bicarbonates, mg/l	100
Carbonates, mg/l	10
Nitrates, mg/l	40
Phosphates, mg/l	40
Chlorides, mg/l	50
Sulphates, mg/l	30
Calcium, mg/l	40
Magnesium, mg/l	40
Potassium, mg/l	15
Sodium, mg/l	70

Normally untreated sewage would find its way to natural drainage system which ultimately confluences into the lake. It is proposed to treat the sewage from labour camps before disposal.

Mitigation measures: Proper infrastructure for storage and if required treatment e.g. disinfection or other units, shall be provided to ensure potable water supply to the labour population.

During construction phase, total about 132.2 m^3/day of sewage is expected to be generated at all the proposed sites. One community toilet shall be provided for 20 persons at the each site and construction camps. The sewage from the community toilets can be treated in a septic tank with biodigester. The treated effluent can be used for meeting irrigation requirements of areas being afforested under greenbelt development. The total cost required shall be Rs.125.0 lakh. The details are given in Table-4.6.

Table-4.6: Cost estimate for sanitation facilities in labour camps

Item	Unit	Number	Total cost (Rs. lakh)
Community toilet	Rs.50,000/community toilet	150	75.0
Bio digester	Lumpsum		50.0
Total			**125.0**

Responsibility: *The contractor shall be responsible to implement the managements measures suggested for water environment during construction phase. These aspects will be made mandatory as a part of the contract agreement.*

b) Effluent from other sources

Substantial quantities of water would be used in the construction activities. With regard to water quality, waste water from construction activities and runoff from construction site would mostly contain suspended impurities. Adequate care should be taken so that excess suspended solids in the wastewater are removed before discharge into water body.

Mitigation measures; The effluent is proposed to be treated by collecting waste water and runoff from construction sites and treating the same in settling tanks. The settling tanks shall be so designed that it has a detention time of 1.5 to 2 hours. No flocculants I are proposed to be used for this purpose.

c) Effluent from workshops, oil storage, etc.

The effluent from workshops, oil storage, etc. will contain oil and grease and needs to be treated prior to disposal.

Mitigation measures: The effluent shall be treated in oil skimmer and the decanted effluent shall be disposed. The collected oily matter is stored in cans, etc. and disposed through authorized vendors of the Pollution control board

d) Impacts due to deepening operation

The depth of canals have been reduced over time as there are uncontrolled dumping on canal banks and to maintain navigation depth dredging activities are proposed to be undertaken.

As per the navigation standards of IWAI, for a canal influenced by tidal level fluctuations a minimum navigation requirement depth is to be maintained all throughout the year. To fulfil the depth requirement, the criteria as per standard guidelines for small canals was followed. A depth of 1.2 m below the low water level (LWL) of +0.3m MSL is estimated and the deepening quantity estimated accordingly. The quantity estimated from deepening is 4,54,013 m^3 and from widening is 241401 m^3, Thus total quantity to be dredged is 6,95,414m^3 (refer Table-4.7). Out of the total quantity estimated 20% is proposed to be used for canal embankment, landscape works and remaining conveyed to land filling sites. Before transportation, excavated earth will be deposited over polythene sheets in the 2m width land acquired, on either side at different stretches. The soil will be conveyed after the water content in the soil is drained back into the canal and fit for conveying.

Table-4.7: Details of dredging quantity from each canal

S. No	Name of the Canal	Deepening Quantity (m3)	Widening Quantity (m3)	Total
1	Edappally Canal	1,66,607.77	46,768.34	2,13,376.11
2	Chilavanoor Canal	1,41,591.12	1,09,554.11	2,51,145.23
3	Thevara_Perandoor Canal	1,14,539.16	74,872.30	1,89,411.46

S. No	Name of the Canal	Deepening Quantity (m3)	Widening Quantity (m3)	Total
4	Thevara Canal	24,641.47	2,688.10	27,329.57
5	Market Canal	6,633.53	7,518.35	14,151.88
	Total	**4,54,013**	**2,41,401**	**6,95,414.00**

The deepening and other construction activities normally increase the turbidity levels in the water column. The change in water-column turbidity during deepening is a short-term impact. The increase in turbidity lasts as long as the material is being excavated. The turbidity level returns to the pre-project level after the operations. The time required for the turbidity level to return to its original turbidity level increases with the increase in clay content. The turbidity increase also depends on the type of dredging method adopted.

The innovative dredger Dino 6 available in international markets is generally used for widening canals with lesser width. This dredger has the capability of cutting the soil with a cutter fixed on the front side. The dredged or excavated soil is sucked by means of powerful submersible pumps and transported to the shore in slurry form through a pipe. The end of the pipe is connected to geo-synthetic tubes placed in the shore and the same used for low lying area filling. Hence, the whole process has no adverse impact on the ecosystem within the canal and canal banks.

e) Disposal plan for Deepening and widening of canals

Impacts due to disposal of dredged material

Long boom excavators and pontoon operated excavators will unload the dredged material to the area of 2m acquired on either sides of the canal through land acquisition process and the same is proposed to be used for land filling and grading of land on either sides of the canals. Out of the total quantity estimated 20% is proposed to be used for canal embankment, landscape works and remaining conveyed to land filling sites. Before transportation, excavated earth will be deposited over polythene sheets in the 2m width land acquired, on either side at different stretches. The soil will be conveyed after the water content in the soil is drained back into the canal and fit for conveying. The Quantity of the material to be conveyed for disposal is 4,29,681 m^3. The details are given in Table-4.8.

Table 4.8: Details of Quantity of materials to be disposed

S No.	Total deepening quantity (m^3)	Total widening quantity (m^3)	Total quantity available after deduction of 20% as slump (m^3)	Total quantity for bio engineering embankment filling (m^3)	Total quantity Canal beautification (m^3)	Total quantity to be conveyed (70 %) (m^3)
1	4,54,013	2,41,401	5,56,331	36,650	90,000	4,29,681

The disposal of dredged soil from the canals, shall be disposed of to M/s Kerala Enviro Infrastructure Ltd (KEIL), is operating “Common Treatment, Storage and Disposal Facilities (TSDF) Project. The agreement with KEIL and KMRL for the disposal of the material is given in **Annexure-III.** The proposed soil disposal would be done in the existing KEIL landfill site premises as shown in Figure 4.1.

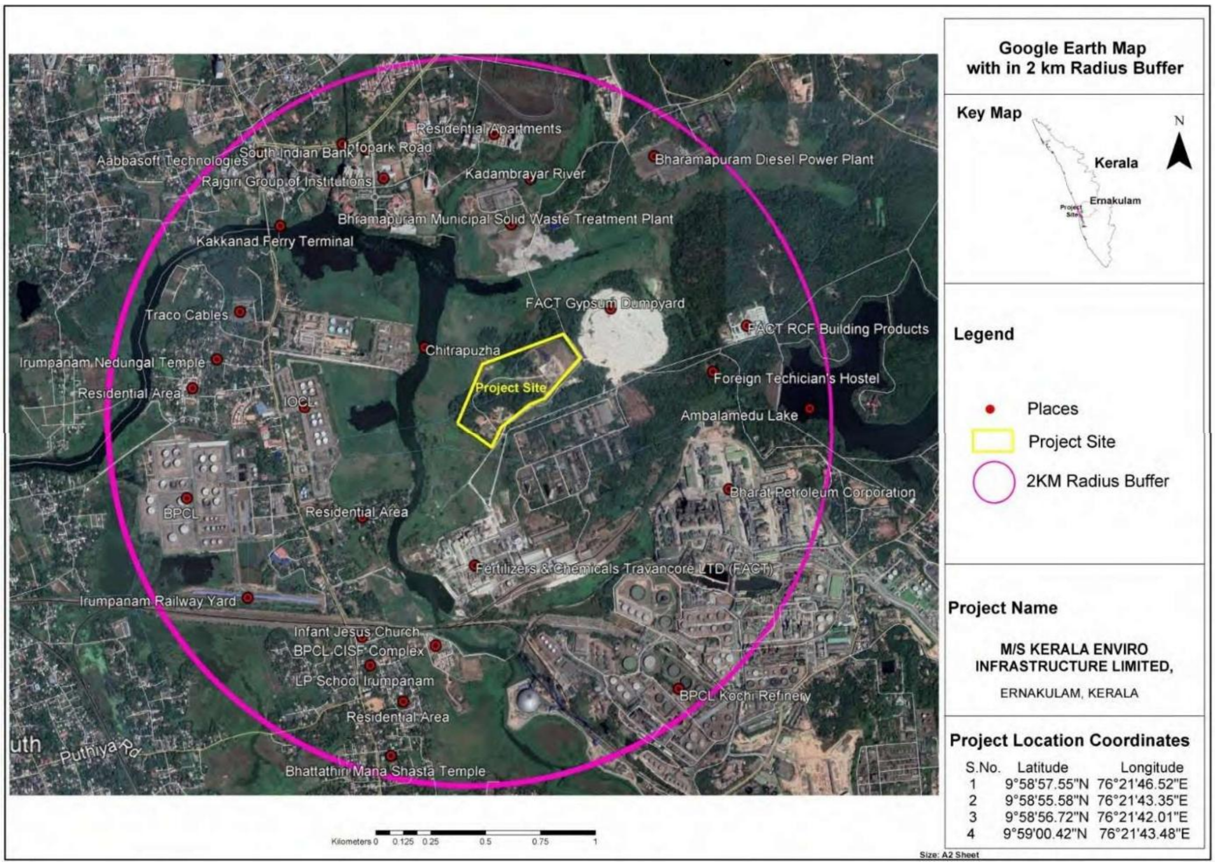


Figure 4.1: Existing KEIL landfill site premises

The Common TSDF site of KEIL is situated inside the FACT-Cochin Division Campus. The FACT property at Ambalamedu is in the Puthenkurissu Village, Kunnathunad Taluk of Ernakulam District. It is a very extensive property spanning over 1470 acres. The areas surrounding the FACT property, i.e. Ambalamugal, Karimugal, Irumbanam and Brahmapuram, are mostly occupied by major industrial activity. The major industries in the vicinity are BPCL-Kochi Refinery, HOCL, Petroleum Storage Terminals of IOCL, BPCL & HPCL, Philips Carbon Black Ltd and KSEB’s Brahmapuram Power Station.. There are vast sectors of unused lands, which are now home to trees and bushes and are forest like.

The site is selected based on the following considerations:

- KEIL is already operating the common TSDF at 50 acres of land in block no. 37, survey no. 205 of Puthenkurissu village, Kunnathunad taluk, Ernakulam district.
- The distances from IURWTS canals to the KEIL landfill is minimal. The maximum distance from the IURWTS to the proposed landfill site is 20.2 as seen in the Table 5 and Figure-4.2.

The samples has analysed in the KEIL and found to be used for the disposal at the KEIL disposal site. Since KEIL authorities have come up with a requirement for excavated soil for filling the land fill site,

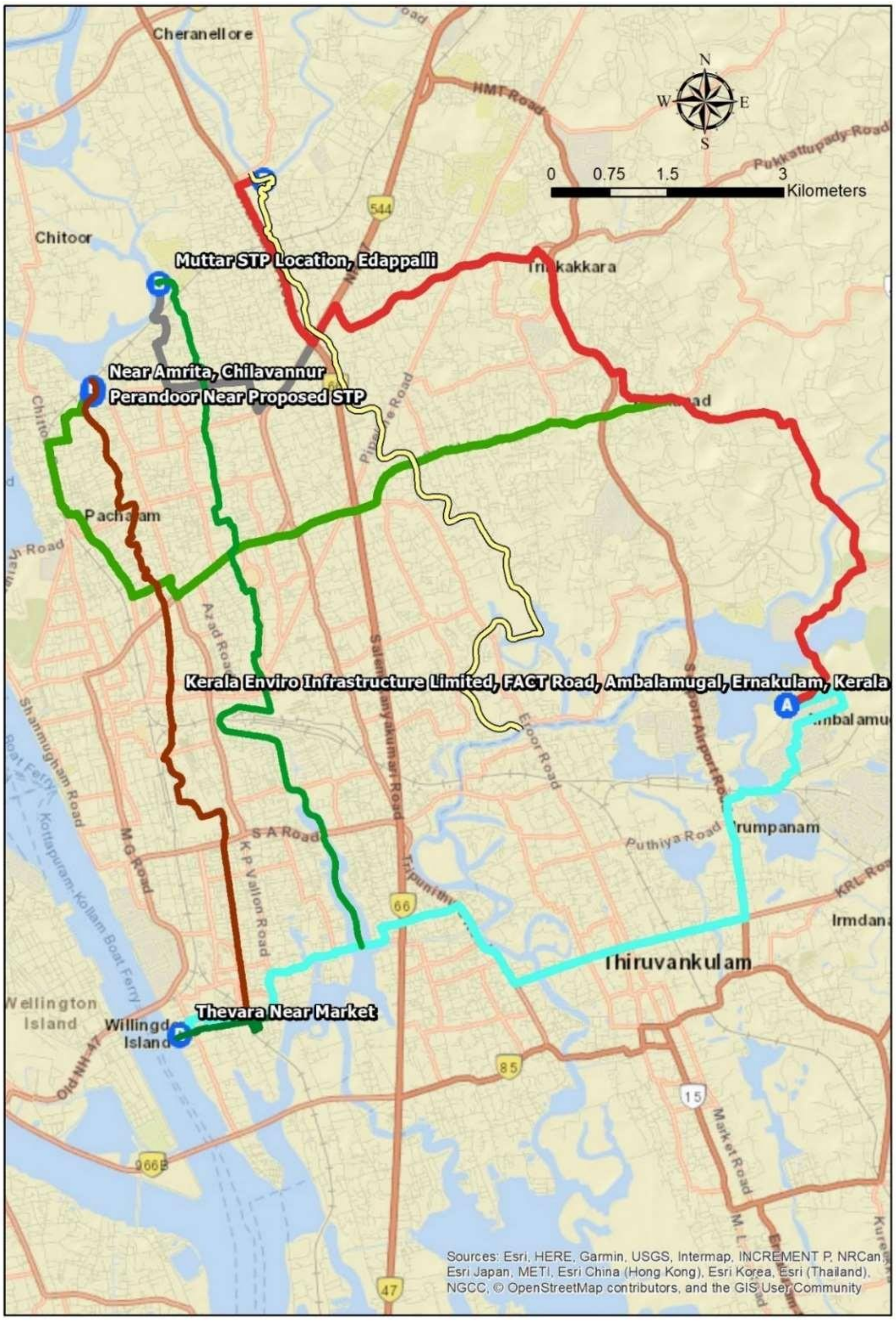


Figure-4.2: Distance of KEIL landfill site from each canal

4.2.3 Impacts on Terrestrial Ecology

Proposed project site is located in various parts of Kochi and no forest land is envisaged as a part of the project. The direct impact of construction activity for any project is generally limited in the vicinity of the construction sites only. Around 1357 plant trees are proposed for cutting in the various banks of the canals and details are given in Table-4.9. compensatory afforestation is proposed as part of the project and details are given in green belt plan section.

Table-4.9: Details of Tree cutting as part of IURWTS Project.

S. No	Canal	LHS	RHS	Total
1	Edappally Canal	203	212	415
2	Chilavanoor Canal	299	239	538
3	T-P Canal	204	159	363
4	Thevara Canal	31	10	41
	Total			**1357**

The study area has no major forest cover. Hence, no significant impacts are envisaged on terrestrial flora as a result of the construction and operation of the proposed project.

Mangalavanam is a small patch of primarily mangrove species in a small tidal wetland, situated amidst Kochi, in Ernakulam district, Kerala. The mangrove serves as a shelter for birds both residents and migratory. The sanctuary is located at a distance of about 300 m from Market Canal (Refer Figure-4.3). NBWL clearance is required as the canal is within 10 km radius of Bird Sanctuary. The shortest distance of various canals with respect to Mangalavanam bird sanctuary is given in Table 4.10.

Table-4.10: Distance from Mangalavanam Bird Sanctuary to various Canals

Sl No.	From	To	Distance (m)
1	Mangalavanam	Edappally Canal	4286 m
2	Mangalavanam	Chilavanoor Canal	2139 m
3	Mangalavanam	Thevara_Perandoor Canal	1058 m
4	Mangalavanam	Thevara Canal	5130 m
5	Mangalavanam	Market Canal	270 m

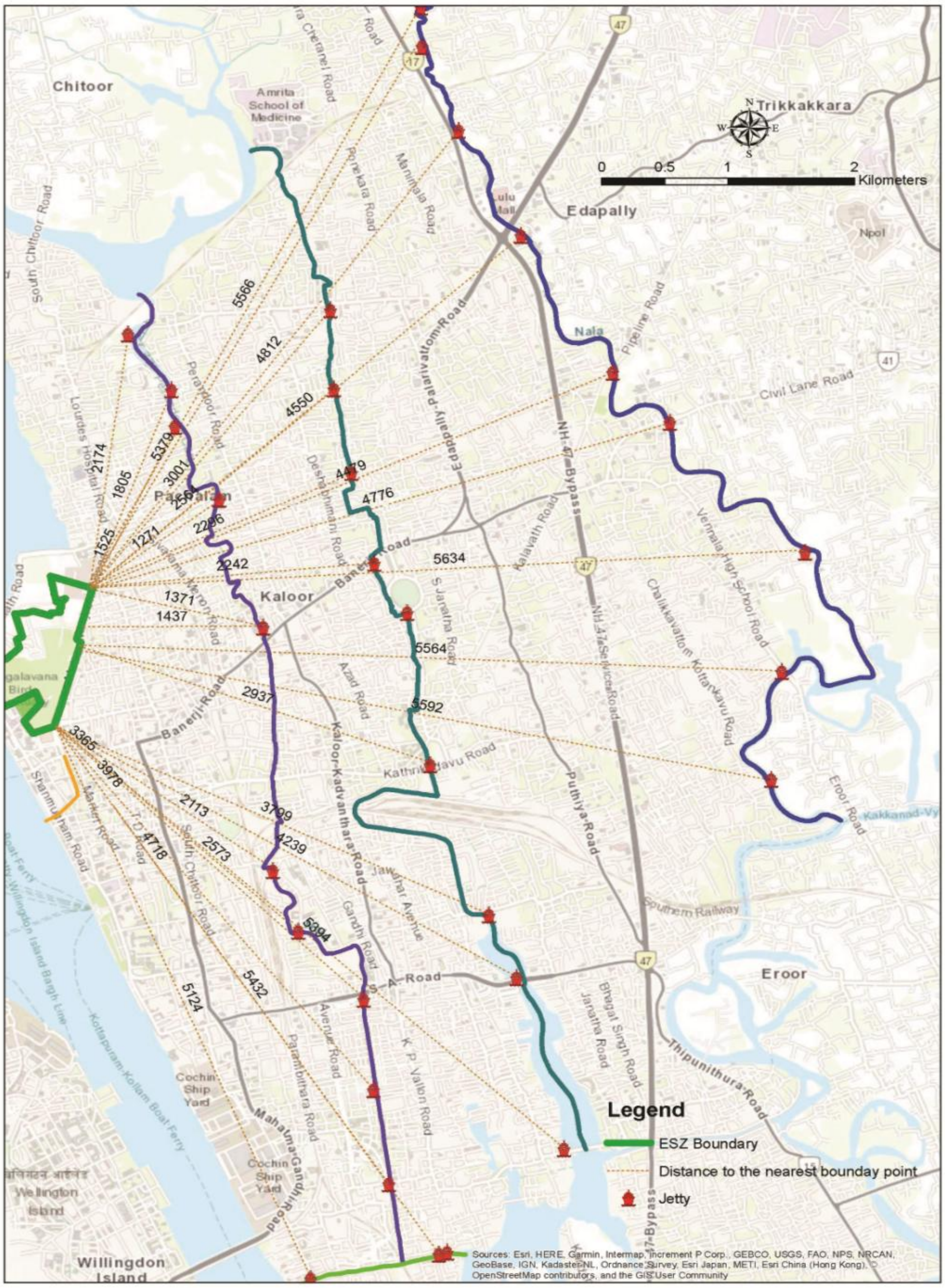


Figure-4.3: Location of Magalavanam Bird Sanctuary with respect to project site

Mitigation measures: Green Belt development plan as suggested in the management measures shall be implemented to avoid the impacts of cutting the tress. As the Market canal is located nearby, necessary precautionary measures shall be taken to minimise the adverse impacts. The mitigation measures as suggested in NBWL clearance shall be followed.

4.2.4 Impacts on Aquatic Ecology

The deepening process involves the removal of varying levels of sediment, mud, trash, and other debris from the bottom zone. The canals selected for the current investigation were once the safest and the fastest navigable route since the erstwhile Travancore-Cochin period. However, a drastic reduction in the depth of the canals has occurred, which is one of the impacts of dredging.

An overall decrease in the benthic biodiversity of the canals was a notable feature of the present investigation which is another impact of deepening of the canals. Fishery composition from the canals during the present study included only 10 species (*Etroplus maculatus*, *Danio sp.*, *Megalops cyprinoides, Caranx sp., Trichopodus trichopterus, Trypauchen vagina, Oreochromis sp., Channa striata, Anabas testudineus* and *Aplocheilus panchax*). From the reference stations also, only 13 fish species were recorded. *Trypauchen vagina* (Burrowing goby) an omnivorous detritus feeder burying themselves in the bottom mud was identified only from Thevara canal and not from any other canals. This perhaps, could be due to the disturbance of the bottom zone at the time of dredging that have occurred earlier. Many of the native fish species like *Mugil cephalus, Etroplus maculatus, Etroplus suratensis, Oreochromis sp.* were absent in many of the canals during the study. The overall low diversity of the fishery ie, 4 spp. in Edappally canal, followed by Thevara and Chilavanoor canals (2 spp.), Perandoor canal and Market canal (1 sp.) could be due to unscientific dredging that have occurred earlier, waste disposal and dumping in the canals.

Eventhough the fishery abundance and diversity was generally poor in the canals as well as reference station, it was observed during the field survey that the bottom zone of the canals were desilted and many places had large scale deposition of waste and plastic contamination that, severely affected the breeding (including egg laying), feeding and other life sustainable activities of the marine fishery resources. Dredging is the single largest issue impacting the natural breeding including larval recruitments, feeding and natural activities of fishery and other benthic invertebrates. The disturbance in the natural habitat of the canal system ecology through unscientific dredging and other waste disposal and mining activities has almost led to the loss of native endemic fauna of fishery and other resources replaced by opportunistic invasive organisms like African catfish, Tilapia, Three spotted gourami, *Mytella strigata*, *Mytilopsis sallei* and other fauna.

Dredging also causes changes in the physicochemical characteristics of the sediment, especially granulometric composition and organic content, which in turn affects the biomass, abundance and community composition of macrobenthic fauna (mollusca, amphipoda, ostracoda etc). In the current study, the macrobenthic biomass, abundance and diversity in the canals were very low just limiting to 4 to 5 species (clams, mussels,barnacles and gastropods).Also, an invasive gastropod genus *Physella* was identified from E3 (Chalikkavattom) station of Edappally canal. Since these invasive species lack competition and predators, they could easily occupy new niches by altering the biodiversity of that area.

A fall in the number of taxa and abundance of macrobenthic communities is also a post-dredging effect. As far as the current study is concerned, even though an average macrobenthic abundance ranging from 10 (Market canal) to 63 ±75 ind.m^2 (Perandoor canal) was noted, which is comparatively higher to that of the reference stations, an overall comparison with the studies conducted in Cochin Estuary revealed that the macrobenthic abundance of the canals are very poor. This could be attributed to either the overall unhealthy condition of the canals or it could be the “recovery and re-establishment” of the macrobenthic community after a specific period post-dredging. The macrobenthic organisms, during dredging operations, gets disturbed from within the substratum, thereby affording a chance for the inhabitants to migrate or face mortality.

Mitigation measures:

Deepening and beautification of the canals on later stage needs to be carefully and scientifically conducted without seriously affecting the existing aquatic biodiversity of the water bodies. The aquatic macrophytes, plants and other endemic/ native vegetation along the bottom and edges of the canals provide the productivity and life sustenance to the water bodies. So any, dredging that will be undertaken has to be carefully managed without seriously destroying the vegetation and its ecosystem character. A thorough assessment of the aquatic vegetation, its reproductive character, maturity and propagation should be documented before dredging and beautification work, so that, it can be rejuvenated.

4.2.5 Impacts on Ambient Air Quality

The project includes the activities of construction of jetties, Bridges, STPs and canal oriented developmental activities. The potential source of air quality impact arising from the establishment/ construction of the proposed project is fugitive dust generation. The dust, measurable as PM_{10} and $PM_{2.5}$ would be generated as a result of construction activities. The potential dust sources associated with the construction activities are loading and unloading of the materials, top soil removal, vehicular movement over roads, etc.

The construction activities that contribute to the environmental impacts are broadly given below:

- Dust generation during leveling of earth
- Dust generation due to the movement of vehicles on unpaved roads
- Emission of pollutants from vehicular exhaust
- Unloading of raw materials and removal of unwanted waste material from site
- Accumulation of excavated earth material

The impacts will be for short duration and confined within the project boundary and is expected to be negligible outside the boundaries. However, the project site is cordoned off with proper temporary covering and planned green belt; such impacts will be confined only within the project site.

Impacts due to fugitive emissions

The major pollutant in the construction phase is SPM being air-borne due to various construction activities. The vehicular movement generates pollutants such as NOx, CO and HC. But, the vehicular pollution is not expected to lead to any major impacts. The soils in the project area are sandy in texture, and are likely to generate dust as a result of vehicular movement. However, the fugitive emissions generated due to vehicular movement are not expected to travel beyond a distance of 200 to 300 m. The impact on air environment during construction phase is not expected to be significant, since, as the site shall be properly covered and proper management measures shall be followed.

Impacts due to construction equipment

The combustion of diesel various construction equipment could be one of the possible sources of incremental air pollution during the construction phase. The fuel utilization rates of various equipment expected to be in operation during construction phase is given in Table-4.11. Under the worst case scenario, it has been considered that equipment used for construction of berth and earthwork at each site, are operating at a common point.

Table-4.11: Fuel combustion during construction phase

Equipment	Fuel consumption rate (lph)	No. of Units	Total fuel consumption (lph)
Dumpers	30	4	120
Generators	30	2	60
Batching plant	40	1	40
Dumpers	20	4	80
Loaders and unloaders	25	3	75
Excavators	25	2	50
Water tanker	8	5	40
Total			**465**

The major pollutant likely to be emitted due to construction of diesel in various construction equipment shall be SO_2. The short-term increase in SO_2 concentration has been predicted using Gaussian plume dispersion model. The results are summarized in Table-4.12.

Table-4.12: Short-term (24 hr) increase in concentration of SO_2 ($\mu g/m^3$)

Wind Speed (m/s)	Distance (km)			
	0.1	0.2	0.3	0.4
0.2	0.47×10^{-34}	2.3×10^{-11}	1.15×10^{-6}	9.4×10^{-5}
0.85	2.8×10^{-8}	5.3×10^{-4}	4.4×10^{-4}	4.2×10^{-5}
1.53	7.4×10^{-5}	1.75×10^{-4}	4.2×10^{-5}	2.2×10^{-4}
2.78	1.09×10^{-4}	1.23×10^{-4}	2.6×10^{-5}	8.1×10^{-6}
4.30	9.4×10^{-5}	1.23×10^{-4}	2.6×10^{-5}	8.1×10^{-6}
5.98	7.1×10^{-5}	6.4×10^{-5}	1.28×10^{-5}	5.8×10^{-5}
7.00	6.8×10^{-5}	5.5×10^{-5}	1.09×10^{-5}	5.0×10^{-6}

It is evident from Table 4.9 that the maximum short-term increase in SO_2 is observed as 0.00053 $\mu g/m^3$, which is at a distance of 200 m from the emission source. The incremental concentration is quite low and does not require any specific control measure. Thus, the operation of construction equipment is not expected to have any major impact on the ambient air quality as a result of the project.

Mitigation measures:

Control of Pollution due to increased vehicles

The major source of air pollution in the proposed project sites is the increased vehicular movement in the project construction and operation phases.

The movement of other vehicles is likely to increase as the commissioning of the project would lead to significant development in the area. Thus, as a control measure, vehicles emitting pollutants above the standards shall not be allowed to ply either in the project construction or in the operation phases. Vehicles and construction equipment shall be fitted with internal devices i.e. catalytic converters to reduce CO and HC emissions.

All the roads in the vicinity of the project site and the roads connecting the quarry sites to the construction site should be paved or black topped to minimize the entrainment of fugitive emissions. If any of the road stretches cannot be blacktopped or paved, then adequate arrangements shall be made to spray water on such stretches of the road.

Control of Emissions from Vehicles

Minor air quality impacts will be caused by emissions from construction vehicles, equipment and DG sets, and emissions from transportation traffic. Frequent truck trips will be required during the construction period for removal of excavated material and delivery of select concrete and other equipment and materials.

The following measures are recommended to control air pollution:

- The contractor will be responsible for maintaining properly functioning construction equipment to minimize exhaust.
- Construction equipment and vehicles will be turned off when not used for extended periods of time.
- Unnecessary idling of construction vehicles to be prohibited.
- Effective traffic management to be undertaken to avoid significant delays in and around the project area.
- Road damage caused by sub-project activities will be promptly attended to with proper road repair and maintenance work.

Various measures listed above shall be made mandatory in the Tender Specifications for construction of the project. The project contractor while preparing the estimate shall include the cost and above measures while preparing the plan and cost estimate for the project.

Control of emission for DG sets

The measures to control emissions due to DG sets are recommended as below:

- Location of DG sets and other emission generating equipment should be decided keeping in view the predominant wind direction so that emissions do not effect nearby residential areas.
- Stack height of DG sets to be kept in accordance with CPCB norms, which prescribes the minimum height of stack to be provided with each generator set to be calculated using the following formula:

H = h+0.2x √KVA

H = Total height of stack in meter

h = Height of the building in meters where the generator set is installed

KVA = Total generator capacity of the set in KVA

Dust Control

The project authorities will work closely with representatives from the community living in the vicinity of project area to identify areas of concern and to mitigate dust-related impacts effectively (e.g., through direct meetings, utilization of construction management and inspection program, and/or through the complaint response program). To minimize issues related to the generation of dust during the construction phase of the project, the following measures have been identified:

- Identification of construction limits (minimal area required for construction activities).
- When practical, excavated spoils will be removed as the contractor proceeds along the length of the activity.
- Excessive soil on paved areas will be sprayed (wet) and/or swept and unpaved areas will be sprayed and/or mulched.

Contractors will be required to cover stockpiled soils and trucks hauling soil, sand, and other loose materials (or require trucks to maintain at least two feet of freeboard).

- Regular spray of water over unpaved areas.
- Contractor shall ensure that there is effective traffic management at site. The number of trucks/vehicles to move at various construction sites to be fixed.
- The construction area and vicinity (access roads, and working areas) shall be swept with water sweepers on a daily basis or as necessary to ensure there is no visible dust.

An amount of **Rs. 30.00 lakh** has been earmarked for implementing the measures for controlling the air pollution. Various measures listed above shall be made mandatory in the Tender Specifications for construction of the project.

Responsibility: *The contractor shall be responsible to implement the managements measures suggested for air environment during construction phase. These aspects will be made mandatory as a part of the contract agreement.*

4.2.6 Impacts on Noise environment

a) Impacts due to operation of construction equipments

The noise during construction phase are due to operation of various construction equipment. The noise levels generated by various construction equipments are given in Table-4.13.

Table-4.13: Average noise levels generated by the operation of various construction equipment

Equipment	Noise level (dB(A))
Batching Plant	90
Transit mixer	75
Winch-7.5 t capacity	75
Generator	85
Hydraulic Rig	85
Compressor	80
Hydra 12/15t	80
Wibro hammer	80
Bentonite pump	85
Concrete mixer	75
JCB-3D	85
Trailor	85
Excavator	80
Dumper	85
EoT cranes	80
Ordinary cranes	75

Under the worst case scenario, considered for prediction of noise levels during construction phase, it has been assumed that equipment required during construction phase is operating at a common point. Likewise, to predict the worst case scenario, attenuation due to various factors too has not been considered during noise modelling.

Modelling studies were conducted to assess the increase in noise level due to operation of various construction equipments, and the results of this exercise are given in Table-4.14.

Table-4.14: Predicted noise levels due to the operation of various construction equipment

Distance (m)	Ambient noise level (dB(A))	Increase in noise level due to construction activities (dB(A))	Noise level due to construction activities (dB(A))	Increase in ambient noise level due to construction activities (dB(A))
30	45	70	70	25
50	45	66	66	21
100	45	60	60	15
200	45	54	55	10
500	45	46	49	4
1000	45	36	46	1
1500	45	36	45.5	0.5
2000	45	34	45	-

It is clear from Table-4.16, that at a distance of 1 km from the construction site, the increase in noise levels will be only 1 dB(A). The nearest residential areas are at a distance of 0.5 km from the each project site. Hence, no adverse impacts are anticipated on ambient noise levels during construction phase of the proposed project.

It would be worthwhile to mention here that in absence of the data on actual location of various construction equipments, all the equipment have been assumed to operate at a common point. This assumption leads to over-estimation of the increase in noise levels. Also, it is a known fact that there is a reduction in noise level as the sound wave passes through a barrier.

Walls of various houses or other structure will attenuate at least 30 dB(A) of noise. In addition there is noise attenuation due to the following factors.

- Air absorption
- Rain
- Atmospheric in-homogeneities
- Vegetal cover

No increase in ambient noise level is anticipated, as a result of various activities, during project construction phase due to the following:

- Assumption that all equipment are operating from a common point leads to over-estimation of increase in noise level
- Attenuation of 30 dB(A) of noise by wall of any structure
- Noise attenuation due to various factors.

b) Impacts due to increased vehicular movement

During construction phase, there will be significant increase in vehicular movement for transportation of construction material. During construction phase, the increase in vehicular movement is expected to increase upto a maximum of 32 trucks/day.

As a part of EIA study, impact on noise level due to increased vehicular movement was studied using Federal Highway Administration model. The results of modelling are outlined in Table-4.15.

Table-4.15: Increase in noise levels due to increased vehicular movement

Distance (m)	Ambient noise level dB(A)	Increase in noise level due to increased vehicular movement dB(A)	Noise levels due to increased vehicular movement dB(A)	Increase in ambient noise level due to increased vehicular movement dB(A)
10	36	72	72	60
20	36	67	67	55
50	36	61	61	49
100	36	57	57	45
200	36	52	52	40
500	36	46	47	35
1000	36	42	44	31

As mentioned earlier, there will be significant attenuation due to various factors, e.g. absorption by construction material, air absorption, atmospheric in-homogeneties, and vegetal cover. Thus, no significant impact on this account is anticipated. Appropriate measures have been suggested as a part of Environmental Management Plan (EMP) report to minimize impacts on wildlife.

Mitigation measures

Measures to control noise pollution from vehicles:

- Vehicles to be equipped with mufflers recommended by the vehicle manufacturer.
- The construction activities shall be limited to day time. Suitable barriers shall be provided around construction sites.
- Staging of construction equipment and unnecessary idling of equipment within noise sensitive areas to be avoided whenever possible.
- Notification will be given to residents within 100 m of project area noise generating activities. The notification will describe the noise abatement measures that will be implemented.
- Monitoring of noise levels will be conducted during construction phase of the project. In case of exceeding of pre-determined acceptable noise levels by the machinery will require the contractor(s) to stop work and remedy the situation prior to continuing construction.

The effect of exposure of high noise levels on the workers operating the various construction equipment is likely to be harmful. It is known that continuous exposure to high noise levels above 90 dB(A) affects the hearing acuity of the workers/operators and hence, has to be avoided. To prevent the adverse impacts, the exposure to high noise levels should be restricted as per the exposure period outlined in Table-4.16. Workers operating in the high noise areas shall be provided with ear plugs.

Table-4.16: Maximum Exposure Periods specified by OSHA

Maximum equivalent continuous Noise level dB(A)	**Unprotected exposure period per day for 8 hrs/day and 5 days/week**
90	8
95	4
100	2
105	1
110	½
115	¼
120	No exposure permitted at or above this level

Noise Control Measures

Measures to control noise from construction equipment are as follows:

- Noise from air compressors could be reduced by fitting exhaust mufflers and intake mufflers.
- Chassis and engine structural vibration noise can be dealt by isolating the engine from the chassis and by covering various sections of the engines.
- Noise levels from the drillers can be reduced by fitting of exhaust mufflers and the provision of damping on the steel tool.
- Exposure of workers near the high noise levels areas can be minimized. This can be achieved by job rotation/automation, use of ear plugs, etc.

The effect of exposure of high noise levels on the workers operating the various construction equipment is likely to be harmful. It is known that continuous exposure to high noise levels above 90 dB(A) affects the hearing acuity of the workers/operators and hence, has to be avoided. Workers operating in the high noise areas shall be provided with ear plugs.

Control of Noise due to DG Sets

The following Noise Standards for DG sets are recommended for the running of DG sets during the construction:

- Noise from the DG set should be controlled by providing an acoustic enclosure or by treating the enclosure acoustically.
- The Acoustic Enclosure should be made of material of appropriate thickness and structural/ sheet metal base. The walls of the enclosure should be insulated with fire retardant foam.
- The acoustic enclosure/acoustic treatment of the room should be designed for minimum 25 dB(A) Insertion Loss or for meeting the ambient noise standards, whichever is on the higher side.
- The DG set should also be provided with proper exhaust muffler.
- Proper efforts to be made to bring down the noise levels due to the DG set, outside its premises, within the ambient noise requirements by proper siting and control measures.
- A proper routine and preventive maintenance procedure for the DG set should be set and followed in consultation with the DG set manufacturer which would help prevent noise levels of the DG set from deteriorating with use.

.

Responsibility: *The contractor shall be responsible to implement the managements measures suggested for control of noise pollution during construction phase. These aspects will be made mandatory as a part of the contract agreement.*

4.2.7 Impacts on Socio-Economic Environment

The project may dismantle many constructions over canal like bridges, culverts, walkways etc. This may lead to years' long blockage of access to residential area. Foreseen measures and system for timely address the issues are needed to include in the detailed project implementation plan.

The project partly affected several commercial structures and residence cum commercial structures. But access to canal transport may marginally increase the commercial value of the buildings and it will mitigate the impact.

The major livelihood activity in the Sea mouth and river mouth of canals are fishing and it's sorting or selling. The people involved in this livelihood are coming from the lower strata of population. They developed some structures and systems to harboring the boats and unload the fish and loading items for fishing. Resettling these traditional structures or installed advanced facilities will mitigate the impact.

Several venders are doing business in the banks of the Market Canal which is the major commercial canal of Kochi. Resettlement of these venders by getting opportunity to enjoy the developed canal facilities may mitigate the impact and ensure community participation.

Rejuvenating major canals of Kochi city is a major development initiative which develop the commercial and tourism potential of the city. Therefor develop special policy on Rehabilitation and Resettlement and land acquisition within the LARRACT 2013 and rules thereafter may give scope to address area specific issues and it will help to mitigate the impact. Several Colonies are situated within the COI. Developing a plan which protects the interest of these habitants may mitigate the impact.

The project area is commercial in nature and the cost of land and living standards are increasing day by day. Therefore, fixing compensation in consultation with people and local body leadership may mitigate the impact and minimize the grievance. Since there are 311 families need to rehabilitate the impact of the project to rejuvenate the major Canals of Kochi city considered as major and necessary to prepare comprehensive rehabilitation and resettlement plan to mitigate the impact. 82.67% of the displaced residential houses are occupied by non-titleholders (either squatter or encroacher). This increases the importance of prepared rehabilitation policy other than the RFCTLARR Act 2013. Most of the displaced families are living in the project location since before the year 2000. Moreover, most of the family members are having their livelihood in an around the project area. Therefore, rehabilitation not far away from the project location may mitigate the impact.

The construction phase of the project is likely to expand over a period 24 months and total will require good amount of labour force. The construction phase would lead to generation of temporary employment opportunities and would temporarily increase the income levels of the local population. Locals will get opportunity to supply construction materials. The demand generated from the employees working at site for basic facilities will increase the local business opportunities in the area. Any development, either temporary or permanent will support the family of many villagers. Thus, positive impacts on socio-economic environment are envisaged during construction phase.

4.2.8 Impacts on Archaeology and Heritage

No Archaeological Structure is coming nearby the canal alignment. There will be no impact on this aspect

4.3 IMPACTS DURING PROJECT OPERATION PHASE

4.3.1 Impact on Land Environment

a) Impacts on Land Use Pattern of the Area

The proposed project is proposed near the sides of the canals in Kochi. The land required for these projects falls within periphery of the Canal and belongs to the government and private land. The projects will not interfere with natural drainage in the area. The operation of the proposed project infrastructure will provide an impetus to the mushrooming of secondary and tertiary activities in the area. The project would stimulate lot of ancillary developments like shops, restaurant, repair shops, etc. in and around the jetty. This will lead to conversion of barren land into commercial use.

Mitigation Measures: There is acquisition of private land in the proposed project, and compensation will be provided as per LARR 2013. However there will be employment generation during operation phase of the project.

b) Impacts due to Generation of Solid Waste

The solid waste generation is envisaged during operation phase could be the disposal of garbage or solid waste generated from various sources. The solid waste generated shall mainly comprise of packaging, polythene or plastic materials etc. Therefore, a system needs be devised whereby undue quantity of garbage is not permitted to accumulate in the project area and the same could be disposed off at designated sites in a proper manner.

The solid waste generated in the catchment of the 5 canals has been estimated and the cost involved in collection of the solid waste through innovative methods is estimated. Kochi municipal corporation has already envisaged a proposal for converting the solid waste into energy at Brahmapuram, Kochi. The requirement of daily waste is 250 tons. The project catchment falls within corporation municipality and occupies nearly 50 percent of Kochi municipal corporation area. Hence rather than having a separate plant it is proposed to have a coordinated effort with KMC. The estimate cost for collection of solid waste for the initial 3-year period is estimated as Rs. 3.83 crores and the same is added in the estimate.

Mitigation Measures: Adequate facilities for collection, conveyance and disposal of solid waste will be developed. Provisions shall be made to separately store the degradable and non-degradable solid waste. The solid waste will be disposed at the designated landfill sites.

Various aspects of solid waste management include:

- Reuse/Recycling
- Refuse storage
- Collection and Transportation
- Disposal

Reuse/Recycling

Project proponent will explore opportunity to recycle the waste generated at the project site, in this context project will identify authorized vendors and send used batteries, used oil, and used oil filters for recycling. The municipal solid waste will be disposed at the landfilling site of Kochi Municipal Corporation and a proposal for converting the solid waste into energy at Brahmapuram, Kochi is already envisaged.

4.3.2 Impact on Water Environment

a) Impacts due to Generation of Waste Water from Jetties

As per NBC, Minimum Requirement of Fire fighting Installations, each jetty requires 10000 litres water for fire fighting. Each boat would be requiring around 250 liters of water for cleaning. On an average, the total water. For major jetties, an average of 200 persons per day @ 45 litre of water is calculated for sanitation facilities and for minor jetties its calculated as 150persons @ 45 litres per day. Requirement for cleaning 10 boats would be 2,500 Liters per day which would be shared among 26 terminals, 100 liters/ day per terminal. This water requirement would be in addition to the utility and Fire water capacity of the respective terminal. The two STPs would require a total of 20000 litres of water for fire demand and 2500 litres of water for sanitary facilities. Thus, the total daily demand is 5,15,000 liters. The washing & wiping is to be done manually using powered low pressure portable washer jets and using organic detergents (phosphate free & bio degradable materials) & soft sponge, so that the channel waters are not polluted. The intention of washing is to get rid of salt build-up or saline deposits & algae. Fire demand would be a dead storage and will be used only if there are any fire hazards at the terminals.

The total water required for passengers and staff expected as 225.0 KLD. The sewage that would be generated from these terminals would be about 80% of the water demand. Sewage generated is expected to be 180 KLD. The jetty wise water demand is given in Table-4.17.

Table-4..17: Details of quantum of construction material required

Sl. No	Location	Water requirement	
		Domestic	Fire Demand
A	**Jetties**		
Edappally canal			
1	Edappally	9000	10000
2	Near Pipeline Bridge	6750	10000
3	Near Ayyanad Bridge	6750	10000
4	Near Palachuvadu Bridge	6750	10000
5	Near Arakkakadavu Bridge	9000	10000
6	Near Kuzhuvelippalam	9000	10000
7	Muttar	6750	10000
8	Near Railway cross	9000	10000
TP Canal			
9	Perandoor	9000	10000
10	Near Chinmaya Vidyalaya	9000	10000
11	Near Pottakkuzhy Bridge	6750	10000
12	Near Kaloor Market	9000	10000
13	Near GCDA Metro station	9000	10000
14	Near Kochu Kadavanthra Bridge	9000	10000
15	P&T colony	6750	10000
16	Near Journalist colony	6750	10000
Chilavanoor canal			
17	Near Railway Bridge	9000	10000

18	Near SCB Road Bridge	6750	10000
19	Near Elamkulam Bridge	9000	10000
20	Near Chilavanoor Bridge	9000	10000
21	Near Kathrikadavu	6750	10000
22	Near Kaloor stadium	9000	10000
23	Near Alpha ENT Hospital	6750	10000
24	Near Housing complex	6750	10000
25	Near Amritha Hospital	9000	10000
Thevara Canal			
26	Near Market	9000	10000
	New Jetties for Infrastructure		
1	Mini India	9000	10000
2	Near PJ Antony Ground	6750	10000
3	Eco Park	9000	10000
Total		**2,25,000**	**290000**

Mitigation Measures: Suitable waste water treatment measures will be provided for the treatment of domestic sewerage from the jetty premises. Septic tank with biodigestors shall be provided for sewage treatment at all the terminals.

b) Impacts of Boat Movement

During the operational phase there will be activities of boat movement in the region. The boat will be electric and no toilet shall be in the same. All these activities may have little impacts on aquatic life. Possible sources of such impacts on aquatic environment would be washing of boats. Environmental implications during routine operations at the jetty could be due to release of wastes generated from the boats including garbage, solid waste as well as sewage.

C) Impacts on Canal Water Quality

As part of the project all the waste water mixing in the canal is diverted through sewage network and treated in 4 different STPs. The structured collection of household sewage and treatment indiscriminate mixing of sewage in many water bodies are eliminated as part of the project and make it the canals clean. The treated sewage from the STP is proposed to be sent to existing canal after meeting the discharge criteria set by CPCB for discharging to the surface waste water.

4.3.3 Impact on Aquatic Ecology

a) Impacts due to maintenance dredging

One of the main concerns over dredging and dumping of sediments for maintenance dredging is the suspension of fine sediments into the water column, causing temporary increases in turbidity. The designated channel area will have continuous dredging for maintenance of defined depth and continuous siltation. This constant sediment disturbance keeps the channel devoid of fauna or with very low biodiversity.

Increased turbidity may lead to short-lived effects on organisms that are light-dependent, but these are generally considered to be negligible. However, the release contaminants such as heavy metals associated with the suspended sediments can lead to increased availability of contaminants to the food chain. Nutrients released from dumped dredge spoil may cause higher algal biomass once the sediments settle and turbidity reduces, and would be available to key secondary producers such as copepods, decapods and chetognaths. Dumping sediments on the seabed may smother and crush meroplanktonic and other organisms living on the seafloor and may cause changes in benthic habitats and biological communities. The impact of dumping on biological communities in dump sites does not extend far beyond the dump sites.

4.3.4 Impacts on Noise Environment

a) Impacts due to Noise on Aquatic Ecology

During operation phase, there could be less noise levels due to operation of boats. As the boats are modern facilities, no adverse impacts on noise environment are anticipated during operation phase of proposed project.

As a part of the environmental protection activities, trees and ornamental horticultural trees and shrubs would be developed around the project area, which will attenuate noise levels to a certain extent.

4.3.5 Impact on Air Environment

During project operation phase, major activity would be passenger service and operation of STPs. The propulsion of the boats will be electric. The operation of STPs will create foul smells in the surrounding area.

The key source of air pollution in the proposed project is due to the increased vehicular movement in the project are and the operation of STPs.

Mitigation measures: The following management plan would reduce the impact of such emissions on the general environment.

- All equipment shall be properly maintained to minimize exhaust.
- Vehicles will be turned off when not used for extended periods of time.
- Proper Greenbelt plan around the periphery of the STPs.
- Effective traffic management to be undertaken to avoid significant delays in and around the project area.

4.3.6 Impact due to operation of STPs

The operation and maintenance of 4 STPs and sewer lines shall be done during the operation of the IURWTS project. The following are the major impacts because of the O&M activities:

- Impairment of receiving water quality in surface/sub-surface source due to inadequate /inefficient treatment.
- Contamination of groundwater supplies due to leaching and impact on soil and agriculture

- Problems arising due to bad odour, insects, polluted air, noise pollution, etc.
- Indiscriminate disposal of sludge leading to contamination of land and soil.
- Reduced land values in nearby areas and aesthetics affected.
- The toxic gases are likely to contract communicable diseases from exposure to pathogens present in the sewage
- Leakage and overflow from Water pollution and possibility of mixing with water supply line

Mitigation measures

- Monitor the treated sewage/effluent quality and ensure compliance with PCB standards for effluent disposal into surface water bodies, on land or for the agricultural use.
- Provide buffer zones in the form of green belt around the STP; to be ensured during the design and construction phase itself.
- Prepares a sludge disposal plan and adheres to the same.
- Disposal of sludge through authorized agencies.
- Regular monitoring of sewer line and manholes for visible leakages/ overflows.
- Immediate repair operation for the damaged portion of sewer line.
- De-siltation of blocked sewers/ manholes with sewage pumping machines-storing and disposal at appropriate refusal area after treatment.
- Ensure proper covering of manhole and avoid dumping of solid waste to prevent chocking of sewer line

4.3.7 Impacts on Socio-Economic Environment

The proposed project is one of the long due development initiatives of the government. The water logging happened during the last two years (2018 and 2019) flood made an attitudinal change in people's mind regarding the canal development. But absences of authentic communication regarding the project development, lot of confusion develop in the minds of people regarding the project and it gives scope for misleading information. Developing a system for regular communication and addressing the grievance may mitigate the impact an ensure community participation.

CHAPTER-5
ANALYSIS OF ALTERNATIVES

5.1 GENERAL

Kochi Metro Rail Limited (KMRL) have been entrusted the work of Integrated Urban Regeneration and Water Transport System (IURWTS) in Kochi by the Government of Kerala. The proposed project envisages the development of the Edappally Canal (11.23 km), Thevara – Perandoor Canal (11.15 km), Chilavanoor Canal (9.88 km), Thevara Canal (1.405 km) and Market Canal (0.664 km) in Kochi. The major aim of the project is to regenerate the urban area in and around the canals, rehabilitate the slum dwellers, and make use of the commercial area in the vicinity of the canal along with creation of tourism destinations and navigation through the canals.

On successful implementation of the proposed project will lead to Cleaner and Greener Environment, better drainage, sewage & Storm water drainage from sub catchments, effective and enhanced connectivity from various locations , improved landscape around the facility, reduced risk of potential flooding near the canals.

The Following alternatives in the proposal and technology has considered for the project.

5.2 WIDENING AND DEEPENING OF THE CANAL

The project involves widening the canal by removing the squatters and encroachers from the canal banks adhering to the Village record standards. Due to the urban sprawl and lack of maintenance in the canals many of the road bridges and foot bridges constructed were constructed haphazardly by encroaching into the canals and also not adhering to the navigation standards. This has resulted in frequent flooding at these locations.

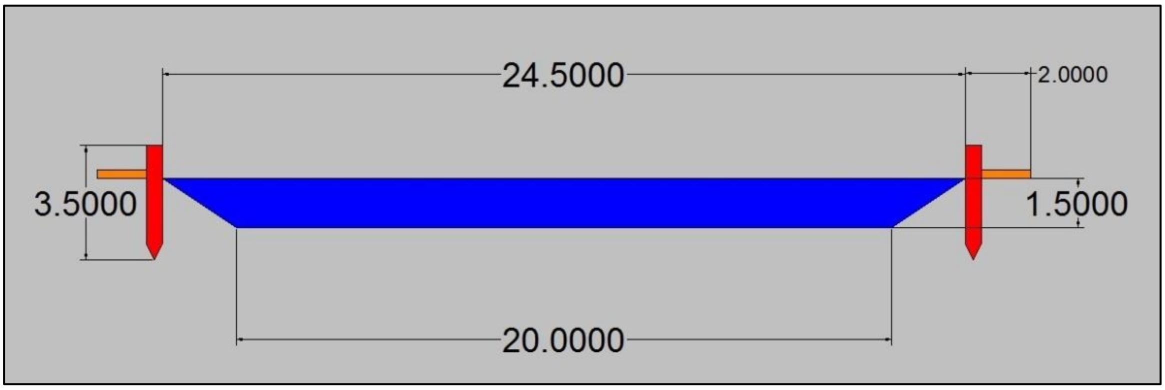
As a part of this project widening and deepening involves the reconstruction of the road bridges and foot bridges to mitigate floods and adhering to the navigation standards by maintain a vertical clearance of 4 m above the HTL and thereby help to achieve the project objectives of flood mitigation and restoring navigation. . Based on the design guidelines for navigation and Hydraulic model studies undertaken the minimum width required is estimated as 16.5m and the bottom depth as -0.9m below Chart datum

A width of 2.0 m is also proposed to be acquired on either sides of the canals beyond 16.5m width of the canals through land acquisition process to align the primary sewer lines. This is to reduce the resistance from the public by way of dismantling the existing roads for this purpose.

5.3 FAIRWAY FOR VESSEL MOVEMENT

As per PINC guidelines, the width required for movement for passenger and tourist vessel is 3.40m and for cargo vessel (100T) barge requires a minimum width of 4.25m. Considering the above aspects, two types of fairways were proposed. The fairway design was considered as two options

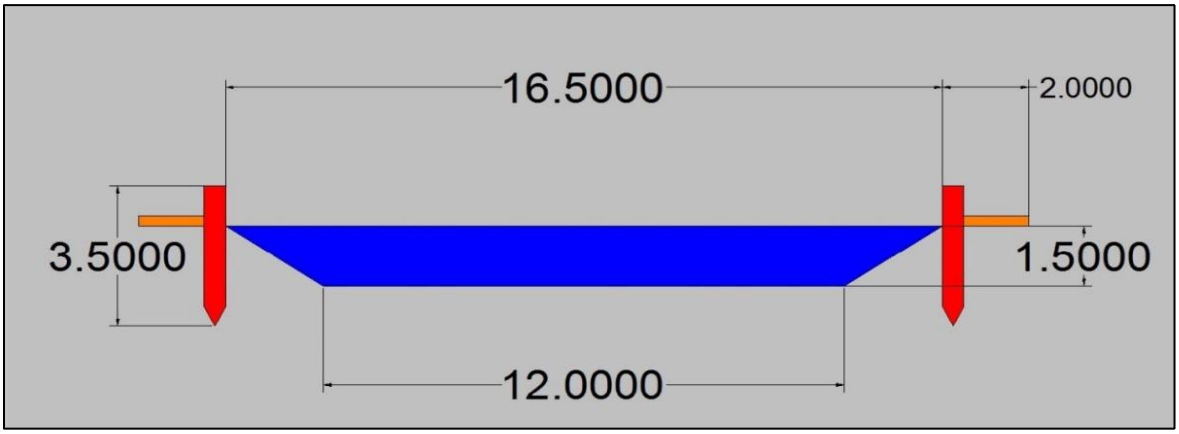
Option-1: 20m fairway in canal stretches having width greater than 16.5m by providing a side slope of 1:1.5 and a depth of -1.2m CD the presently available depth in most of the stretches.



Option:2

In stretches were the width of the canal is 16.5m. A rectangular section with width of 16.5m and depth uniformly maintained to a level of -0.9m chart Datum as given in figure below

The level of -0-9m CD was fixed based on the bore log details along the canal stretches so that the depth excavated does not go below the moorum layer of the soil profile.



5.4 DISPOSAL ALTERNATIVES

The following wise use of the dredged materials will also be considered during the execution:

Land Creation/Reclamation or Land Improvement

Land creation or reclamation using dredged material is one of the most common beneficial uses of dredged material and is achieved by filling, raising and grading and if necessary, protecting an area to create new land that might otherwise remain submerged. Material from capital dredging is often used. Land improvement involves placing dredged material in a partially or periodically submerged area which requires improvement. These beneficial uses are particularly attractive where the dredged material recovery site and the proposed reclamation/creation site are in close proximity

Shore Protection Works (including Geotubes)

Dredged material has been applied in coastal protection works internationally in a variety of different ways and has often involved the direct use on-site of dredged material generated locally as a construction material. It has commonly been used in the core of rubble mound breakwaters (typically sand) or potentially on the outer layers of breakwaters where the appropriate rock grading is available. In such cases the dredged material produced (rock or otherwise) must meet the specific design requirements of the particular coastal structure.

An alternative (and innovative) approach to the direct use of dredged material in coastal structures is to fill geotextile retaining material, geo-tubes, with dredged material. Geotubes are high tensile strength woven polypropylene geotextiles designed to receive and retain pumped material, with the water content allowed to escape through fine pores until the required density of contained material is achieved. Geo-tubes may then be used to retain and dewater dredged material to form the core of different types of coastal structure. dredged material may be pumped or hydraulically placed into the geo-tubes either directly from a dredging vessel or from a barge/storage area.

Habitat Creation/ Enhancement

Dredged material has been widely used to establish new habitats like wetland areas, to nourish and enhance existing habitats or to provide stability to eroding wetlands. Habitat development is a viable disposal alternative when one or more of the following conditions are present:

a) Public/agency opinion strongly opposes other alternatives;

b) Recognized habitat needs exist;

c) Enhancement measures on existing placement sites are identified;

d) Feasibility has been demonstrated locally;

e) Stability of dredged material deposits is desired;

f) Habitat development is economically feasible;

g) Extensive quantities of dredged material are available

5.5 SELECTION OF APPROPRIATE SEWAGE TREATMENT TECHNOLOGY

One of the most challenging aspects of a sustainable sewage treatment system design is the analysis and selection of the treatment processes and technologies capable of meeting the requirements. The process is to be selected based on required quality of treated water. While treatment costs are important, other factors should also be given due consideration. The effluent quality, process complexity, process reliability, environmental issues and land requirements should be evaluated and weighted against cost considerations.

The following factors are also to be considered while evaluating different treatment processes:

- Capability of the plant to give desired performance
- Availability of land
- Overall costs both capital as well as recurring
- Energy input - There are two aspects, minimum power or energy requirements and the effect of its dependability on the process.
- Ease of operation
- Manpower requirement both skilled and unskilled
- Bearing on local conditions such as climate
- Ultimate use or disposal of treated effluent
- Use of greener technologies

Technological options for sewage treatment plant

The following methods of sewage treatment have been considered for evaluation of performance characteristics, land requirement, energy input, equipment requirement and operational characteristics:

- Membrane Biological Reactor Process
- FAB/MBBR technology
- Sequential Batch Reactor (SBR)
- Extended Aeration

A detailed report of 7 IIT's in India titled "Sewage treatment in Class-1 towns: Recommendations and guidelines" (2010) headed by IIT Kanpur brings out the criteria for selecting STP technology and also has undertaken a life cycle cost analysis on different technologies adopted in India. A comparison on the treatment cost was made on the various parameters as given in Table-5.1, as extracted from IIT report.

Table-5.1: Parametric analysis of different STP technologies

Sl. No	Assessment parameter/technology	ASP	MBBR	SBR	MBR
1	**Performance after tertiary treatment**				
1.1	Effluent BOD, mg/L	<10	<10	<10	<10
1.2	Effluent SS, mg/L	<5	<5	<5	<5
1.3	Effluent NH3N, mg/L	<1	<1	<1	<1
1.4	Effluent total coliform/MPN/100ml	10	10	10	10
2	**Total Capital Cost (secondary + Tertiary) lacs/MLD**	**108**	**108**	**115**	**300**
3	**Total Area requirement M^2 per MLD**	**1000**	**550**	**550**	**450**
4	**Operation & Maintenance cost**				
4.1	Energy cost Lacs pa/MLD	4.07	4.9	3.37	2.75

Sl. No	Assessment parameter/technology	ASP	MBBR	SBR	MBR
4.2	Repair cost Lacs pa/MLD	2.38	1.94	1.84	NA
4.3	Chemical cost lacs pa/MLD	5.3	5.3	3.3	NA
4.4	Manpower cost (assuming 50 MLD)	42.12	30.96	25.92	42.12
	Total annual O&M cost lacs pa/MLD	**629.26**	**638.11**	**451.22**	**832.55**

Source: IIT consortium report 2010

From the above table it is clear, that the energy cost, repair cost, chemical cost, manpower power cost for SBR technology is comparatively low with respect to other technologies. A cost comparison with other studies undertaken by Yamuna Pollution Control Unit (YPCU) was also reviewed by GC and the findings show that SBR technology is a better option to other technologies.

As per the detailed analysis life cycle cost of SBR technology has the minimum life cycle cost when all the parameters are analyzed in a holistic manner. The SBR is a true batch treatment process reactor having ability to acts as an equilibrium basin, aeration basin and clarifier basin within a single batch reactor. The SBR is operated in a batch reactor mode this eliminates all the inefficiencies of the continuous processes. The complete process takes place in a single reactor, within which all biological treatment steps take place sequentially. The optimum effluent quality is obtained during each cycle in SBR. The SBR process is often preferred over continuous flow process (CFP) due to reduction in energy consumption and enhancement in the selective pressures for BOD, nutrient removal, and control of filamentous bacteria. Due to these reasons, SBR process is gaining immense popularity in the recent years. The benefits envisaged include:

- 50 % Reduction in power consumption.
- 50 % Reduction in land requirement
- Fully automatic, Computerized (PLC/ SCADA)
- Much higher plant life due to excellent material.
- Low maintenance cost.
- Treated effluent can be used for Horticulture/ Industrial purposes

The techno-economic viability of different technologies in vogue need to be studied under site specific conditions like prevailing local conditions, urban settings, community acceptability. Each of these technologies has its own merits and demerits. Ministry of Urban Development (GOI) (2012) had recommended under JNNURM projects, Sequencing Batch Reactor (SBR) and Moving Bed Biofilm Reactor (MBBR)/ Fluidized Aerobic Bioreactor due to their advantages such as less requirement of land, high effluent quality etc. As the environmental discharge standards are getting more and more stringent, the traditional continuous flow-based biological wastewater treatment process faces severe challenges.

The sequencing batch reactor (SBR) technology is a modification of the much popular activated sludge process (ASP). Such a conversion of the continuous nature of the ASP-based treatment process to a batch process as in SBR helps introduce various process flexibilities and alternatives in process controls and design to have the latest effluent discharge standards.

As the SBR process can be effectively automated, it is known to save more than 60% of the operating expenses required for a conventional ASP and is able to achieve high effluent quality in a very short aeration time. Considering the density of population in IURWTS-KOCHI project command, SBR is being considered as a preferable technology due to its low requirement of area, land cost, energy efficiency as well as manpower for operation.

5.6 ALTERNATIVES FOR DISPOSAL

The Excavated earth obtained from deepening and widening needs to be disposal to safe places that are adhering to the regulatory needs for obtaining MoEF & CC clearance for IURWTS project. Among the three options analysed for the disposal of dredged soil from the canals, the option to use the soil as the soil cover of the landfill of KEIL is found to be viable and environmentally sound option.

Option-1: Usage of remaining soil as soil cover of KEIL Landfill

M/s Kerala Enviro Infrastructure Ltd (KEIL), is operating "Common Treatment, Storage and Disposal Facilities (TSDF) Project with participation of 85 industries in the State, inside FACT – CD Campus, Ambalamedu an industrial hub, situated about 25 KM on the Eastern side of Kochi City.

The existing site is finally selected based on the following considerations:

- KEIL is already operating the common TSDF at 50 acres of land in block no. 37, survey no. 205 of Puthenkurissu village, Kunnathunad taluk, Ernakulam district.
- The distances from IURWTS canals to the KEIL landfill is minimal. The maximum distance from the IURWTS to the proposed landfill site is 20.2 km.
- The State has only one common Secured landfill facility namely M/s Kerala Enviro Infrastructure Ltd., for treatment and disposal of only landfillable hazardous waste. Further, about 49% of the total hazardous waste generated in the State is disposed in the captive secured landfill facilities of Kollam and Ernakulam district.
- The site has been declared as Industrial Area by the Govt. of Kerala. The Kerala State Pollution Control Board has granted permission for operating the common TSDF in these 50 acres of land. Out of this, 31-acre land is being utilized for secured landfill facility after the proposed enhancement of landfill capacity. KSPCB has also given in-principle approval for the proposed expansion of

secured landfill of the common TSDF vide letter dated PCB/HO/HWM/ SCMC /506/2004 dated 14.02.2019.

- The existing site is suitable for expansion due to rapid industrialization in the state leading to generation of large quantity of Hazardous waste and to have continued process of disposal of hazardous waste in eco-friendly and sustainable manner.
- The existing and expansion of landfill require huge quantity of good earth and currently KEIL is in urgent need of good earth for the landfill. As generation of hazardous waste in the State will be a continuing process, the need for scientific disposal meeting environmental norms will also be continuous.

Option-2: Disposal for filling abandoned quarries in the district

Ernakulam District has a very large number of quarries, a staggering 700- 900 according to the Kerala Quarry Owners Association - a self-interest group. It roughly works out to be 8 or 10 quarries per panchayat. The quarries are primarily used for extraction of runoff quarry rubble or to produce value added products or for producing brick and tile clays. Due to the relatively low unit cost of the quarry products, this industry is distributed far and wide in the state and the only ruling constraints regarding spatial distribution are purely geological. Even though quarries have a wide range of size, (say anywhere between 10 or 15 Ares to several hectares), the smaller quarries have a low operational life whereas the larger ones are of the order of hectares in terms of the areal extent, and most have been operational for the last several decades.

Currently, the Department of Mining and Geology keeps an automated data base of quarries of the state. According to this database, there are 776 quarries in Ernakulam district among which 297 are in Kunnathunad Thaluk itself. According to the data available with department of mining and Geology, GoK, there are 776 stone quarries (Granite - Building Stone) available in the district of Ernakulam and nearly 260 quarries are abandoned. Most of these quarries are in the Thaluk of Kunnathunad, which is near to the IURWTS project. General locations where quarry sites and IURWTS canals are in relatively close proximity are also identified.

Most of the quarries in the Ernakulam district function in Kunnathunad, Muvattupuzha and Aluva taluks. Currently, there are more than 120 active quarries in the district. The quarry operators to face difficulties to reclaim site before leaving a site due to the lack of soil and filling materials. Hence, the use of dredged material from IURWTS canals to reclaim the abandoned quarries was considered as an option.

However, this option was found less feasible due to the following issues:

- Willingness of quarry owners to reclaim the quarry

- The abandoned quarries are located in various parts of the district, transporting the excavated soil to these locations is a herculean task
- Public objection in reclaiming the quarries-Many quarries are serving as a water storage and public are using it as a source of water during summer months. Some quarries are being used for fish cultivation also
- Issues in getting special order from GoK for transporting and filling the quarries.

Option-3: Disposal of soil for Mangrove afforestation in ICT Road.

Another alternative considered for the disposal of soil was the direct use of dredged material in coastal structures of ICT road to fill geo textile retaining material, geo textile tubes, with dredged material and to create a mangrove habitat. Dredged material can be used to establish mangrove habitat areas, to nourish and enhance existing habitats or to provide stability to eroding coasts

National Highway 966A (NH 966A) starts at Kalamassery (junction with NH 544) and ends at Vallarpadom International Container Trans-shipment Terminal in Kochi, Kerala, India. The road is managed by the NHAI.

A 6km stretch on the International container terminal road has been identified for the "Earth disposal management plan through mangrove afforestation program" of the IURWTS project in Kochi for which five native mangrove species have also been identified. The proposal aims at generating a healthy mangrove belt which encourages environmental benefits, social wellbeing, and economic opportunities via Eco-Tourism. The use of Geo textile tube will assure fast installation with limited budget allocation resulting in quick project completion. The present proposal will accommodate approximately 1 Lakh m3 of soil.

The sites proposed as two stretches are already owned by National Highway Authority (NHAI) which are kept idle without developing service road or foot path due to the lack of proper filling material. Additionally, around 6.5 acres of land is available as puramboke, which can also be used for this purpose. About 26 acres of land is available on the LHS of ICT road as two stretches:

1) Stretch 1, From the LHS near Bolgatty Bus stop up to Toll Gate which have a length of 2 kms.
2) Stretch 2 From the Toll Plaza up to Mulavukad Panchayath Bus stop which have a length of 1.64 kms.
3) Stretch 3 After Mulavukad Panchayath Bus stop up to Moolampalli bus stop.
4) Additionally, around 6.5 acres of puramboke land is available at Mulavukad Viewpoint.

This alternative was also found less viable due to the following reasons:

- Possible public agitation:, As the site is by the side of container terminal road, there is a possibility of objection from the public in disturbing the area by transporting, filling with soil.

The options considered have been evaluated as per site evaluation criteria given in the Table-5.2.

Table-5.2: Criteria for site selection

No	Parameter	Criteria	KEIL Disposal	Quarry Filling	Mangrove afforestation
1	Lake or pond	Should not be within 200m	None within 200m	within 200m	within 200m
2	River or stream	Should not be within 100 m	None within 100m	within 100m	within 100m
3	Flood plain	Should not be within100 years flood plain	Site is not located in flood plain	Site is not located in flood plain	Site is located in flood plain
4	Highway (State or National)	Should not be within 500 m	The nearest Highway is Cochin- Madurai-Tondi Point (NH-85) at 3.4 km (aerial) in the South direction and NH-47 at a distance of 5km (aerial) from project site in west direction.	Not within 500m	On the sides of NH itself
5	Habitation	Should not be within 500m	Nearest settlement is at 600m in West direction.	Near to settlement	Nearest settlement is at 400 m in East direction
6	Public Parks	Should not be within 500 m	None within the 500m	None within the 500m	None within the 500m
7	Critical habitat area — area in which one or more endangered Species live	Should not be within such area.	Not within such area.	Not within such area	Area is mangrove habitat
8	Wetlands	Should not be within such area	None within 500 m radius area	None within 500 m radius area	The proposed site is part of wetland
9	Airport	Should not be within zone around the airport(s)	Nearest airport is Cochin International Airport -app 19 km	Nearest airport is Cochin International Airport -app 15 -38 km	Nearest airport is Cochin International Airport -app 28 km
10	Water supply	No Water supply well within 500 m	None within 500 m radius area	Some quarries are being used as a water storage area	None within 500 m radius area
11	Coastal	Should not be	Not within a coastal	Not within a	Falls within CRZ

No	Parameter	Criteria	KEIL Disposal	Quarry Filling	Mangrove afforestation
	regulation area	within a coastal regulation zone	regulation zone	coastal regulation zone	
12	Ground water table level	GW table should be > 2m from the base of the landfill	Ground water table is 0.75-12.05 mbgl in pre-monsoon and 0.54- 10.42 mbgl in post monsoon.	Ground water table is 2 - 12.05 mbgl in pre-monsoon	GW table within 2m from

CHAPTER-6

ENVIRONMENTAL MONITORING PROGRAMME

6.1 THE NEED

Monitoring is an essential component for sustainability of any developmental project. It is an integral part of any environmental assessment process. Any development project introduces complex inter-relationships in the project area between people, various natural resources, biota and the many developing forces. Thus, a new environment is created. It is very difficult to predict with complete certainty the environmental scenario during project construction and operation phases. Hence, monitoring of critical parameters is essential during project construction and operation phases.

Monitoring of environmental indicators signal potential problems and facilitate timely prompt implementation of effective remedial measures. It will also allow for validation of the assumptions and assessments made in the present study.

Monitoring becomes essential to ensure that the mitigation measures planned for environmental protection function effectively during the entire period of project operation. The data so generated also serves as a data bank for prediction of scenarios during construction and operation phases in similar projects.

6.2 AREAS OF CONCERN

From the monitoring point of view, the important parameters are resettlement and rehabilitation of project-affected persons, water quality, ambient air quality, noise, etc. An attempt is made to establish early warning system which indicate the stress on the environment. Suggested monitoring parameters and programmes are described in the subsequent sections.

6.3 AQUATIC WATER & SEDIMENT QUALITY

Construction phase

The chemical characteristics of canal water quality shall be monitored once in three months during project construction phase, close to the major construction sites. Both surface and bottom waters shall be sampled and analysed. The parameters to be monitored are as follows:

Water

Physico-chemical parameters

- pH
- Salinity
- Conductivity
- TDS
- Turbidity
- D.O.

- BOD
- Phosphates
- Nitrates
- Sulphates
- Chlorides

Biological parameters

- Light penetration
- Chlorophyll
- Primary Productivity
- Phytoplanktons (No. of species and their density)
- Zooplanktons (No. of species and their density)

Sediments

Physio-chemical parameters

- Texture
- pH
- Total Kjeldahl Nitrogen
- COD
- Sodium
- Potassium
- Phosphates
- Chlorides
- Sulphates

Biological Parameters

- Benthic Meio-fauna
- Benthic Macro-fauna

The water and sediment sampling and analysis be conducted by an external agency. A provision of Rs. 12 lakh/year has been earmarked for this purpose. Assuming construction phase is to last for 2 years and considering an escalation of 10%, an amount of Rs. 25.2 lakh can be earmarked.

Operation Phase

The chemical characteristics of water quality should be monitored once in three months and biological parameters once a year during project operation phase to understand the effect of the dredging. Both surface and bottom waters should be sampled and analysed. The parameters to be monitored are as follows:

Water

Physico-chemical parameters

- pH
- Salinity
- Conductivity
- TDS
- Turbidity

- D.O.
- BOD
- Phosphates
- Nitrates
- Sulphates
- Chlorides

Biological parameters

- Light penetration
- Chlorophyll
- Primary Productivity
- Phytoplanktons (No. of species and their density)
- Zooplanktons (No. of species and their density)

Sediments

Physio-chemical parameters

- Texture
- pH
- Total Kjeldahl Nitrogen
- COD
- Sodium
- Potassium
- Phosphates
- Chlorides
- Sulphates

Biological Parameters

- Benthic Meio-fauna
- Benthic Macro-fauna

The water and sediment sampling and analysis be conducted by an external agency. A provision of Rs.12 lakh/year has been earmarked for this purpose.

The Various parameters prescribed by KSPCB for the STP also has to be monitored as per the guidelines.

6.4 AMBIENT AIR QUALITY

Construction Phase

Ambient air quality monitoring is recommended to be monitored at close to the major construction sites. The monitoring can be conducted for three seasons. For each season monitoring can be conducted twice a week for 4 consecutive weeks. The parameters to be monitored are PM_{10}, $PM_{2.5}$, SO_2 and NO_2. An amount of Rs. 9 lakh/year would be required. Considering, construction phase of two years and escalation of 10%, an amount of Rs. 18.9 lakh can be earmarked for this purpose. The ambient air quality monitoring during project operation phase can be conducted by an agency approved by Kerala Pollution Control Board.

Operation phase

The ambient air quality monitoring will have to be conducted at six locations. Air quality could be monitored for three seasons in a year. High volume samplers can be used for this purpose. The frequency of monitoring shall be twice a week for 24 hours for four consecutive weeks. The parameters to be monitored are PM_{10}, $PM_{2.5}$, SO_2 and NO_2. The ambient air quality monitoring during project operation phase can be conducted by an agency approved by Kerala Pollution Control Board. An amount of Rs. 3 lakh/year can be earmarked for this purpose.

6.5 NOISE

Personnel involved in work areas, where high noise levels are likely to be observed during project construction and operation phases. For such in-plant personnel, audiometric examination shall be arranged at least once a year.

The noise level monitoring during construction phase will be carried out by the project staff and a noise meter can be purchased. An amount of Rs. 5 lakh has been earmarked for this purpose.

6.6 SUMMARY OF ENVIRONMENTAL MONITORING PROGRAMME

The summary of Environmental Monitoring Programme for implementation during project construction and operation phases is given in Tables-6.1 and 6.2 respectively.

Table-6.1: Summary of Environmental Monitoring Programme implementation during project construction phase

S. No.	Aspects	Parameters to be monitored	Frequency of monitoring	Location
1.	**Canal water**			
	Physico-chemical parameters	pH, Salinity, EC, TDS, Turbidity, Phosphates, Nitrates, Sulphates, Chlorides.	Once in three months	6-8 sites
	Biological parameters	Light penetration, Chlorophyll, Primary Productivity, Phytoplanktons, Zooplanktons	Once in three months	6-8 sites
2.	**Sediments**			
	Physico-chemical parameters	Texture, pH, Sodium, Potassium, Phosphate, Chlorides, Sulphates	Once in three months	6-8 sites
	Biological parameters	Benthic Meio-fauna, Benthic Macro-fauna	Once in three months	6-8 sites
3.	Ambient air quality	$PM_{2.5}$, PM_{10}, SO_2 and NO_2	- Summer, Post-monsoon and Winter seasons. - Twice a week for four consecutive weeks per season.	Sites Close to construction site(s)

4.	Noise	Equivalent Noise Level	During peak construction activities	Construction Site(s)

Table-6.2: Summary of Environmental Monitoring Programme for implementation during project operation phase

S. No.	Aspects	Parameters to be monitored	Frequency of monitoring	Location
1.	**Canal water**			
	Physico-chemical parameters	pH, Salinity, EC, TDS, Turbidity, Phosphates, Nitrates, Sulphates, Chlorides.	Once in three months	6-8 sites
	Biological parameters	Light penetration, Chlorophyll, Primary Productivity, Phytoplanktons, Zooplanktons	Once in three months	6-8 sites
2.	**Sediments**			
	Physico-chemical parameters	Texture, pH, Sodium, Potassium, Phosphate, Chlorides, Sulphates	Once in three months	6-8 sites
	Biological parameters	Benthic Meio-fauna, Benthic Macro-fauna	Once in three months	6-8 sites
3.	Ambient air quality	$PM_{2.5}$, PM_{10}, SO_2 and NO_2	- Summer, Post-monsoon & Winter seasons. - Twice a week for four consecutive weeks per season.	4 sites near project works
4	Sewage Treatment Plant	As per KSPCB	As per CTO	As per CTO

CHAPTER-7

ADDITIONAL STUDIES

7.1 GENERAL

Following Additional studies were carried out for the proposed project:

- Project specific HTL/LTL demarcation
- Hydraulic Modelling and Flood Plain Studies
- Biodiversity Management plan
- Risk and Disaster Management Plan
- Stakeholder Consultation
- R&R Plan
- Sediment Load study
- Public Hearing proceedings

7.2 HTL/LTL DEMARCATION

The proposed project envisages the construction of jetties, cleaning of canal routes and construction of 30 small jetties, 4 STPS, 56 road bridges and 31 foot bridges in Kochi. Since, the project is proposed in the coastal domain area, CRZ Clearance would also be required as per the CRZ Notification of January 2011. As per the Coastal Regulation Zone (CRZ) notification dated 6th January 2011, project specific HTL/LTL demarcation is required for the projects requiring CRZ clearance. Terms Reference (TOR) for the EIA study was issued by MoEF & CC also recommended that project specific HTL/LTL demarcation be done for the proposed project. Hence, CRZ mapping for the proposed project has been done through Institute of Remote Sensing (IRS) Anna University, Chennai, an agency authorized by MoEF, Government of India for the demarcation of HTL&LTL. IRS has conducted required field survey sand measurements for demarcation of CRZ (covering 7Km radius area around the proposed project site) in the Third week of October 2020. Findings of the HTL /LTL report prepared by Institute of Remote Sensing (IRS) Anna University, Chennai are summarised as below. The detailed CRZ Report is attached as **Annexure-IV.**

The cadastral/village map was used as the Base Map. Based on topography and geomorphic features, HTL for the project site has been identified and traced in the field by Kinematic GPS survey. The HTL were superimposed on to geo-referenced cadastral map to prepare a local level CRZ map at a scale of 1:4000.

7.2.1 Objectives

The objective of the present study is to examine the site for the proposed project (covering 7 Km radius area around the proposed project sites)"with reference to CRZ Notification 2011. Keeping in view of the requirements of notification, Institute of Remote Sensing, Anna University under took the project with following agreed scope of work:

- Demarcation of HTL,LTL near project site (covering 7km radius area) by conducting DGPS survey in the field.
- Demarcation of ecologically sensitive entities such as Mangroves, Sand dunes, etc. if any in the vicinity of project site.
- Superimposition of HTL, LTL and ecologically sensitive areas along with the project site on geo referenced cadastral map.
- Demarcation of Coastal Regulation Zones in the neighbourhood of the project site.

7.2.2 Methodology

The cadastral map of part of Kochi Municipal Corporation has been used as the base map. The Geomorphology of the Coastal Zone has been studied from the temporal medium resolution satellite data. In order to prepare the local level map on 1:4,000 scale, the site has been inspected by IRS Scientists in the last week of October 2020. Based on the geomorphic units, high tide line has been identified in the field and traced by field survey using GNSS. The tide level observations were collected from the Tide Tables. The highest high tide level and lowest low tide level for the past 19 years were determined from these tide tables.

As per the definition of high tide line, “The High Tide Line means the line on the land up to which the highest water line reaches during the spring tide”. There is a clear boundary between the areal spread of mudflats and vegetation usually very much apparent. This boundary line coincides with the HTL line interpreted from the satellite imagery. On the other hand LTL is defined as the seaward limit to which the waves recede during low tide.

In case of in land waters such as creeks and backwaters, the ICRZ guidelines indicates that the development along rivers, creeks, creek lets and backwaters has to be regulated up to a distance where the tidal effects are experienced which has to be determined as ed on salinity concentration of 5 parts per thousand (ppt).

7.2.3 GNSS Surveying

The Trimble R5 GNSS receivers were used to conduct the surveying at the project site. The survey involves three components namely, 1. Establishing Base Station, 2. Control Survey for Village Maps and 3. Real Time Kinematic Survey for HTL Demarcation.

7.2.4 Establishing Base Station

The survey involves establishing one base station for Static Survey. The base stations were identified on stable locations with clear view of sky for uninterrupted access to GNSS satellite signals. The control point with known elevation was used as initial reference station. The base station for the project site was established on firm ground and observed with static GNSS survey from the known coordinates of the control point. The observations times were fixed based on the length of base lines to obtain highest possible accuracies.

7.2.5 Static Survey

The conduct of Static Survey using GNSS requires two GNSS receivers, one to be setup over the control point (with known co-ordinate) and another one over a reference station whose coordinates and distance from the control point are to be determined. Both these receivers must record data simultaneously. These known co-ordinates of the control point were fed and fixed for processing of the logged data to accurately determine the co-ordinates of the base stations.

7.2.6 Control Survey for Geo referencing Village Maps

The cadastral map pertaining to the project site was provided by the client. The hard copy cadastral map was scanned and geo referenced with the help of GNSS coordinates of boundary points provided by the client and used for the preparation of local level HTL Maps.

7.2.7 Real Kinematic Survey for HTL Demarcation

Kinematic Surveying enables a very rapid survey of a number of base lines in areas where there is good satellite visibility. At least, two GNSS receivers are required to perform a kinematic survey. One receiver is designated as the reference receiver and is set up over the Base Station. All baselines are measured relative to this station. The other receivers, called rovers, are moved in succession to trace and record the HTL on ground through ground profiling.

7.2.8 Demarcation of HTL

Surrogate data such as coastal geomorphologic features identified from the satellite imagery, indicators available on the ground and tidal data were used to verify the HTL demarcated by Kinematic Survey.

7.2.9 Results and Conclusions

The details of CRZ category of proposed development in each canal for the proposed IURWTS Project as per CRZ notifications, 2011 are as given in Table-7.1 to 7.4.

Table-7.1: CRZ categorization of the various activities in Edapally Canal

S. No.	Description	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
PROPOSED CANAL BANK BEAUTIFICATION				
1	Beautification Location	CRZ - II	42,730.0	68770.1
		CRZ - IB	283.6	
		CRZ - IVB	10,977.9	
		Out of CRZ	14,778.6	
PROPOSED BRIDGE / FOOT BRIDGE / EXISTING TO BE RECONSTRUCTION				
1	Arkkakadavu Bridge	CRZ - II	131.9	546.8
		CRZ - IVB	414.9	
2	Chembookadav Bridge	Out of CRZ	110.4	110.4
3	Chembumukku Bridge	Out of CRZ	434.8	434.8
4	Foot Over Bridge 4	CRZ - II	14.8	25.1

S. No.	Description	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
		CRZ - IVB	10.3	
5	Foot Over Bridge 5	CRZ - II	3.7	47.2
		CRZ - IVB	43.5	
6	Foot Over Bridge 6	CRZ - II	1.0	47.2
		CRZ - IVB	46.2	
7	Foot Over Bridge 7	Out of CRZ	47.2	47.2
8	Indraji Bridge	Out of CRZ	162.1	162.1
9	Kuzhuvelippalam Bridge	CRZ - II	2.8	152.2
		CRZ - IB	6.9	
		CRZ - IVB	142.5	
10	Lulu Mall Parking Bridge	Out of CRZ	241.4	241.4
11	Marottichodu Bridge	Out of CRZ	273.1	273.1
12	Muttarkadavu Bridge	Out of CRZ	28.4	28.4
13	Oriental Timber Bridge	Out of CRZ	52.5	52.5
14	Palachuvadu Bridge	CRZ - II	13.4	192.7
		CRZ - IVB	179.3	
15	Pipe Line Road Bridge	Out of CRZ	142.5	142.5
16	Foot Over Bridge 1	CRZ - II	18.4	18.5
		CRZ - IB	0.1	
17	Foot Over Bridge 2	CRZ - IB	8.8	47.2
		CRZ - IVB	38.4	
18	Foot Over Bridge 3	CRZ - II	18.1	57.0
		CRZ - IVB	38.9	
19	Puravankara Iron Bridge 1	Out of CRZ	150.7	150.7
20	Puravankara PVT Bridge 2	Out of CRZ	2,170.7	2,170.7
PROPOSED JETTY LOCATION				
1	Muttar Jetty	Out of CRZ	1,876.5	1,876.5
2	Jetty Near Pipe Line Bridge	Out of CRZ	736.5	736.5
3	Jetty Near Kuzhivelipalam	CRZ - II	591.4	591.4
4	Jetty Near Indiraji Bridge	Out of CRZ	1,655.6	1,655.6
5	SPV Office and Jetty Near Chembokadavu Bridge	Out of CRZ	4,167.2	4,167.2
6	Jetty Edappaly Near LuluMall	Out of CRZ	621.2	621.2
7	JETTY NEAR CHEMBUMUKKU BRIDGE	Out of CRZ	819.3	819.3
8	Jetty Near Palachuvadu Bridge	CRZ - II	3,133.8	6,796.4
		Out of CRZ	3,662.6	
9	Jetty Near Arakkadavu Bridge	CRZ - II	1,345.3	1,464.7
		CRZ - IVB	119.4	
PROPOSED DEEPENING & WIDENING OF EXISTING CANAL				
1	Deepaning and Widening Area	CRZ - II	1,975.9	
		CRZ - IVB	579.5	34,594.5

S. No.	Description	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
		Out of CRZ	32,039.1	
PROPOSED SEWER LINE LAYING AREA				
1	Sewer Line Laying Area	CRZ - IB	1,104.7	49,817.2
		CRZ - II	15,461.9	
		CRZ - IVB	8,404.6	
		Out of CRZ	24,846.0	
PROPOSED STP LOCATION				
1	Proposed STP @ Muttar	Out of CRZ	11,789.5	11,789.5
2	Vennala STP	CRZ - II	7,304.6	17,482.4
		Out of CRZ	10,177.8	

Table-7.2: CRZ categorization of the various activities in Chilavannor canal

S No.	Description	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
PROPOSED JETTY LOCATION				
1	Edappalli Raghavan Pillai Road	Out of CRZ	565.6	565.6
2	Kathrikadavu	Out of CRZ	422.5	422.5
3	Keerthi Nagar	Out of CRZ	568.6	568.6
4	Near Elamakulam Metro Station	CRZ - II	105.5	968.6
	Near Elamakulam Metro Station	CRZ - IB	863.1	
5	Near JLN Stadium	Out of CRZ	333.3	333.3
6	Near JLN Metro Station	Out of CRZ	176.7	176.7
7	Near National Public School	Out of CRZ	271.7	271.7
8	SCB Road	CRZ - II	670.4	691.5
		CRZ - IB	21.1	
PROPOSED DEEPENING & WIDENING OF EXISTING CANAL				
1	Deepaning and Widening Area	CRZ - II	8762.9	71367.1
		CRZ - IB	34.8	
		CRZ - IVB	4703.5	
		Out of CRZ	57865.8	
PROPOSED STP LOCATION				
1	STP Location	CRZ - II	18317.1	
		CRZ - IB	1035.4	29808.9
		Out of CRZ	10456.4	
PROPOSED SEWER LINE LAYING AREA				
1	Sewer Line Laying Area	CRZ - II	18601.4	54857.3
		CRZ - IB	1642.8	
		CRZ - IVB	5944.7	
		Out of CRZ	28668.4	
PROPOSED BRIDGE / FOOT BRIDGE / EXISTING TO BE RECONSTRUCTION				
1	Elamakulam Bridge	CRZ - II	357.0	1,137.2
		CRZ - IB	401.9	
		CRZ - IVB	378.3	
2	RCC Road Bridge Geroge	Out of CRZ		

S No.	Description	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
	Edan Road		13.5	13.5
3	BTS Road	Out of CRZ	31.2	31.2
4	Raghavan Pillai Road	CRZ - II	97.4	97.4
5	Chilavanoor Bridge	CRZ - II	49.6	419.5
		CRZ - IVB	369.9	
6	Foot Bridge 2	Out of CRZ	12.4	12.4
7	Foot Over Bridge 12	CRZ - II	17.5	50.9
		CRZ - IVB	33.4	
8	Foot Over Bridge 13	CRZ - II	8.3	25.5
		CRZ - IVB	17.2	
9	Foot Over Bridge 14	CRZ - IVB	50.9	50.9
10	SCB Road Bridge	CRZ - II	63.7	102.5
		CRZ - IVB	38.8	
11	Private Road Bridge	CRZ - II	4.1	19.5
		CRZ - IVB	15.4	
12	St.Sebastien Road Bridge	CRZ - II	4.8	32.5
		CRZ - IVB	27.7	
13	VV Road Freinds Ave Road Bridge	CRZ - IVB	25.2	25.2
14	Railnagar Bridge-2	CRZ - II	66.3	81.0
		CRZ - IVB	14.7	
15	Railnagar Bridge-1	Out of CRZ	43.1	43.1
16	Panorama Residency Road Bridge	Out of CRZ	50.9	50.9
17	Railway Quarters Bridge	Out of CRZ	54.6	54.6
18	Karanakoodam Bridge 1	Out of CRZ	102.4	102.4
19	Karanakoodam Bridge 2	Out of CRZ	69.3	69.3
20	Skyline Bridge	Out of CRZ	75.0	75.0
21	Ima House Bridge	Out of CRZ	66.9	66.9
22	Vyloppilly Lane Bridge	Out of CRZ	30.8	30.8
23	Kent Construction Bridge	Out of CRZ	61.9	61.9
24	Foot Bridge 10	Out of CRZ	18.8	18.8
25	Noel Builders Bridge	Out of CRZ	67.6	67.6
26	Stadium Complex Gate Bridge	Out of CRZ	23.8	23.8
27	Stadium Gate Bridge	Out of CRZ	34.1	34.1
28	Greenz Villa Bridge	Out of CRZ	19.1	19.1
29	National Public School Road Bridge	Out of CRZ	19.1	19.1
30	Pottakuzhy-Mamngalam Road	Out of CRZ	38.5	38.5
31	Keerthi Nagar Road,Bridge	Out of CRZ	26.8	26.8
32	Foot Bridge 6	Out of CRZ	4.9	4.9
33	RCC Road Bridge	Out of CRZ	37.7	37.7
34	RCC Foot Bridge 7	Out of CRZ	2.3	2.3
35	Keerthi Nagar Extension Bridge	Out of CRZ	21.5	21.5
36	Steel Road Bridge	Out of CRZ	17.6	17.6
37	Foot Bridge 5	Out of CRZ	8.1	8.1
38	Foot Bridge 4	Out of CRZ	36.8	36.8
39	Foot Bridge 3	Out of CRZ	8.9	8.9
40	Anganawadi Foot Bridge	Out of CRZ	5.5	5.5

S No.	Description	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
41	Foot Bridge 1	Out of CRZ	11.7	11.7

Table-7.3: CRZ categorization of the various activities in TP Canal

Sl. No.	Description	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
PROPOSED DEEPENING & WIDENING OF EXISTING CANAL				
1	Deepaning and Widening Area	CRZ - II	1925.9	35861.2
		CRZ - IB	1.9	
		CRZ - IVB	1736.1	
		Out of CRZ	32197.4	
PROPOSED JETTY LOCATION				
1	Jetty Opposite To Chinmaya Vidyalaya	CRZ - II	14.8	84.7
	Jetty Opposite To Chinmaya Vidyalaya	CRZ - IVB	69.9	
2	Jetty Near Yuvajana Samajam Road	CRZ - II	257.8	257.8
3	Panampally Nagar Near Lag	CRZ - II	217.2	410.4
	Panampally Nagar Near Lag	Out of CRZ	193.2	
4	Jetty Near Kadavanthara Metro Station	Out of CRZ	421.0	421.0
5	Jetty Near P&T Colony	Out of CRZ	705.3	705.3
6	Jetty Near Ksrtc	Out of CRZ	779.3	779.3
7	Jetty Near Kaloor Metro	Out of CRZ	568.7	568.7
8	Jetty Near Pottakuzhy Bridge	CRZ - II	390.7	1002.8
	Jetty Near Pottakuzhy Bridge	CRZ - IVB	10.2	
	Jetty Near Pottakuzhy Bridge	Out of CRZ	601.9	
9	Jetty Near Karshaka Road	CRZ - II	797.9	797.9
10	Jetty Perandoor	CRZ - II	250.9	314.3
	Jetty Perandoor	CRZ - IVB	63.4	
PROPOSED SEWER LINE LAYING AREA				
1	Sewer Line Laying Area	CRZ - II	13902.0	37455.6
		CRZ - IB	16.3	
		CRZ - IVB	6005.3	
		Out of CRZ	175312.0	
PROPOSED STP LOCATION				
1	STP Location	CRZ - II	3921.5	4037.6
		CRZ - IVB	116.1	
Proposed bridge / foot bridge / existing to be reconstructed				
1	Anamthuruthu Road Bridge	CRZ - II	47.0	165.2
		CRZ - IVB	118.2	
2	Chemmani Road Bridge	Out of CRZ	46.5	46.5
3	Church Road Bridge	Out of CRZ	62.0	62.0
4	Concrete Foot Bridge 1	Out of CRZ	17.2	17.2
5	Concrete Foot Bridge 2	Out of CRZ	13.7	13.7
6	Concrete Slab Foot Bridge	Out of CRZ	11.9	11.9
7	Elders Forum Road Bridge	CRZ - II	67.8	71.4
		CRZ - IVB	3.6	
8	Foot Bridge 1	Out of CRZ	73.0	73.0
9	Foot Bridge 2	Out of CRZ	46.2	46.2
10	Foot Bridge 3	Out of CRZ	9.7	9.7
11	Foot Bridge 4	Out of CRZ	12.2	12.2
12	Foot Bridge 5	Out of CRZ	18.4	18.4

Sl. No.	Description	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
13	Iron Foot Bridge 1	Out of CRZ	13.5	13.5
14	Iron Foot Bridge 2	CRZ - II	1.8	32.4
		CRZ - IVB	30.6	
15	Kadavanthra Market Bridge	Out of CRZ	114.1	114.1
16	Kaloor Manappattiparambu Bridge	Out of CRZ	120.8	120.8
17	Karshaka Road Bridge	Out of CRZ	131.8	131.8
18	Kochu Kadavanthra Road Bridge	CRZ - II	38.5	151.7
		CRZ - IVB	113.2	
19	Panampilly Nagar-Girinagar Road Bridge	CRZ - IVB	81.2	81.2
20	Panampilly Nagar-Vidhya Nagar Road Bridge	CRZ - II	6.2	73.0
		CRZ - IVB	66.8	
21	Panampilly Nagar Link Road Bridge	CRZ - II	2.9	61.6
		CRZ - IVB	58.7	
22	Pottakuzhy Road Bridge	CRZ - II	155.3	312.1
		CRZ - IVB	156.8	
23	Rbi Quaters Road Bridge	Out of CRZ	56.8	56.8
24	Refinery Pipeline Bridge	Out of CRZ	29.5	29.5
25	Road Bridge	Out of CRZ	55.0	55.0
26	Sahodaran Ayyappan Road Bridge	Out of CRZ	365.4	365.4
27	Salim Rajan Road Bridge	Out of CRZ	419.0	419.0
28	Sasthri Nagar Bridge	CRZ - II	17.9	108.0
		CRZ - IVB	90.1	
29	Sebastan Road Bridge	Out of CRZ	31.1	31.1
30	Shastha Temple Road Bridge	Out of CRZ	93.3	93.3
31	St Augustines School Road Bridge	Out of CRZ	55.0	55.0
32	Steel Foot Bridge 1	Out of CRZ	46.1	46.1
33	Steel Foot Bridge 2	Out of CRZ	46.1	46.1
34	Steel Foot Bridge 3	Out of CRZ	24.2	24.2
35	Thammanam-Pulleppady Road Bridge	Out of CRZ	67.2	67.2

Table-7.4: CRZ categorization of the various activities in Tevara canal

Sl. No.	Description	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
PROPOSED JETTY LOCATION				
1	Thevara Market Jetty	CRZ - II	53.9	80.3
		CRZ - IVB	26.4	
2	Kallupalam Jetty	CRZ - II	187.0	381.1
		CRZ - IVB	0.2	
		Out of CRZ	193.9	
PROPOSED APPROACH ROAD				
1	Approach Road	CRZ - II	690.4	963.7
		Out of CRZ	273.3	
PROPOSED SEWER LINE LAYING AREA				
1	Proposed Bridge / Foot Bridge / Existing to be Reconstructed	CRZ - IB	586.7	14,132.0
		CRZ - II	10814.2	
		CRZ - IVB	2695.3	

Sl. No.	Description	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
		Out of CRZ	35.8	
PROPOSED BRIDGE / FOOT BRIDGE / EXISTING TO BE RECONSTRUCTION				
1	Kallupalam Bridge	CRZ - II	9.4	45.4
		CRZ - IVB	36.0	
2	Konthuruthy Road Bridge	Out of CRZ	286.4	286.4
3	Pandit Karuppan Road Bridge	CRZ - II	259.3	553.1
		CRZ - IVB	185.0	
		Out of CRZ	108.8	
4	Proposed Foot Bridge 1	CRZ - II	209.4	286.4
		CRZ - IB	60.9	
		CRZ - IVB	16.1	
5	Proposed Foot Bridge 2	CRZ - II	173.8	286.4
		CRZ - IB	74.2	
		Out of CRZ	38.4	
6	Proposed Road Bridge	CRZ - II	64.3	221.7
		CRZ - IVB	157.4	

Table-7.5: CRZ categorization of the various activities in Market canal

Sl.No.	Description	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
PROPOSED WALKWAY				
1	Walkway	CRZ - II	1400.2	1897.5
		CRZ - IB	472.1	
		CRZ - IVB	25.3	
PROPOSED BRIDGE / FOOT BRIDGE / EXISTING TO BE RECONSTRUCTION				
1	Marine Drive Bridge	CRZ - IB	48.0	111.6
		CRZ - II	63.6	
2	Shanmughom Road	CRZ - IB	443.6	517.2
		CRZ - II	73.6	
3	Broadway Road	CRZ - IB	117.4	120.7
		CRZ - II	3.3	
4	Ernakulam Market Canal Bridge	CRZ - IB	29.2	40.9
		CRZ - II	11.7	

7.3 HYDRAULIC MODELLING AND FLOOD PLAIN STUDIES

Hydraulic and Floodplain Studies is carried out to assess the drainage capacities and affected flooded areas of the canals during extreme events. Hydrologic and hydraulic models have been used to assess both the existing state and the restored state of the canals under different return periods of extreme precipitation events, tidal conditions and river floods. The restored state of the canals is designed to address both flood mitigation and navigation requirements. The flood plain modelling study done by General consultant is vetted by Central Water and Power Research Station (CWPRS), Pune. The detailed report is attached as **Annexure-V.**

The IURWTS project addresses two main components,

1. Restoration of five major dilapidated canals and associated catchments to mitigate stormwater flooding, and to allow public transport navigation to enhance last mile connectivity and provide pollution free water bodies.
2. **Urban regeneration** of the canal catchments by a canal-oriented development (COD) approach, incorporating sewer connectivity up to the households in the catchments with purpose built sewerage infrastructure.

The three major canals (Edappally, Chilavanoor and the combined catchment of Thevara Perandoor) are currently in a dilapidated state with many bottlenecks such as encroachment into the canal boundaries by squatters , unplanned road and footbridge crossings and major utility crossings of the canals without adequate vertical clearances for draining the flood waters.

This has resulted in drainage congestion leading to overbank flooding in many pockets along the canals during heavy rain storm events. In the existing condition, navigation through the canals is not possible due to encroachments and siltation. Under the proposed restored state the canal width and depth are increased as per PIANC guidelines for ensuring two-way movement of vessels.

7.3.1 Methodology

The methodology adopted has followed these steps:

1. **Generation of rainfall Intensity-Duration-Frequency (IDF) curves and design rain storm hyetographs:** An IDF Curve gives the expected rainfall intensity (mm/hr.) of a given duration of a storm and its frequency of occurrence. IDF curves have been generated for a range of probabilities and durations from historical data. From the IDF relations, design storm hyetographs defining the temporal distribution of the rainfall have been derived using the alternating block method.
2. **Hydrologic Analysis:** This analysis is undertaken to obtain estimates of catchment inflows to the canals for the selected rainfall design return periods. The catchment runoff hydrographs are generated using **HEC HMS** software. As the canal catchments are ungauged, no flow data was available for calibration of the model, however peak flows from HEC-HMS have been compared with a simple Rational Method as a means to cross-check the hydrograph estimates.
3. **Hydraulic and floodplain modelling:** Routing the runoff hydrographs through the canal systems has been undertaken using **HEC RAS** software. The hydraulic modelling has assumed one dimensional unsteady flow regimes and has generated the water surface water surface profiles and flows along the canals as well as inflow/outflow hydrographs at the canal boundaries. Energy losses due to channel contractions and expansions as well as the effects of obstructions such as bridges

and cross structures have also been taken into account in the computations. Flood maps generated for extreme events along the canal are also brought out.

7.3.2 Result

Hydraulic modelling of the three canals shows that drainage from local storm water runoff occurs in both directions, to the north and south of each canal. When the same water level is imposed at each end of the canal, only outward flow is observed. In the asymmetrical case representing a river flood condition, a net north to south flow in the canal occurs as expected with the stormwater flood event superimposed. This results in a reversal of flow at the northern end of the canal at the peak of the runoff.

Restoring the canal through widening and deepening to a minimum of -0.9m CD results in reduced flood levels in all cases. The maximum reductions occur in Edappally canal where the current flow capacity is the most constrained and which therefore benefits the most from the restoration. In contrast the smallest reductions in flood level are seen in the Thevara-TP canal where modification to the canal bathymetry in the restored condition are more modest.

The maximum water level in the different exercises for Edappally Canal with its existing terrain and geometry conditions is found to be 1.86m for the highest astronomical tide condition whereas it has considerably reduced to 1.55m in the restored condition. For the Chilavanoor canal with its existing terrain and geometry conditions, the maximum water level is found to be 1.60m for the highest astronomical tide condition, whereas the same for the restored state is 1.57m. For the Thevara- Perandoor Canal also, the maximum water level has occurred for the highest astronomical tide conditions as 1.59m for the existing conditions whereas the same for restored condition is 1.55m. It has been seen that the flood water levels have been reduced in the restored condition for all the three canals. It is also found that the maximum water level in the restored condition is within the proposed canal height level in any of the simulations with different boundary conditions and flow data for different return periods.

The maximum water level in the canals in the existing condition and Maximum discharge is given below:

Maximum Water level in the Canals

Canal	**Maximum water level m**
Edappally	1.86
Chilavanoor	1.6
Thevara- Perandoor	1.59

Maximum Discharge in the canals

Canal	**Maximum Discharge m3/s**
Edappally	56.11
Chilavanoor	48.28
Thevara- Perandoor	50.66

Terrain modification and removal of cross structures has resulted in improved flow patterns both at downstream and upstream boundaries for all the three canals. Based on the hydraulic studies performed, it is revealed that when the bottlenecks of the existing conditions are removed, no flooding is seen to occur in the restored condition within the canal cross section of the three canals. But in the adjacent flood plain of the canals, water logging is seen in places where the ground levels are lesser than the boundary conditions which will get subsequently drained out.

Based on the hydraulic modelling of the three canals, the maximum water surface elevation anticipated is 1.85m CD in the existing condition. It is found that the maximum water surface elevation in the restored condition in the worst case is 1.55m CD and the water level is within the canal cross section.

7.3.3 Limitations

The main limitations relating to the hydrological modelling are as follows:

- The 16 years of observed rainfall is a relatively short period on which to base more rare storm events. Extrapolation to 20-25 years would generally regarded as acceptable however there is increasing uncertainty when considering less frequent 50 or 100 year events. For the purposes of this project the main interest is in the 25 year event and therefore this is not a major issue.
- The infilling and extrapolation of the 16 years of observed hourly data was based on daily reanalysis data using an empirical formulation. This was considered necessary especially to include the major rainstorm events of 2018 and 2019, which unfortunately hourly rainfall data was not available. The results of the IDF analysis only displays small changes (increases in rainfall depth) compared to the values based on the 16 years of observation only, and therefore no significant issues are flagged here.
- The IDF tables have been used to derive a synthetic rainfall profile (hyetograph) using a well-accepted (alternating bar) method. As the shortest observed duration was one hour, this is reflected in the hyetograph.
- The hydrological model cannot be validated due to the absence of recorded flow data, and therefore peak flow estimate have been compared to a standard Rational Method assessment as a cross check for gross errors.

The hydraulic study has been carried out with an extensive topographical data set, incorporating details of the canal bathymetry LiDAR derived floodplain levels. The main limitations relating to the hydraulic model are as follows:

- The LiDAR data was restricted to 125m each side of the canal which is therefore the maximum extent of the cross sections represented in the model. Floods which reach these extents are therefore artificially constrained which may results in modelled water levels being higher may otherwise occur.
- There is limited information with which to formulate appropriate boundary conditions in the rivers which bound each end of the canals. There is sufficient tidal level data which has been used to assess the levels due to tides but there is no information regarding the influence of river flows, apart from flood markers retrieved from the 2018 flood. Therefore the effect of river flow influences have been estimated.
- There is no flow data against which the hydrological / hydraulic model can be validated.
- The model boundary conditions imposed at the canal ends are the most influential factor in determining the flood levels in the interior canal areas. As described above these are set based on a number of assumptions. The model is best considered as a comparative tool to determine the relative effects of changes to the canal bathymetries that will be applied as part of the restoration program.

7.3.4 Conclusions

- Based on the hydraulic modelling of the three canals, the maximum water surface elevation anticipated is 1.85m CD in the existing condition.
- The maximum water surface elevation in the restored condition in the worst case is found to be 1.55m CD and the water level is within the canal cross section.
- Terrain modification and removal of cross structures has resulted in improved flow patterns both at downstream and upstream boundaries for all the three canals
- It is revealed that when the bottlenecks of the existing conditions are removed, no flooding occurs in the restored condition in any of the three canals.
- The maximum discharge in the canals is found to be 56 m^3/s
- The restored canals sections are found to be adequate to accommodate the maximum discharge in the canals.
- Flood plain studies revealed that flooding occurs in adjacent regions of the canals with ground level lower than the boundary conditions

7.3.5 Flood management plan

Mitigation measures in IURWTS catchment are undertaken to significantly reduce the risk of flooding before it occurs. The magnitude of the risk in IURWTS catchment is seen to be a function of the flood hazard, the characteristics of a particular lay out of the canals (its elevation, proximity to the river reaching the water bodies of the Kochi lagoon and the canals in the catchment, tidal fluctuation impact on the canal system etc.). The measures taken to mitigate the potential impact of flooding, the vulnerability of people and property, and the consequences that result from a particular flood event also depends on the magnitude of risk. Elimination of flooding risk cannot be completely eliminated in the catchment. Hence mitigation measures taken to reduce the overall risk and the residual risk that remains have been studied. For residual risk has been assessed by considering the impact of flood in High Astronomical tide conditions for individual IURWTS canal catchments separately.

The list of mitigation measures taken in IURWTS catchment is as given below:

- As part of floodplain Management Planning flood zone maps identifying the flooding pockets in the catchment have been developed for the inhabitants of IURWTS catchment to manage substantial damages to their properties in areas flooding is anticipated.
- Enforcement of local ordinances/ building codes are already in vogue for buildings constructed in the project command. Recommendation to Kochi Municipal corporation and adjoining municipalities to adopt and enforce measures to allow construction of new buildings only with a minimum free board of 30cm over the HFL In the flood zones identified in the catchment will be ensured.
- Canal oriented development with open areas and parks are proposed in a 4Km stretch along Edappally canal that will be preserved after development in their natural state with afforestation measures like Miyawaki forests accommodating nearly 42000 saplings and other worthy preservation measures as a part of the habitat conservation plan. A typical Miyawaki forests stretch proposed. As part of the project under the Green Belt development, 22000 trees are proposed to be planted in various stretches of the canals in areas identified.
- Drainage System Maintenance forms part of this project. Regulatory orders have been issued by Govt. of Kerala to prevent dumping of waste and sewage inlets into the canals. Existing 113 Littering points have been identified and littering boards with recreational facilities have been proposed with innovative messages along the canal banks. These regulations will help protect water quality, protect the flora and fauna and also the environment upkeep of the canal banks.
- Annual Sediment load deposition in the canals have been estimated and it has been assessed that the suspended sediments are within reasonable limit which will not endanger the fish species, flora and fauna. The bed load deposition estimated revealed that every 2 years desilting of the canals will be required in adverse conditions.

- Water harvesting measures by way of natural storage ponds is also proposed in site suitable areas as part of the canal oriented development (COD) activities proposed in the catchment.
- Storm water management through drainage improvement in each of the sub catchments of the canals has also been studied as part of the hydraulic modeling. The flood discharge generated from the sub catchment have been brought out and the natural drains in the sub catchments have been surveyed are also being improved for the free flow of the flood waters.
- Bio engineering embankments, side protections are also conceived where the canal banks are at lower levels to contain the flood generated from the catchment based on hydraulic model studies. This was following the coastal zone regulation map generated for the catchment.
- IURWTS catchment lies in close proximity with the coastal stretches and hence the impact of salinity intrusion by way of the development proposed in the canal was studied. The study has revealed that there will be no impact of salinity intrusion into the wells of the catchments..
- Flood plain species assessment and the impact of biodiversity of species in the canals and the canal catchment has been studied by Cochin University of Science and Technology (CUSAT). Innovative measures have been taken as part of the Canal Oriented development undertaken in the project for a 4Km stretch along Edappally canal. This was recognizing the close relationship between protection of flood-prone property and protection of threatened and endangered species. Innovative floodplain management practices, such as keeping wetlands, canal banks, in their undisturbed natural condition in most of the site-specific stretches, that are essential for the survival of many threatened and endangered species have been conceived as part of the IURWTS project.
- The infrastructures proposed in the project are flood resilient structures which are proposed considering the High flood levels measured from a 1 in 100yr flood that occurred in the premises of the catchment in the year 2018 and an extreme precipitation event in the catchment in the year 2019.

7.4 BIODIVERSITY ASSESSMENT AND MANAGEMENT PLAN

Biodiversity Assessment was conducted by Department of Marine Biology, Microbiology & Biochemistry, School of Marine Sciences, Cochin University of Science & Technology (CUSAT) during September 2020 to November 2020 in the five canals (Thevara canal, Perandoor canal, Edappally canal, Chilavannoor canal and Market canal) along with its corresponding reference stations, (Thevara, South Chittoor, Thuthiyoor, Maradu and

Bolghatty) revealed that the environmental quality and biological productivity and the biodiversity were seriously impaired in the canals. The findings and management of the study are given in following paragraphs.

7.4.1 Findings of the study

The water and sediment quality were generally poor in most of the canals with the grading trend of followed by Thevara, Perandoor, Edapally, Maradu and Chilavannoor canals. The salinity pattern in the canal showed freshwater condition during the study period. The pH was slightly acidic; higher alkalinity values were observed in Perandoor, Chilavannoor and market canal whereas, comparatively low values were in Thevara and Edappally canals. All the canals recorded low dissolved oxygen (DO) level whereas BOD level was higher. Low DO and high BOD value revealed the extremely polluted condition in the canals. Large scale release of sewages from domestic, industrial and spread of invasive water opportunistic organisms and water plants play a crucial role in the hypoxic to anoxic DO and increasing BOD trend in most of the canals.

The average heavy metal concentration in water was higher in the five canals that followed the trend Cd<Mn<Cr< Ni<Cu<Pb<Zn <Fe where the highest values observed in Perandoor canal. Heavy metal concentration in sediment followed the trend Fe>Mn>Pb>Cr>Zn>Cu>Ni>Hg. Iron, zinc, manganese and lead was considerably high in the reference stations compared to all the canals. Geoaccumulation index and contamination also corroborated to the metal contamination in the canals where mercury, cadmium and nickel showed exceedingly higher values in sediments creating a serious polluted condition for the biodiversity of the canals.

Thus the present investigation indicates that, all the canals are facing serious heavy metal pollution. Dumping of wastes, use of agro-chemicals such as fertilizers and pesticides, sewage-sludge, municipal runoff and other developmental activities are the main contestant in anthropogenic enrichment of heavy metals in canal systems.

From a comparison of the water quality in the canals and the reference stations with the national and international standards (BIS, ICMR, CPCB, WHO, US EPA) it can be documented that the parameters DO, BOD, magnesium, alkalinity, chloride were well above the permissible limit prescribed by the various agencies. This clearly established that environmental quality was really alarming in five canal ecosystems.

The primary production was totally collapsed mainly arising from the unhealthy water quality condition prevailing in the canals. However, the reference stations showed better water, sediment, general productivity condition compared with national and international standards. Biomass, abundance and diversity of phytoplankton, microzooplankton, mesozooplankton and macrobenthos were showing poor trends in all the canals and also in the reference canals because of the poor water sediment quality and productivity prevailing in the area.

The fishery and aquatic macrophytes from the canals were generally poor for the study. However, the species recorded were unique and needs suitable conservation and management plans.

The disturbance in the natural habitat and ecology of the canal system ecology through unscientific dredging, waste disposal and mining activities has led to the loss of native endemic fishery and other resources along with proliferation of opportunistic invasive species of fishes like African catfish, Tilapia, Three spotted gourami, mussels *Mytella strigata*, *Mytilopsis sallei* and various other fauna. In spite of the degrading canal and its terrestrial habitat from pollution and other encroachment issues they provide a fair repository for the birds, mammals, reptiles, mangroves, plants and other biodiversity in the region. Comparison of the biodiversity in the present study with that of the LBSAP (Local Biodiversity and Action Plan), it was noted that, the flora and fauna were higher in composition, abundance and diversity in the five canals. Therefore, suitable management plans as highlighted in the report has to be implemented for its long-term conservation.

From this study, it is concluded that the environmental quality and biodiversity of Chilavannoor, Market, Edappally, Thevara-Perandoor and Thevara canals are seriously affected by contamination and pollution from various anthropogenic activities. When compared to the reference stations, all the environmental and biological parameters in all the five canals can be considered to be the “pollution hot spots”. Ill-maintenance of the canal, rampant encroachments, and garbage-sewage disposal by nearby- residents have turned the five canals into cess pools of environmental sensitive zone

Severe contamination with heavy metals, plastics, disposal and dumping of kitchen garbage, slaughter house and poultry waste has all steered to the deterioration of the study area. Rampant encroachment and unchecked pollution have sounded the death knell for almost all the canals. The canals which were navigable till a couple of decades ago are now being stifled by encroachments along its embracements.

Documentation of the water quality status of the canals and the reference stations in comparison with the national and international standards (BIS, ICMR, CPCB, WHO, US EPA) revealed that the parameters DO, BOD, magnesium, alkalinity, chloride were well above the permissible limit prescribed by the various agencies that clearly established the distressing condition in the five canals.

High concentrations of Iron, cadmium, nickel and mercury detected in water as well as the sediment samples enhanced the eutrophication in the study area. Geoaccumulation index and contamination factor indicated that all the canals are in extremely polluted condition in terms of mercury, cadmium and nickel.

The macrobenthos which are generally non migrant, can be used as indices of ecological changes in the aquatic ecosystem. The reduced macrobenthic biomass, abundance and diversity in the canals, just limiting to 4 to 5 species (Clams, Mussels, Barnacles and Gastropods) could be related to the alarming environmental quality status of the selected canals. The disruption in the natural habitat of the canal system ecology through unscientific dredging and other waste disposal and mining activities has almost steered to the loss of native endemic fauna of fishery and other resources substituted by opportunistic invasive organisms like African catfish, Tilapia, Three spotted gourami, *Mytella strigata*, *Mytilopsis sallei* and other fauna.

7.4.2 Management Strategies and Action Plan

7.4.2.1 Threats and challenges in selected canals under IURWTS project

Based on the environmental quality and biodiversity assessment a ten point scale has been evolved from which, it is derived that most of the canal fall under poor and fair category which requires immediate attention for its rejuvenation and maintenance as a canal ecosystem having all the vital ecological function as any aquatic habitat providing the life resources and the sustenance of all community and human population. But it faces a myriad of diverse and severe threats. Drainage from human settlements and residential complexes, land transformation, pollution and fertilization, unattainable resources partitioning, over siltation due to poor canal management and uncontrolled dredging, over flooding due to catchment degradation upstream and blockage of waterways, encroachment for settlement due to increasing demands for land and over removal of biodiversity (fauna and flora). Private sector involvement is a major threat and there seems to be true scramble for the canal resources without regard to the rights of local communities. Poor management and lack of or just the poor implementation of environmental laws and guidelines and climate change add to the Kochi canal problems. These threats have induced changes that have eroded the ecological and socio-economic values and services derived from selected canals under IURWTS project. The canals should be considered as an ecosystem having its own life structure and wetland character. So, they are to be protected and considered under the National and State wetland conservation and coastal regulation rules.

The underlying threat remains lack of recognition of the importance of selected canals under IURWTS project as a finite resource whose roles in both the state economy and community livelihoods is taken for granted.

7.4.2.2 Reclamation and Conversion of canal ecosystem

Developmental activities due to urbanisation and increasing anthropogenic needs led to large-scale conversion and reclamation of canal ecosystem for alternative uses without regard to ecological, biological and socio-economic values is one of the biggest threats to the conservation and management of selected canals under IURWTS project. The horizontal and vertical shrinkage due to various forms of unscientific and unplanned developmental projects on canal noticeable with large scale encroachment in several sectors of the canal especially Chilavanoor canal, Thevara canal, Perandoor canal, Edappally canal and market canal. This seriously affected the water flow rate along the canals and also due to soil erosion affecting the water flow. So regular water flow with scientific management so as to have suitable change with the coastal estuary and reference station. This will keep the canal in the healthy state. Also deepening and removal of accumulated silt, waste and sewage is required so that the environmental quality and productivity is improved

Management strategies:

- Drainage and reclamation of canal ecosystem will not be allowed unless a greater public interest is demonstrated within a framework of maintained ecological integrity of Canal ecosystems.
- Canal ecosystems will be zoned for multiple land uses restricting any degrading developments to the already opened up areas.
- Any alteration of Canal ecosystems for public interest will be subject to Environmental Impact Assessment (EIA), cost benefit analysis, and wide stakeholder consultations.
- Any conversion should be in harmony with the integrity of the Canal ecosystems, and maintain the functions of the Canal ecosystems.
- Undesirable developments and plant species that negatively impact the ecology and hydrology of the Canal ecosystems will be disallowed, and where already introduced, will be replaced with appropriate developments and plant species.
- Uncontrolled reclamation of adjacent wetland areas will be prohibited and strict implementation of Kerala wetland act 2008, Wetlands (Conservation and Management) Rules, 2008, Wetland rules 2017, CRZ rules, 2019.
- Land uses that allow maintain ecological integrity within a sustainable development framework will be promoted.

7.4.2.3 Pollution and Eutrophication of Canal ecosystems

The quality of many water sources in Kochi is declining as a result of municipal, industrial and agricultural wastes/ discharges. These have negatively impacted water quality and biodiversity within the wetland ecosystems thereby reducing their values. Increased nutrient loads have led to eutrophication and episodes of aquatic weed/algal blooms in most canals. In the Canal ecosystems, excessive pollution, eutrophication and siltation have led to reduced water quality and reduction on canal ecosystem goods and services.

Management Strategies:

- Appropriate measures will be taken to protect canal banks and adjacent wetlands.
- Dumping of waste in canals will be disallowed and any disposal sites close to canals should be subjected to Environmental Impact Assessment.
- In light of the industrial developments and urbanisation, any effluent discharged into will be regulated and treated to meet appropriate wastewater standards. Where appropriate

industries/residential complexes will be asked to treat and recycle their water as proof that safe standards are met.

- Environmentally friendly agricultural techniques that reduce nutrient, silt and pollutant loading in the canals will be promoted.
- Public awareness including at household level on proper management of waste including reduction, reuse and recycling will be promoted.
- Coordination and enforcement of wetland and general environmental laws will be promoted.

7.4.2.4 Alien Invasive Species

Like many wetlands and other ecosystems in Kerala, selected canals under IURWTS project are highly vulnerable to alien and potentially invasive species. Many wetlands/water bodies have in the past been affected by the introduction of alien invasive species such as Water hyacinth (*Eichhornia crassipes*), Giant African Snail (*Achatina fulica*) and African sharptooth catfish (*Clarias gariepinus*) that have altered the biodiversity characteristic and diminished the services provided by wetlands and aquatic ecosystem. Introduced species easily occupy new niches due to lack of competition and predators.

Management strategies:

- Introduction of alien and potentially invasive species without due appraisal of their potential impacts in canal ecosystem is prohibited.
- Conditions that are conducive for the establishment and proliferation of invasive species will be managed.
- Guidelines, regulations and procedures will be developed and enforced to control introductions of alien and genetically modified organisms.
- Public education and awareness campaigns on the dangers of alien species will be carried out, and stakeholders will be involved in the management of wetlands threatened by invasive species.
- Research collaboration with universities to promote understanding on alien species will be promoted to help develop strategies and actions to manage alien species.

7.4.2.5 Aquatic weeds

The presence of excessive aquatic vegetation in the canals influences the management of water in waterways and they also pose serious threat to fisheries and other aquatic fauna. They compete with fish and other fauna for water, nutrients, light, niche and oxygen and thus reduce the secondary productivity. Considering the losses caused by aquatic weeds, their management is of utmost importance to improve the quality and efficiency of canal ecosystem.

Effects of excessive aquatic weeds on canal ecosystems

(a). *Aquatic weeds create situation which are ideal for mosquito growth.*

(b). *Aquatic weeds also affect quality of water:*

(c). *Increase the organic matter content of water:*

(d). *Hindrance for water flow*

(e). *Water clogging*

(g). *Pose pollution and health problem*

(h). *Hinder navigation*

(i). *Increase sedimentations*

(j). *Effect on Fish production*

Management strategies:

- Aquatic weeds in selected canals under IURWTS project can be controlled or reduced/suppressed with dredging, shredding, or chaining. As weeds grow back, these tasks are repeated as needed.The harvested material could be used as a fertilizer; livestock feed, or mulch in gardens or could be sent to a land fill. These techniques leave large amounts of debris that must be removed safely to avoid plugging structures or spreading seeds or plant fragments.
- Physical structures can be added to the canals. Physical structures may be worth the cost in particularly troublesome areas. Booms can be temporary solutions to prevent or contain infestations, particularly for invasive species. Containment booms require a high degree of maintenance. An unmaintained boom can break and spread the infestation.

7.4.3 Conservation and management

All the canals we manage are designated as locally important water ways. Scrub and tree growth on these structures causes damage to them and can lead to failures. Conversely, fringing vegetation in our canals can help to reduce bank erosion. Trees, other terrestrial and aquatic vegetation are an important habitat and landscape element of the waterways. They have the potential to pose safety risks, navigation and access hazards.

Invasive non-native species on our waterways can reduce intrinsic biodiversity value, pose safety risks or cause expensive damage to structures. So we need to reduce the risk of spread of non-native species to other unaffected areas.

7.4.3.1 Establishment of the selected canals under IURWTS project conservation Area

The ecological, biological and socio-economic benefits, values and services provided by the selected canals under IURWTS project are critical and must be maintained at all costs for posterity. There is no reason why selected canals under IURWTS project should guarantee these invaluable services in the long-term unless the management of the area is addressed. The Government has established ecological parks and safe heavens to ensure that areas similar to the canal ecosystem are protected and managed sustainably however the selected canals under IURWTS project remain waiting for this conservation benefit.

Management strategies:

- Selected canals under IURWTS project will be accorded protection and conservation status necessary for the maintenance of its functions that support existing indigenous local community multiple land uses.
- An estimated 90% of canal land is not subject to any form of vegetation management. The maintenance regime of vegetated land and water varies by location (grass cutting, aquatic plant management, woodland and tree management and invasive plant species control) and is designed to promote biodiversity whilst facilitating safe access for local peoples.
- Nature Reserve/ Safe Heavens —for strict protection in areas that will function as natural gene banks and conservation of germplasm: thriving and breeding place for different fauna and flora. It also acts as biodiversity refuge for animals such as mammals, reptiles, amphibians and birds and help to reduce loosing of native species. In designating such sites the representative nature of different services of selected canals under IURWTS project will be taken into consideration.
- Strict implementation of various wetland protection acts/rules, wildlife protection rules (Wild life protection act, 1972, Environmental Protection Act, 1986, Indian Forest Act, 1927, Indian Fisheries Act 1897, Kerala wetland act 2008, Wetlands (Conservation and Management) Rules, 2008, Wetland rules 2017, CRZ rules, 2019)to conserve remaining biodiversity and wilderness in and around selected canals under IURWTS project and adjacent water bodies So that terrestrial and aquatic territory should be protected for the community and mankind.

7.4.3.2 Fishery Management

Threats to Fishery:

Poaching, dynamiting and unethical fishery practices along with intense contamination and pollution is rampant in the most of the canals. The catch of fishery was also very poor which reflected from the study. The canals were mostly clogged with waste and other materials that prevented the fishes from movement and migration for breeding, feeding and other livelihoods.

Management strategies:

- Native endemic species like Pearl spot, Channa, Stinging catfish, Yellow catfish, Anabas, Mullet, Wallagoare to be propagated in the canals and their smooth movement and passage of the fishes along the canal and the coastal area for feeding, breeding and other reagent.
- “Bring back the Natives” should be propagated for the fishery and other biodiversity of the canals.

- The canals can be managed by the local self-government agencies and also a Canal Development Authority for the management of the biodiversity.
- The canals can be developed as seed repository and propagation centers especially for the native species.
- Ranching of the native species can be conducted after proper changes and protective measures in the canal ecosystem.

7.4.3.3 Green Belt /Corridor Development Plan

While improving the aesthetic of the area the greenbelt though functioning as pollutant sinks while scavenging pollutants, also incidentally help in developing habitats for birds and animals. The plants in their function as scavenger of pollutants are also prone to suffer toxicity of air pollutants like any other living organism. In order to mitigate and minimize environmental impacts from air pollution, noise pollution, soil erosion etc. arising due to construction of project, greenbelt development around the project sites is a good option. Green canopy not only absorbs some of these pollutants but also improves the environment. Therefore, a "Green Belt Development Plan" by using the local species has been proposed along the bank of canals. Local species are economically important, soil binding in nature and can thrive well under local conditions. Such species shall be planted to maintain species diversity, rational utilization of nutrients and also to maintain health of the trees and comply with the CPCB Guidelines (CPCB (2000) Guidelines for Development of Greenbelts Published by CPCB, Delhi).

7.4.3.4 Conservation of Mangrove Habitat

Mangroves provide a wide range of ecosystem services to human populations. Coastal communities especially mangrove dwellers have long relied on the provisioning services of mangroves like extraction of fuel wood as well as building materials, capture of food sources like fin fish and shellfish. Further, these unique ecosystems provide a range of regulating services like coastal protection, pollutant assimilation, macroclimate regulation and mitigation of global climatic change through carbon storage and sequestration.

With this background, the study proposes to develop Mangrove Island in the buffer zone of all the study stations. For that, ecological mangrove restoration (EMR) method can be followed, in which the intertidal zone is manipulated (dredged/ filled) so that biophysical conditions (particularly inundation) are within tolerable limits for mangrove establishment, growth, and reproduction.

7.4.3.5 Monitoring & evaluation of wetland ecosystems and biodiversity hotspot

To identify ecologically fragile area and integrated to GIS platform; Regular monitoring surveillance using GIS mobile app or cloud; Establishment of a permanent monitoring station; Formation of task force.

7.4.3.6 Restriction of Environmentally Harmful Activities in selected canals under IURWTS project

The following anthropogenic activities are potentially damaging for the canal environment. Their allowance, prohibition or regulation should be based on their actual environmental impacts assessed in specific situations as also their social and economic implications.

- Discharge of sewage (either treated or untreated) from households, residential complexes and flats directly or indirectly, into rivers.
- Disposal of industrial/ municipal solid wastes and sludge (from treatment of sewage or effluents) to be restricted everywhere.
- Discharge of industrial effluents (either treated or untreated) from small scale industrial units into canals.
- Disposal and/or discharge of mining and construction debris in bank or in the canal itself.
- Construction of bridges and associated roads, jetties, ports and permanent hydraulic structures (for water storage, diversion or control, or channelization) in rivers.
- Washing of clothes, vehicles, etc. in canals.
- Deforestation of mangrove forests and other sensitive areas.
- Use of chemical fertilizers and pesticides in agriculture, horticulture, aquaculture, animal husbandry etc.

7.4.3.7 Promotion of Environmentally Beneficial Activities in selected canals under IURWTS project

The following activities and interventions shall be promoted through both public and private mobilization to improve and invigorate the canal environment.

- Reuse and/or recycle of domestic and industrial wastewaters (after due treatment) and use of products derived from sewage sludge, with appropriate mechanism for commercial use/ reuse wherever possible. Such mechanism may include higher pricing for fresh water over recycled water and for chemical fertilizers over organic fertilizers.
- Development of much-needed pollution-controlling infrastructure, such as sanitation, sewerage and sewage treatment facilities for residential areas, industrial effluent treatment plants, and secure solid waste and hazardous waste landfill sites.
- Afforestation/ green belt development for control of surface runoff and soil erosion, slope stabilization and enhanced groundwater recharge.
- Appropriate measures for flood mitigation in floodplains.
- Protection of breeding areas and natural habitats of indigenous and migratory species (including fishes, birds, reptiles, amphibians and mammals), and preventing the spread of exotic species in rivers and water bodies.
- Promote eco-friendly tourism and recreational activities in canals and canal banks.

- Removal of unwanted construction and other human encroachments from active flood plains of canals/ water bodies, and the use of the flood plains for development of ecological parks.
- Use of bio-fertilizers and bio-pesticides (in place of chemical fertilizers and pesticides) in agriculture, horticulture, aquaculture etc., to protect water from agricultural pollutants.
- Regular collection, compilation and dissemination of environmental data of canals (including hydrological, geological, meteorological, land-use and pollution data) and maintenance of a historical database in public domain for ready access by any person/ agency.
- Continuous ground-level monitoring through competent non-profit/ for-profit agencies of: (i) Selected canals under IURWTS project environmental status, and (ii) implementation of Prohibited, Restricted and Promoted Activities.
- Conducting regular environmental education programs – through competent non-profit/ for-profit agencies and institutions – for: (i) public awareness of selected canals under IURWTS project environmental problems and their remediation, and (ii) developing a healthy civic sense of environmental proprieties.
- Periodic review of “Kochi canal Action Plans and Their Implementation” with feedback from all concerned individuals and agencies including rural and urban local bodies.

7.4.4. Implementation Mechanism

As evident from the above, a long-term program for implementation, monitoring, review and evaluation of environmental problems and interventions pertinent to selected canals under IURWTS project are needed. Since these measures cover a wide variety of activities involving continuous monitoring and feedback from diverse sources, institutions and individuals, an independent agency is essential to conduct these activities in a coordinated manner. It is therefore proposed that a nodal agency, tentatively termed “Kochi canal Management Commission (KCMC)” with adequate resources and authority be set up to ensure the environmental health of selected canals under IURWTS project. The KCMC should comprise Legal Luminaries, Technical Experts, Government Functionaries and Civil Society Members.

The main task of this authority may be summarily stated as follows:

(1) They should take all measures necessary for the environmental conservation and development of Kochi Canal in a transparent and inclusive manner.

(2) Such measures shall include the following:

(a) Ensuring that water flows are maintained in all canals of the Kochi canal Network at different locations and in different seasons.

(b) Protecting the geology and ecology of the selected canals under IURWTS project.

(c) Using of floodplains in appropriate manner, and after ensuring Environmental Impact Assessment for approval of major projects in flood plains.

d) Ensuring both short-term and long-term measures for conservation and improvement of aquatic resources in selected canals under IURWTS project.

(e) Monitoring, review and dissemination of the selected canals under IURWTS project environmental status in the public domain.

An amount of Rs. 60 lakh is earmarked for Biodiversity Management Plan.

7.5 RISK AND DISASTER MANAGEMENT PLAN

The IURWTS Project is complex in nature and involve wide ranging components with the objective to improve the water transport system and promote tourism and leisure activities through restoration of canals and urban regeneration in the project command. Such new ideas always give birth to new challenges and new risks, which come across during the development and execution of the project of this magnitude.

Risks/threats to this project could involve financial/monetary, schedule, scope, safety, environmental, and many other types. For this reason, the Risk Evaluation Mitigation Strategy (REMS) given below addresses all known risks through the life of the Project. REMS is primarily to identify the probability of risk during the various stages of the Project. Those risks, which are more directly associated with the construction phase, will be addressed, and added to the Risk Register later. More detail regarding risk will be added and provided during the latter part of the design phase and well before the construction phase begins. Further identified risks during the construction and operating phase will added to the Risk Register proposed to be maintained.

7.5.1 Risk Evaluation and Mitigation Strategies (REMS)

An approach for a risk assessment and evaluation strategy is as shown in **Figure 7.1.** The purpose for risk identification is to search for, and locate, sources of risk exposure, termed risk event before they realized. Risk identification workshops will be conducted for all Project packages as shown below. However, the activities involved in this project categorized under four risk groups as given in **Table 7.6**.

The Risk Mitigation Plan (RMP) and Environment Management Plan (EMP) approved by MoEF&CC will be part of the contract obligations. Monitoring in this regard will be undertaken by the General Consultant and communicated to the SPV for this project.

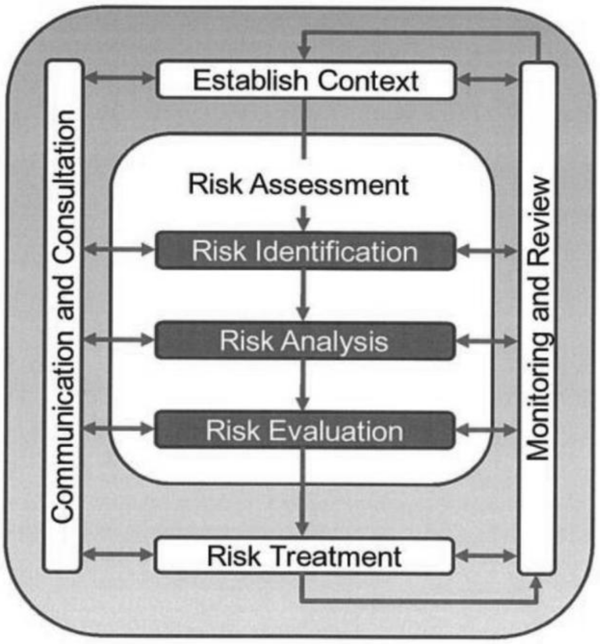


Figure-7.1: An approach for a risk assessment and evaluation strategy

Table-7.6 : Classification of risk groups for activities under IURWTS Project

Risk Group	Description
RG 01	Canal Development (deepening, widening, shore protection, canal beautification)
RG 02	Sewage Treatment/ Sewerage System
RG 03	Jetty and Jetty Terminal Construction
RG 02	Boats, Navigation Aids Package
RG 04	Alternative revenue streams

The primary tool to be used to record, analyze, evaluate, and disseminate risk information will be the Risk Register.

The methodology involved under REMS will involve six steps given in **Figure 7.2**.

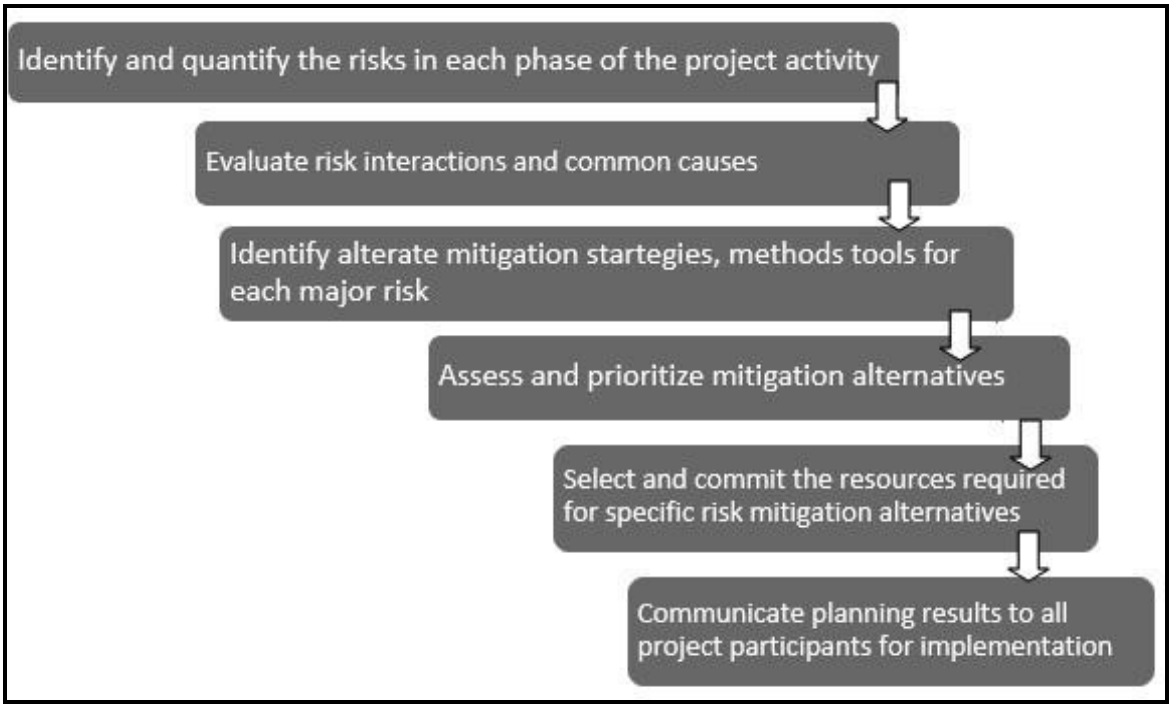


Figure 7.2: Methodology for REMS

7.5.2 Risk Mitigation Planning

The ultimate purpose of risk identification and analysis is to prepare for risk mitigation. Risk mitigation planning needs to be an ongoing effort that cannot stop after a qualitative risk assessment, or a Monte Carlo simulation, or the setting of contingency levels. Risk mitigation includes front-end planning of how major risks will be mitigated and managed once identified. Therefore, risk mitigation strategies and specific action plans should be incorporated in the project execution plan.

Transfer of risk

Risk transfer can be possible only when both the contractor and owner fully understand the risks and the rewards apportioned for the same. Unless there is a quantitative measurement of the risks, attempts by the project participants to shift the responsibility for risks will not provide fruitful results. Contractors generally agree to take risks only in exchange for adequate rewards and this is possible only if the risk is contractors and the owners should be made known. This is to avoid unpleasant surprises and subsequent litigation.

Risk avoidance

One of the risk response strategies is **risk avoidance**. This strategy entails adjusting the project plan so that the conditions triggering a risk event are no longer present and the risk is eliminated. While this strategy cannot be applied to all project risks, it is most effective for preventing risks.

Risk control

Risk control refers to assuming a risk buffering step to reduce, mitigate, otherwise manage its impact or likelihood. Risk control is not necessarily inexpensive.

7.5.3 Development of Risk Matrix for IURWTS Project

7.5.3.1 Qualitative Risk Analysis

For this project, qualitative analysis will be utilized to define relative risk ratings for the purpose of risk prioritization at the individual package level.

The probability and impact scale reflected in the **Table 7.7** will be used to assess all identified risk events and a risk rating matrix will be applied to determine the rating of each risk. Qualitative risk probability scale and Qualitative risk rating matrix for this project is shown in **Table 7.8** and **Table 7.9,** respectively. Quantitative risk analysis for Project risk management is undertaken as a separate procedure.

Table 7.7: Qualitative Risk Impact Assessment Scales

Loss type	Risk Impact				
	C1 Insignificant	**C2 Minor**	**C3 Moderate**	**C4 Major**	**C5 Severe**
Timeline	Overall impact on timeline is less than 7 days	Overall impact on timeline is less than 14 days but more than 7 days	Overall impact on timeline is less than 30 days but more than 14 days	Overall impact on timeline is less than 60 days but more than 30 days	Overall Impact on Timeline is more than 60 days
Budget	Overall impact on budget is less than 5% of total budget	Overall impact on budget is less than 10% but more than 5% of total budget	Overall impact on budget is less than 25% but more than 10% of total budget	Overall impact on budget is less than 50% billion but more 25% of total budget	Overall impact on Budget is More than 50% of total budget
Operating loss	No significant impact on base operation	Minor impact on base operation	Moderate impact on base operation	Major impact on base operation	Severe impact on base operation
Quality	No impact on quality of Project deliverables	Minimal quality issues that can be addressed in short time Frame with minimal interaction	Some quality Issue that require immediate management action	Significant quality issue That require Project Director's intervention	Significant quality issue that require Project Owners's intervention
Safety/ Health	First aid case/ exposure to minor health	Medical treatment case/ exposure to	Lost time injury/ Reversible impact on	Single fatality or loss of quality of life/ Irreversible	Multiple fatalities/ Widespread impact on

Loss type	Risk Impact				
	C1 Insignificant	C2 Minor	C3 Moderate	C4 Major	C5 Severe
	risk	major health risk	health.	impact on health.	health.
Environment	Minimal environmental impact	Material environmental harm short term remedial incident.	Serious environmental harm remediable within Project life.	Major environmental harm remediable post Project completion.	Severe environment Harm Irreversible.
Legal & Regulatory	No legal impact	Minor legal concerns with minor impact	Some legal concern with manageable level of impact.	Serious legal concern with manageable level of impact.	Legal non-compliance with risk of shut down of operation and significant penalties
Reputation/ Social/ Community	Slight impact, slight public awareness may exist but no public concern.	Limited impact local public concern	Considerable impact regional public concern.	National impact national public concern	International impact international public concern

Table 7.8: Qualitative risk probability scale

Scales	Probability	Description
Almost certain (P5)	> 75%	Almost certain to occur
Likely (P4)	51% - 75%	More likely to occur than not
Possible (P3)	26%-50%	Fairly likely to occur
Unlikely (P2)	6% - 25%	Unlikely to occur
Rare (P1)	0-5%	Extremely unlikely

Table 7.9: Qualitative risk rating matrix for IURWTS Project

Scales	C1 Insignificant	C2 Minor	C3 Moderate	C4 Major	C5 Severe
Almost Certain (P5)	(3) Medium	(26) High	(31) High	(5) Extreme	(16) Extreme
Likely (P4)	(19) Medium	(14) Medium	(13) High	(4) High	(21) Extreme
Possible (P3)	(23) Low	(2)	(1), (9), (22), Medium	(7), (18), (27) High	(12) Extreme

		Medium			
Unlikely (P2)	(11) Low	(24) Low	(25), (29) Medium	(8) Medium	(15) High
Rare (P1)	(20) (30) Low	(6) Low	(17) Medium	(10) Medium	(28) High

Upon completion of risk assessment, all risks can be ranked in terms of their individual risk rating, with the risks that have the highest rating constituting those that require the most attention when planning the risk responses.

7.5.3.2 Quantitative Risk Analysis

The analysis of identified risk events will result in priorities using the qualitative risk analysis process. Their effect on Project activities will be estimated and a numerical rating applied to each risk. The result will then be documented in this section of the risk mitigation plan. The quantitative analysis will be performed later after DPR review is completed and package strategies is decided after approval of block cost estimates by KMRL.

7.5.3.3 Risk response planning

Each major risk will be assigned to a Project team member for monitoring purposes to ensure that the risk will not "fall through the cracks". For each major risk, one of the following approaches will be selected to address it:

- Avoid – eliminate the threat by eliminating the cause.
- Mitigate – Identify ways to reduce the probability or the impact of the risk.
- Accept – Nothing will be done.
- Transfer – Make another party responsible for the risk (buy insurance, outsourcing, etc.).

For each risk that will be mitigated, the Project team will identify ways to prevent the risk from occurring or reduce its impact or probability of occurring. This may include prototyping, adding tasks to the Project schedule, adding resources, etc.

For each major risk that is to be mitigated or that is accepted, a course of action will be outlined for the event that the risk does materialize in order to minimize its impact. The mitigation strategy may be coordinated and reviewed by KMRL as required.

7.5.3.4 Risk monitoring, controlling, and reporting

The level of risk on a Project will be tracked, monitored, and reported throughout the Project lifecycle. A "Top 10 Risk List" will be maintained by the Project team and will be reported as a component of the Project status reporting process for this Project. It is to be noted that the Project Risk Register is a dynamic form in which the top 10 risk list changes based on the stage of the project. All Project change requests will be analysed for their possible impact to the Project risks.

A Risk Register will be maintained by the Project Managers and Package Managers for each Project and each package. Summary list of all risks identified under each package to be maintained and followed. The register will be reviewed as a standing agenda item for Project team meetings. Changes to the risk register, especially those where a risk is increasing or remains a high threat, will be highlighted and discussed individually. Charts, schematics, graphs, tables will be used and/or added as appropriate to portray effects and impact properly and effectively.

The major risks have been identified at this stage of the project and accordingly based on experience as explained in detail in the earlier paras, a risk matrix (Model) has been prepared for this project for ready reference and initiating mitigation as required is given in Table 7.10.

Table 7.10: Risk matrix for project activities in IURWTS Project

Sl. No	Risks	Type of Assessed Risk and Response	Mitigation measures proposed
	Planning & Design Phase		
1	Cancellation or Change in Design Scope	Possible (P3) Moderate (C3) Mitigate	Identify ways to reduce the probability of cancellation or design scope by making the entire project transparent
2	Community Opposition	Possible (P3) Minor (C2) Avoid	Public awareness campaigns through electronic and print media can be carried out before execution of the project.
3	Adverse Weather Conditions	Almost certain (P5) Insignificant (C1) Mitigate	Proper planning and scheduling to complete weather impact activities like excavation, deepening & cutting etc to be completed before monsoon and the super structure to be built up.
4	Environmental Permits	Likely (P4) Insignificant (C4) Avoid	Avoid by initiating timely action considering the minimum time required to adhere to the formalities by govt agencies for issue of permit.
	Pre-Construction Phase		
5	Land Acquisition / Availability risk	Almost Certain (P5) Moderate (C3) Mitigate /Transfer	
6	Statutory Permits	P3 (possible) C3 (Moderate) Avoid	Avoid by initiating timely action considering the minimum time required to adhere to the formalities by govt agencies for issue of permit.
7	Disputes with Slum Dwellers (Social risks)	Almost Certain (P5) Major (C4)	Increased communication and reviews to avoid occurrences of

Sl. No	Risks	Type of Assessed Risk and Response	Mitigation measures proposed
		Mitigate /Transfer	disputes. Timely mitigation measures to settle disputes by properly assessing the situation and arriving at a win-win situation. An effective resettlement plan needs to be in place along with the project.
8	Non-adherence of EMP	P2 (unlikely) C4(Major) Transfer	Include provisions in the contract conditions to transfer the liability to the defaulter.
	Construction Phase		
9	Design	P3 (possible) C3 (Moderate) Avoid	To avoid the chances of faulty design by proper check in the design phase.
10	Geotechnical/Geological	Rare (P1) Major (C4) Avoid	To avoid the chance of faulty geotechnical investigation by proper check in the design phase.
11	Removal of Hazardous Material / Wastes	Unlikely (P2) Insignificant (C1) Mitigate	To mitigate the situation by including proper safety measures in the planning stage.
12	Disposal of Dredge / Desilting / Earth Cutting material in project command	Possible (P3) Severe (C5) Mitigate	Mitigated by identifying Government lands in advance and utilising the excavated earth to the maximum for raising the low-lying stretch on the canal banks.
13	Timely Allotment of Funds	likely (P4) Moderate (C3) Mitigate	Sustained allocation of funding adequate for the project and government patronage needs to be ensured for the successful implementation of the project.
14	Completion and Commission	Likely (P4) Minor (C2) Transfer	To mitigate the situation by ensuring in the contract condition proper quality checks and quality monitoring during the construction phase and for transfer of risk to the executing agency.
	Other Construction Phase Risks		
15	Latent Defects	Unlikely (P2) Severe (C5) Mitigate	Mitigate by ensuring proper site investigation at the planning phase and ensuring conditions in the contract to assess the situation during site visits arranged before tender finalisation and quoting the rate accordingly.
16	Utility Relocation	Almost certain (P5) Severe (C5) Transfer	Proper mitigation measures taken at the planning stage by the SPV and conditions in the contract to undertake further geophysical investigation if found necessary before commencement of the work.
17	Archaeological Findings	Rare (P1)	Proper legal framework framed

Sl. No	Risks	Type of Assessed Risk and Response	Mitigation measures proposed
	risk	Severe (C5) Avoid	before the tender process and included in the contract condition to mitigate the risk in a shared manner.
18	Encroachment into the acquired land	Possible (P2) Major (C5) Mitigate	Provision for funds to provide fencing in the contract at the planning stage to prevent encroachment.
19	Sewage Disposal	Likely (P4) Insignificant (C1) Mitigate	Mitigated by provision of fund to provide transitional measures during the construction phase and for Individual houses left out from the sewer networks to be provided with septic tanks, DEWATS etc.
20	Risk on account of improper security issues at site	Rare (P1) Insignificant (C1) Avoid	Avoid by provision for Proper ID cards, Surveillance measures, Entry restrictions, Minimum activities during school time to be ensured.
21	Force Majeure	Likely (P4) Severe (C5) Accept	To mitigate the situations by accepting the facts and taking proper preventive measures and risk shared by both the contracting parties.
	Revenue Risks		
22	Risks for revenue generation stream planned in the project command to identify private partners	Possible (P3) Moderate (C3) Mitigate	Carry out a 'what if' analysis based on the possible scenarios of demand. Indirect benefits also to be considered in order to highlight the economic benefits.
23	Competing facilities and network risk	Possible (P3) insignificant (C1) mitigate	Mitigated by government commitment to the agreement conditions and proper legal framework suggested at the planning stage.
24	Boat demand risk	Possible (P3) Minor (C2) Mitigate	Mitigated by providing buffer stock in the planning stage so that the rise or fall in boat usage can be mitigated.
25	Public perspective risk	Unlikely (P2) Moderate (C3) Transfer	Mitigation by provisions in the contract to transfer the risk which allows for reductions in the payments to the extent that the contracting agency is failing to meet the requirements.
26	Utility cost risk	Almost certain (P5) Moderate (C3) Transfer	Mitigated by having a shared approach by keep a cap on the price fluctuation and ensuring a legal framework and a separate institutional mechanism.

Sl. No	Risks	Type of Assessed Risk and Response	Mitigation measures proposed
27	Technology obsolescence risk Political and regulatory risks	Possible (P3) Major (C4) Mitigate	Mitigated by proper deliberations at the planning stage by identifying the best technology options.
28	Dumbing garbage and waste back into canals after the project has been implemented (Environment risk)	Possible (P1) Major (C5) Mitigate	Proper institutional mechanism with adequate powers to impose fine on the defaulters who throw waste into the water bodies.
29	Risk due to breach of contract	Unlikely (P2) Moderate (C3) Avoid	Mitigated by proper government commitment assured before the commencement of the contract by ensuring a legal framework and institutional mechanism.
30	Risk of asset specific regulation	Rare (P1) Minor (C2) Mitigate	Mitigated by ensuring proper regulations, legal framework, and separate institutional mechanism.
31	Risk during termination phase	Almost certain(P5) Moderate (C3) Mitigate	Institutional mechanism and legal frame works worked out to assess the cost of the assets at the transfer stage.

7.5.4 Disaster Management

"Disaster Management" means a continuous and integrated process of planning, organising, coordinating and implementing measures which are necessary or expedient for the following:

- Prevention of danger or threat of any disaster;
- Mitigation or reduction of risk of any disaster or its severity or consequences;
- Capacity-building;
- Preparedness to deal with any disaster;
- Prompt response to any threatening disaster situation or disaster;
- Assessing the severity or magnitude of effects of any disaster;
- Evacuation, rescue and relief;
- Rehabilitation and reconstruction

7.5.4.1 Objective

The objective of the DMP is:

- To save life and alleviate sufferings;
- To minimize any adverse effects on people, damage to property or harm to the environment;
- To facilitate a rapid and effective emergency response and recovery;
- To provide assistance to emergency and security services;

- To communicate vital information to all relevant persons involved (both internal personnel and external agencies) with a minimum of delay; and
- To keep all systems ready to handle any disastrous situation.

The Disaster Management Manual and the associated Standard Operating Procedures that accompany the DMM serve as the centralized repository for the information, tasks and procedures that would be necessary to facilitate KRML management's decision making process and its timely response to any disruptive or extended interruption of the department's normal business operations and services. This is especially important if the cause of the interruption is such that a prompt resumption of operations cannot be accomplished by employing only normal daily operating procedures.

KMRL shall ensure that its employees are trained and prepared through emergency planning arrangements through specific post and competency requirements, training modules and participation in emergency exercises.

7.5.4.2 Levels of Incidents/ Disaster

Level 0: An event or series of events causing no adverse impact on person(s), property, environment or services, but which may require attention of operation & maintenance staff.

Level 1: An event or series of events causing delay to services up to 30 minutes during peak and 45 minutes in off-peak hours or limited damage to property or minor injury to person or death due to nonoperational reasons e.g. medical condition. OCC manages the level 1 event, with or without the assistance of external services, without the need for immediate information to concessionaire/authorities or trigger of the Disaster Management Manual. However, Chief Controller may inform OCC Manager if required.

Level 2: An event or series of events causing delay of boat services exceeding 30 minutes during peak and 45 minutes in off-peak hours or limited damage to persons, property or the environment. OCC manages the level 2 event as per Incident Management Plan, with or without the assistance of external services. Chief Controller shall inform OCC Manager or On-call Senior Manager who will inform concessionaire/authorities if the disruption is over 30 minutes.

Level 3: An event or series of events causing severe injury or death to one or more persons, significant damage to property or the environment, or security threat which lead to the triggering of the Disaster Management Manual. OCC Chief Controller shall immediately inform the authorities for any event of level 3. OCC Manager or senior member of management shall coordinate activities with other authorities and external agencies. Authorities will trigger Disaster Management Manual and mobilize additional resources.

7.5.4.3 Disasters in IURWTS Project

Following situations shall be treated as Disaster for IURWTS

- Fire

- Boat Accidents (Collision, Capsizing)
- Man over board or Suicide
- Terrorist Attacks and Bomb Blast
- Bomb Threat
- Unmanageable Crowd
- Natural Calamities
- Wide Spread Violence And Public Disturbance
- Reckless Operation of Boat
- Driving under the Influence of Alcohol
- Equipment Failure

The management of incidents causing delays and disruptions to passenger services are dealt separately through IURWTS Operations and Maintenance Plans and the supporting Standard Operating Procedures to these Plans. These incidents of level 0 and 1 are, therefore, not considered in this Plan. Incident / accident of level 2 may lead to the implementation of the DMM, while Level 3 events trigger it automatically.

Approach

Averting a disaster or response to mitigate the severity of disaster, as it relates to passenger boat accidents , require

(i) prior and adequate advance Knowledge of likely incidents;

(ii) availability of instruments/facilities to contain the risks;

(iii) arrangements/ tools to facilitate quick resurrection; and above all

(iv) facility ofskilled manpower support to organize the pre and post event response mechanisms.

Thus the guidelines are presented in five related segments as below:

- Weather Forecasting & Early Warning System- This is dealt in the second chapter wherein the spatial and temporal variations in climate characteristics and the resultant impacts are discussed. It is essential that boat owners and water way management authorities must pay attention on weather bulletins and guidelines issued by local meteorological organizations to avert boat tragedies.
- Safety Standards & Specifications – These aspects have been discussed in chapter 3 wherein the importance of safety measures are discussed in details. The general safety measures expected to be adopted by boat operators are dealt with in this chapter. In addition, safety standards for mechanized and non-mechanized boats are also discussed.
- Regulatory & Legal Issues- This is discussed in chapter 4. The regulatory provisions of national waterways, the existing ferry acts and rules and other legal issues are discussed in this chapter. The model rules are discussed in this chapter with roles and responsibilities of the proposed Inspectorate of Safety.
- Search and Rescue – The Search and Rescue operations in the aftermath of boat accidents are equally important as the mitigation measures. The chapter 5 discusses these issues in details in reference to boat and navigation safety. Some of the important aspects like Standard Operating Procedures (SOPs),

Accident Management Plan, Emergency Search and Rescue, Response mechanisms at boats/vessels, rescue elements at Jetties, medical action plans etc. are discussed in this chapter.

- Capacity Development- The Capacity Development aims to create enabling environment with appropriate policy and legal framework, institutional development including community participation through which individuals, organizations and societies obtain, strengthen and maintain capabilities to set and achieve their own development objectives over time.

The plan includes IURWTS detailed approach to managing disasters by:

- Regular assessment of the risks involved in Operation and Maintenance activities with adopting mitigation measures in order to prevent disasters by improving procedures and the use of the systems that support the safety of IURWTS.
- Continuously development/optimization of Operation and Maintenance procedures in order to prepare for potential disasters and the use of systems based on a change in the assessment of the threat to IURWTS.
- Effective response in managing all categories of disasters by IURWTS in terms of the standard and tested approach.
- Speedy recovery from the disastrous situation to the point of normal planned operations and maintenance activities can resume.
- Analysing the disaster management worldwide, adopting lesson learnt to continuously improve existing processes.

KMRL approach to deal with disaster is based on two different levels of emergency plan:

- The Disaster Management Plan which covers incidents that may affect specific corridors, e.g. stalled boats or loss of local communication or power control through to incidents that impact on all three Corridors I, II, and III involving stations and boats, e.g. major power failure, major loss of communications systems, major flooding and terrorist attack;
- Local plans which cover specific locations, e.g. stations, OCC, maintenance Boatyards e.g. station evacuation due to congestion or local security alert.

Both emergency plans are integrated and mutually support one another. The findings of the Risk Assessment Process are used to structure the content of these plans, as necessary. Rules dealing with operational emergencies and incidents are documented in the KMRL Standard Operating Procedures.

In the Standard Operating Procedures (SOPs) that support this Plan, KMRL will detail the specific activities that will apply to each of the disaster scenarios. The SOPs encompass:

a) Accidents
   - Accident involving people in a Boat between stations
   - Accident involving people at station

b) Fire
   - Dealing with fire at Terminal
   - Dealing with fire in OCC
   - Dealing with fire in Boat (At station or in between stations)
   - Dealing with fire in STPs
   - Dealing with fire adjacent to Terminal

c) Man-made disasters
   - Dealing with acts of Sabotage

- Dealing with act of crime including assault on employees
- Dealing with riots, arson, vandalism on a large scale & civil disobedience
- Dealing with terror attack
- Dealing with bomb blast, bomb threats
- Dealing with stampede
- Dealing with nuclear/ Biological/ Chemical attack
- Dealing with Drunken Crew/Passenger

d. Natural disasters

- Dealing with earthquake
- Dealing with floods
- Dealing with pandemic outbreak or potential Epidemic
- Dealing with stormy weather

e. System related disasters

- Dealing with capsizing with casualty
- Dealing with collision with or without passengers
- Dealing with structural damage in steaming
- Dealing with total power failure during steaming

7.5.4.4 Organisation and their Roles and Responsibilities Authoritise

The Disaster Management Act, 2005 defines formation of different level of authorities, their roles and responsibilities, members and their key functions during disasters. Following chart explains the authority, members and their key functions during disastrous situations:

Central Government Authorities

National Disaster Management Agency (NDMA)

S. No.	Authority	Members
1	NDMA	**Chairperson:** Prime Minister **Other members:** nominated by Chairperson (not exceeding 9)

Roles and Responsibilities of NDMA

- To lay down the policies, plans and guidelines for disaster management for ensuring timely and effective response to disaster
- Approve the National Plan
- Approve plans prepared by the Ministries or Departments of the Government of India in accordance with the National Plan
- Lay down guidelines to be followed by the State Authorities in drawing up the State Plan

National Executive Committee (NEC)

No	Authority	Members
1	NEC	**Chairperson:** The Cabinet Secretary to The Government of

		India **Other members**: The Secretaries to the Government of India in the different Ministries or Departments

Roles and Responsibilities of NEC

- Assist the NDMA in the discharge of its functions
- Implementing the policies and plans of the NDMA
- Prepare National Plan
- Ensure the compliance of directions issued by the Central Govt. for the purpose of disaster management in the country

State Government Authorities

State Disaster Management Authorities (SDMA)

No	Authority	Members
1	SDMA	**Chairperson**: Chief Minister of State **Other members:** (not exceeding 9) nominated by Chairperson; and Chairperson of the State Executive Committee

Roles and Responsibilities of SDMA

- Lay down the State disaster management policy
- Approve the State Plan in accordance with the guidelines laid down by the National Authority
- Approve the Disaster Management Manuals prepared by the departments of the Government of the State Coordinate the implementation of the State Plan
- Recommend provision of funds for mitigation and preparedness measures
- Review the development plans of the different departments of the state and ensure that prevention and mitigation measures are mitigated therein;
- Review the measures being taken for mitigation, capacity building and preparedness by the departments of the Government of the State and issue such guidelines as may be necessary.

District Disaster Management Authority (DDMA)

No	Authority	Members
1	SDMA	**Chairperson:** Collector or District Magistrate **Other Members:**Elected representative of the local authority; Chief Executive Officer of the District Authority; Superintendent of Police; Chief Medical Officer of the district; not exceeding two other district level officers, to be appointed by the State

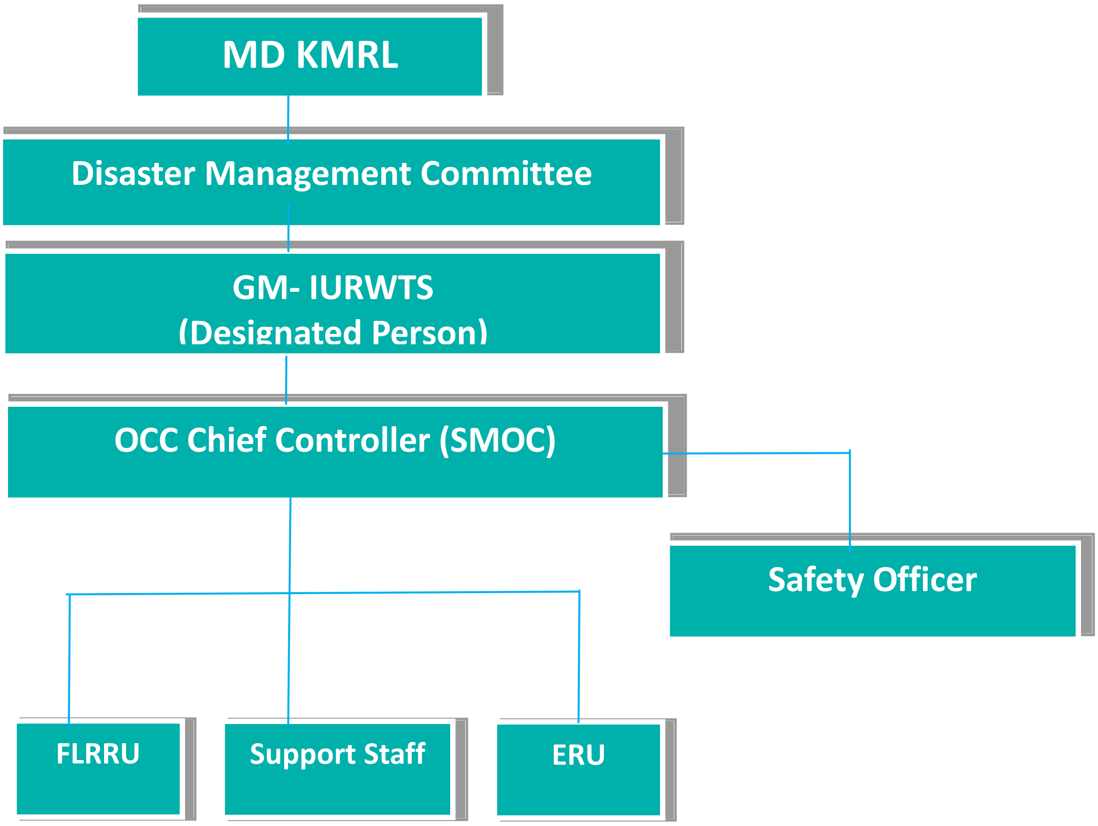
		Government.

Roles and Responsibilities of SDMA

- Prepare a Disaster Management Manual including district response plan for the district
- Coordinate and monitor the implementation of the National Policy, State
- Policy, National Plan, State Plan and District Plan
- Advise, assist and coordinate the activities of the Departments of the
- Government at the district level, statutory bodies and other governmental and nongovernmental organizations in the district engaged in the disaster management;

Kochi Metro Rail Limited

KMRL administration at different level has following set up of organization to deal with the Disastrous situations arising in IURWTS. The organization to deal with any eventualities is as follows. The roles and responsibilities and the standard operating procedures will be captured in a separate document.



Disaster Management Organization (DMO)

First Line Response & Recovery Unit (FLRRU) always on site, initiate recovery actions within the first minutes of an incident, and are trained – and supported by adequate operating procedures – to mitigate and contain the effect of a disruption on service or on passengers comfort, until further intervention of the SLRT. This team includes OCC Staff, Terminal Staff, Boat Operation staff and in some cases Maintenance staff.

Second Line Response Unit (ERU or SLRRU) consisting of systems' specialists provides emergency response capability across the entire system. The ERU is available to attend incidents on 24-hour standby basis and is trained to deal with all foreseeable boat related incidents. These units are located in the boatyard, on site or on-call whenever possible, and are scheduled and deployed so that they can attend to an incident on the mainline within 30 min to 45 min. They are trained and equipped with all necessary spare parts and tooling to permanently fix the failure (if not exceptional failure). This team includes Team leaders of different department of maintenance division, Boat Crew Controllers, Assistant Managers, Safety Manager and other experts from different divisions. Managers of different departments of Operation, Maintenance and Other divisions can also be called upon.

Disaster Management Committee (DMC) consisting of Managing Director, All Directors, Executive assistants – will be involved in providing all needed assistance, damage control and keep liaison with non-emergency external agencies, take strategic decisions.

No	Name of Unit	Members
1	FLRRU	All field staff on duty (Station controller, Boat Operator, Boatyard Controller, Engineers, Technicians, Security Staff, OCC Staff)
2	ERU	System experts/specialists and Managers of concerned Divisions (Operation, Maintenance, QHSE, Other divisions); Nominated LIO; al
3	DMC	MD, Directors (P), Director (S),Delegated representative, Admin Support

Roles and Responsibilities of DMO

No	Name of Unit	Members
1	FLRRU	24/7 on call to attend any emergency across the 3 corridors Gather information, Transmit to all concerned, Evacuate, Provide relief, Save life, Seek assistance, Barricade, Coordinate with external agencies locally
2	ERU	Carry out relief and recovery activities, Coordinate and help with external agencies, Provide technical inputs, Provide probable time of restoration, Assess the loss/damage and seek assistance accordingly. Monitor and supervise the movement on other sections. Provide technical instructions on infrastructure/ system related issues. Update information to DMC about the rescue
3	DMC	Prepare the DMM. Provide advice on safety matters, provide all admin related support, relief and restoration activities. Manage interface with external authorities, Monitor all Relief and Rescue

		activities. Damage control, Media management, Plan Long term response and recovery process, Key strategic decision making, Liaison with nonemergency external bodies like
4	LIO	Monitor and control all rescue & relief activities; Single point of contact with OCC; Close liaison with other agencies;
5	Contractor's Staff	Assist and help LIO as per his instructions.

7.5.4.5 Preventive Capability of KMRL

Preventive capabilities of Kochi Metro may be ensured by drafting Operational procedures and with state of art systems. These can be defined as follows:

KMRL Organizational Capabilities:

Senior Manager (Chief Officer) on Call (SMOC)

Senior Manager shall be called by OCC Chief Controller only for Level 2 and 3 incidents. Exceptionally, Senior Manager can be called upon by Chief Controller if this one has strong presumption the situation could deteriorate to a level 2 or 3 incident without exceptional measures.

Operational Control Centre (OCC)

OCC is a centralized control centre for controlling and coordinating the boat running and other workstation operational activities on the water. The OCC is continuously staffed for:

a) Control Monitoring and control of the boat service,
b) Control of power and environmental systems,
c) Incident Management, and
d) Dissemination of Information, as required.

OCC is fully equipped with system facilities for controlling the boat movements and incident management. In the event that the OCC is rendered inoperable by a disaster.

Communication workstation – For effective communication between different actors

BMS workstation – For controlling Auxiliary systems (Lift/Escalator/ Light/ Ventilation)

CCTV workstation – For monitoring and supervising different areas of station

Fire Alarm Control Panel – For controlling and monitoring Fire detection and suppression system.

OCC is placed under the responsibility of the Chief Controller who is managing all operational activities on the entire IURWTS

Competent and Trained Manpower

KMRL will provide best training to all employees in order to achieve the world class services. All employees are provided with an Initial Training program to bring them to the required competence level and shall also be regularly provided refresher training. In addition to refresher trainings, regular practice sessions on safety critical issues shall also be planned in the form of drills by Respective Assistant Manager Level to keep the knowledge of all employees updated. The drills shall include “First aid and firefighting” practice in addition to other operational and maintenance activities.

Initial Training is split in 3 different phases as follows:

- Induction training
- General training
- Job specific training (includes disaster Management)

KMRL emphasizes to build confident, competent and effective manpower by providing training which involves handling the crisis situations. In regard to disaster management, training includes roles & responsibilities of each employee, first intervention/response by the employee that is specific to their role, individual training in the collective response that is specific to their role and the group drills testing the collective response. Individual skills are emphasised in the initial training as detailed in the Training Modules. Collective skills are emphasised in drills. All employees will receive the following crisis management training apart to job-related training:

a) First aid
b) Fire Fighting training

Practical hands on exercises are part of the training program and ensure every staff member will have the opportunity to perform and learn their role entrusted on him in Standard Operating Procedures of different scenario of crisis/ disaster situations.

Supporting Agencies

In addition to KMRL staffs, supporting agencies are required to manage emergency situation. In order to ensure both KMRL and supporting agencies are capable of handling emergency situation they are required to participate in at least two or more disaster exercises each year including a fire response. This is an exercise simulating a disaster scenario where KMRL emergency response staff must respond and recover from disaster along with supporting agencies.

KMRL Liaison and Interface with Other Agencies

The main point of contact between KMRL and other agencies is the Chief Controller located in the OCC. Chief Controller has all available communication means to enter in contact with agencies. Points of contact within these agencies are identified as follows.

Agency	**Point of contact of OCC Chief Controller**	**Responsible to call**
Fire Brigade		TPC
Police		OCC
Medical		OCC

Site Inspections and Familiarisation

Other agencies will, in order to be able to apprehend the management of an emergency situation, be familiarized with Metro premises, installation and operation. During familiarization the concerned agency shall also be shown the designated place to report during the emergencies. These designated reporting points shall be mentioned in SWO of concerned station. This is done thru site inspections along with KMRL staff.

Joint Drills

Joint drills will be organized between KMRL and other agencies in order to:

- Implement defined process by all parties,
- Test communication channels,
- Test equipment,
- Further improve processes.

Two of such drills will be initiated in a year, nature of the drills will be proposed by (QHSE Division) to agencies.

Staff Deployment

IURWTS proposed deployment of staff is based on our assumptions for minimum number of staff required for smooth operations. KMRL's detailed staff deployment plans are contained in respective Operational Plans.

Depending on the severity of the incident/ accident, and skills required to solve it, the following means can be called out and implemented:

7.5.4.6 Preparedness

Level Of Alertness

Preparedness is of prime importance in order to manage an emergency situation as it shall whether avoid an emergency situation to occur or to limit the consequences of such emergency situation by an early detection.

Alertness is providing KMRL the framework of:

- defined behaviors& attitudes to be followed,
- defined processes to be implemented,
- additional equipment installation and use,
- additional staff to be deployed.

3 levels of alertness are defined for man-made disaster (terrorism) and natural disasters: low, medium and high.

Natural disasters

Pandemic alert

The following table various prevention measures to be taken in case of pandemic alert.

The pandemic alert level shall be initiated/driven by the local DDMA and communicated to KMRL thru OCC Chief Controller in case of status change.

Prevention Measures at Various Pandemic Alert Levels			
Item	Low	Medium	High
Changes in PPE		Face masks issued staff	
Vehicle Cleaning Practices		Disinfect all surfaces in Boat	
Station Cleaning Practices		Disinfect surfaces in public areas	
Vehicle Equipment Checks		Increase replacement frequency of HVAC filters	Staff taken out of public area and will only work in separate areas
Staff Deployment			Staff taken out of public area and will only work in separate areas
Passenger Communications			Communicate to passengers to travel only if its required

Storm Alert

The following table provides various prevention measures to be taken for various storm alert levels.

The storm alert level shall be initiated/driven by the local DDMA and communicated to KMRL through OCC Chief Controller in case of status change.

Prevention Measures at Various Storm Alert Levels			
Item	Low	Medium	High
Vehicle Availability	Normal procedures	As per Law	No preventive maintenance to be undertaken and all vehicles available
Pump Checks	Normal Schedule Checks	Additional visual check of Pumps	Test run pumps
Drainage Checks	Normal scheduled checks	Additional visual check of drainage	As per Medium

Terrorism Alert

The terrorism alert level shall be initiated/driven by the local Police department and communicated to KMRL thru OCC Chief Controller in case of status change.

The following table provides various prevention measures to be taken for various terrorism alert levels.

Prevention Measures at Various Terrorism Alert			
Item	Low	Medium	High
Vigilance	Ensure staff and contractors aware of: • suspicious Items left in high traffic areas or adjacent to key facilities; • unattended • parked vehicles • in secure areas; • suspicious • behaviour (taking photos of infrastructure or storage areas, persons evading view)	Ensure staff and contractors aware of: • suspicious Items left in high traffic areas or adjacent to key facilities; • unattended parked vehicles in secure areas; • suspicious behaviour (taking photos of infrastructure or storage areas, persons evading view)	Ensure staff and contractors remain vigilant for items as for Medium, as well as unusual items in air conditioning systems, fans, and blowers. Especially in isolated areas.
Public Communications	Normal communications focusing on prevention of criminal activity	Provide the travelling public additional message on general alertness	Provide the public with regular PA's regarding leaving items unattended and to report suspicious activities or items to police or facility management
Staff training		Provide staff with specific refreshing course on emergency situation (evacuation, crowd management.	Same as medium + weekly drill for evacuation
Boatyard security		Provide additional security staff for Boatyard roving / CCTV monitoring. Random ID checks within the Boatyard.	Prohibit all external access to the Boatyard (no visitors). Limit if possible supplier delivery. Systematic ID checks inside the Boatyard.
Infrastructure		Additional	Reinforced systematical

		infrastructure checks for lost/suspicious items	infrastructure checks for lost/suspicious items.
Police interface		Police presence within the metro (roving teams)	Daily update on the situation. Higher police presence inside the metro. Army presence within the metro
Operation		Unclaimed or unattended baggage systematically considered as suspicious items Stabled Boat at night on line to be guarded	As for Medium, and particularly for Litter bin management: remove all litter bins from high traffic/circulation/evacuation areas; clear plastic bags on metal or plastic hoops to be retained at low traffic density sites;

7.5.4.7 Response

Communication Flow

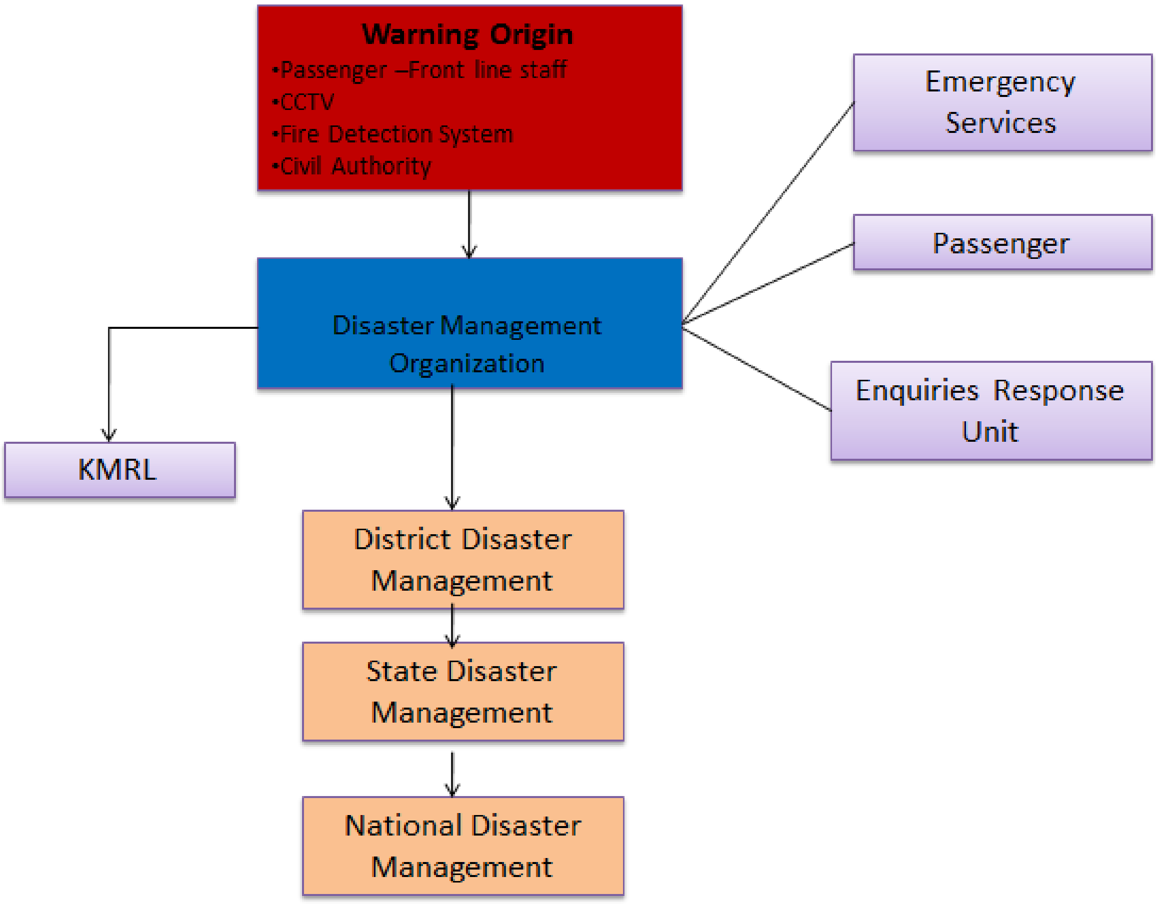
Good communication is vital for the success of the DMO and key to a satisfactory outcome to the incident. It is very important for all members of the DMC to feel they have been heard, and that the OCC Chief Controller resists the temptation to hoard information and utilises broadcast opportunities appropriately, providing up to date summaries on what is happening for everyone in the room.

The warning can come from different sources, such as:

- Passenger or front line staff reporting to the OCC
- CCTV detection from OCC or SCR
- Fire detection system
- Civil Authorities

Contact Details

Communication flow management between agencies following a warning is presented in the below diagram:



Communication protocol (OCC CC to Police or Fire Brigade)

Mobile phone communications, other than those for the purpose of managing the incident, are to be kept to a minimum. Note that mobile phones are likely to be unreliable during a crisis due to overloading of the network. It is important to note that all information collected and recorded may need to be scrutinized later. All logs and notes taken by KMRL staff in the ERU/FLRRU must not be disposed of.

SMOC Communication Protocol (OCC CC to SMOC)

For communication initiation, the following information shall be transmitted by the Chief Controller to the SMOC:

- Date and time of incident
- Description of nature and extent of the incident (including location/affected area)
- Description of impact of incident (including how many customers have been or may be affected)
- Details of the threat or potential threat to transport or public safety
- Reason(s) for the incident occurring / possible cause(s) of the incident
- Actions taken or proposed to be taken to rectify the incident and its impacts

7.5.4.8 Reflex Action

Alert and containment is done at this very first stage. The actions are taken in the first 3 minutes of an incident, on receipt of an incident report. The OCC determine the applicable Disaster Management SOPS, and alert the Senior Manager On-Call (SMOC).

The OCC also warn the different emergency services as required per the situation, and mobilise the right response team (First line response, second line response). Emergency service information is priority on SMOC information.

7.5.4.9 Degraded Operation

Within the next 5 minutes, the OCC Chief Controller make an analysis and introduces the best possible service (dependent upon the incident severity) to enable passenger to reach their destinations with minimum disruption. If the service cannot be maintained, the OCC Chief Controller stops all the boats on stations, with doors open, as far as possible. At this time the OCC Chief Controller designate a Local Incident Officer (LIO) to handle the interface locally with the authorities while he keeps the centralized coordination and to ensure safety precautions are established and procedures followed.

7.5.4.10 Mobilisation

Based upon inputs from the Chief Controller and in consultation with the Managing Director, the SMOC decides the mobilisation of internal resources in case of an event of level 2 or 3. Following his decision, he will request all other members to join the premises.

DMC is located in the OCC building, next to the OCC and is fitted with monitoring and communication equipment.

The purpose of the DMC is to monitor closely the rescue / relief operation, control and minimise loss (human, financial, resource, reputation) related to an escalating critical incident or crisis, and to protect the interests of all those with a vested interest with Kochi Metro Rail Limited. The DMC focuses on the longer term response and recovery arrangements and looks into business continuity.

The DMC provides a high level oversight role, and key strategic decision making and planning for longer term business continuity, including looking into reputation risk that the FLRRU/SLRRU do not involve itself with. The DMC will be responsible for the external liaison with other non-emergency services bodies and media response.

All communications and decision within OCC should go through the OCC Chief Controller who remains the operation in charge, implementing decision taken by DMC. The DMC representatives can use checklists assigned to them presented in Appendix to assist & guide them with carrying out their actions in response to the incident. Below is a summary of the roles and responsibilities of the various roles within the DMO:

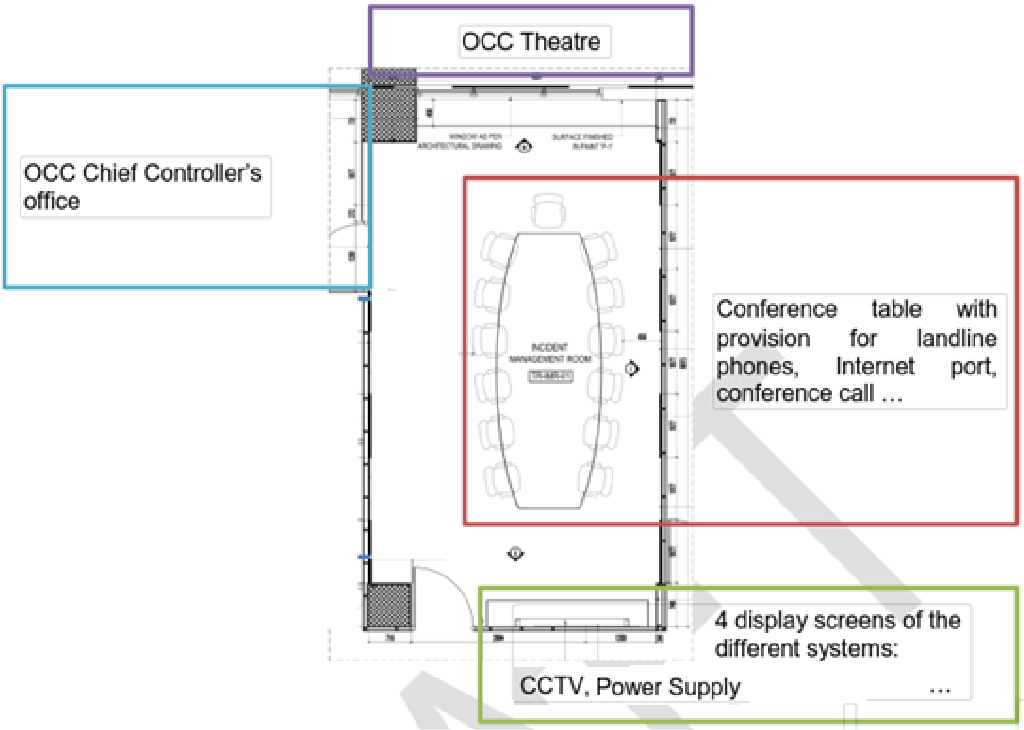
- OCC Chief Controller: This person is the key decision maker for determining the immediate and short term response and recovery arrangements resulting from a disaster or an incident that could lead to a disaster. The OCC Chief Controller shall be part of deliberation/ decisions taken by DMC. OCC Chief Controller may be supported by OCC, Station and Operations manager to provide their advice and manage rosters if required (part of the SLRRU),also provide support on operational procedures, take key decision in consultation with MD, liaise with head of civil authorities for better coordination, make efforts for speedy recovery and introduction of normal services.
- Chief QHSE Officer: Provide safety advice to DMC and maintain contact with the Chief Surveyor, Port of Registry during the incident.
- CFO – Provide financial support as and when required.
- CHR – Provide support to other divisions, liaison with civil defence for additional manpower,
- Help admin to provide drinking water, refreshment for working team
- Admin Support: Provide administrative support to the DMC, including its setup, updating the
- DMC whiteboards, plotting & logging events, updating status of events, send and retrieve faxes & emails, organise vehicles for movement of men/material, arrange petty cash for emergency purchases, organise catering, if required.
- LIO – Coordinate rescue and relief activities, single point of contact between OCC and site, liaise with external agencies; LIO shall wear specially designed jacket so that he can be easily identified by external agencies.
- Representative of external agencies (police, fire brigade, Cost Guard, Navy, Port Trust)

7.5.4.11 Disaster Management Room

The Disaster Management Room is fitted with the below equipment:

- Fax / printer
- Network connection
- Landline connection
- Radio communication equipment
- CCTV monitoring equipment
- Signalling monitoring equipment
- Building Management System monitoring equipment
- Power Supply monitoring equipment

Below is the Disaster Management Room layout showing the position of equipment:



7.5.4.12 Disaster Response Kit

The Disaster Response Kit is kept in Disaster Management Room and should include following items:

- updated KMRL Disaster Response Plan and SOPs
- updated KMRL manuals, policies and procedures
- maps & site plans
- pre – printed forms for log entry as in Appendix
- dedicated laptop with appropriate network access
- marker pens;
- pens
- updated call out list
- catering company contact details

7.5.4.13 Coordination With Emergency Services

While handling incidents which require involvement of emergency services, proper coordination and task distribution between metro personnel and emergency services personnel is imperative. The main principle is that command of rescue work will be with the emergency services. They will carry out actual work while IURWTS personnel will support them by providing necessary information on incident, guidance on safety aspects from OHE and providing available resources as requested for handling the situation.

Following tasks are performed by metro personnel during crisis management:

- Inform the incident details and access points for incident site on call.
- Depute one metro employee in uniform at designated access point for guidance to all external
- agencies summoned for rescue and relief work.
- Liaise with external emergency agencies through LIO.
- Brief In-charge of external agency on safety aspects like Boat movement.
- Guide Emergency Services to the field.
- Provide safe access into metro premises and hand over the incident site.
- Gathering of incident information.
- Assist in/provide rescue and relief work.
- Stay at disposal if required.
- Make necessary arrangement for required action.
- Provide resources if required.
- Take clearance for service resumption.

Following tasks are performed by emergency services personnel while dealing with incidents in metro premises:

- In case of Fire, Fire Service Officer will be overall in-charge of incident management.
- In case of Collision, Law & Order situations Police Officer will be in-charge of the incident
  management.
- Liaise with metro personnel on site (LIO) for necessary information and required arrangements.
- Provide rescue and relief in coordination with LIO.
- Be responsible for safety of their staff and act in liaison with IURWTS personnel in charge to ensure safe working condition on incident site.
- Give clearance to IURWTS personnel for resumption of services.
- During the intervention of emergency services, OCC remains in charge of coordinating metro activities. Thus he shall be informed of emergency services requests.
- Information and support to families of victims is done by the concerned emergency authorities.

Handling of Different Types of Disasters in IURWTS

The main objectives of disaster management are to:

- Arrange rescue and relief work to save life and alleviate sufferings
- Minimize the damage
- Restoration of normal working as soon as practicable.

In order to achieve these objectives KMRL has laid down following guidelines for handling different disaster scenario in IUWRTS. In addition to the basics of disaster handling following actions shall be taken by OCC and LIO during the course of rescue and relief work.

S. No.	Type of Disaster	Actions by Staff
1	Fire	• Use available fire extinguishing material • Regulate Traffic • Barricade area • Evacuate the passengers, if required. • Remove inflammable material from site.
2	Collision	• Regulate Traffic • Evacuate Passengers; seek assistance (Medical, Police, Fire etc.), Barricade area • Save life & administer first aid • Assess damage • Mobilize required assistance • Monitor Rescue & relief work • Collect live information and disseminate to all concerned • Take fitness after rescue operation is over • Restore normal work
3	Capsizing	• Regulate Traffic • Collect vital information • Evacuate passengers, if any • Save life and administer first aid, if required • Mobilize required assistance • Collect information and disseminate • Take clearance and fitness of all vital systems • Restore normal work
4	Passenger in Water, water on board (Suicide)	• Inform all concerned authorities • Take action as per SOP
5	Bomb Threat (detection)	• Collect as much information as available • Inform security, Call Police • Evacuate passengers, if requested by Security • Make relevant announcement • Coordinate with security • Take clearance
6	Terrorist Attack	• Stop Boat movement • Evacuate all passengers from all corridors • Inform Police • Coordinate with Police • Take clearance and restore normal operation
7	Stampede (overcrowding)	• Reduce passenger intake in station • Inform Police • Coordinate with Police

S. No.	Type of Disaster	Actions by Staff
		• Take clearance from Police
8	Law & Order	• Stop Boat or close Jetties • Manage service in other part of the line • Inform Police • Coordinate with police • Take clearance
9	Natural Calamities	• Stop Boat movement • Evacuate passengers • Inform DDMA • Coordinate with DDMA • Take clearance and restore operation
10	Alcohol Consumption by Crew	• Offload from operations of boat • Inform OCC Chief Controller • Mobilize new crew for substitution

7.5.4.14 Evidence Preservation

All evidence potential for investigation shall be protected unless required to be removed:

1) to save lives;
2) to eliminate exposure to hazards;
3) to minimize damage to properties;
4) to comply with existing incident handling procedures.

Staff involved in the incident should seek authorization from LIO before removing or disturbing the evidence at the scene, unless it is necessary to do so expeditiously for any of the following reasons: Local incident Officer will authorize incident recovery, area cleaning or repair at the scene (thus removal or disturbance of evidence) after consulting the Chief Controller and the local Authority representative (Police usually). This shall be strictly followed in particular in case of fatalities or severe injuries. Additional manpower for industrial accident fatality may also be called in by the Police through concerned ministry.

Chief controller will check if evidence shall be preserved in coordination with the in-house technical department prior to his approval. This shall allow on-site investigation if required and also quick service recovery when possible.

Local Incident Officer shall capture incidents details in photographs, where possible, or sketches swiftly to capture available information.

Representatives of parties involved in the on-site investigation shall minimise disruption to passenger service, if it is so affected.

7.5.4.15 Recovery

The aim of the recovery phase is to restore operation to a normal level of service. It differs from the response phase in its focus, as recovery efforts are concerned with issues and decisions that must be made after immediate needs are addressed. The recovery phase starts after the immediate threat to human life has subsided.

At the onset of a disaster scenario, actions are to be taken to enhance the effectiveness of recovery operations. Recovery is both a short–term activity intended to make the affected areas safe, in addition to returning some level of boat service to operation, and a long–term activity designed to return infrastructure and boat operations systems to pre–incident conditions.

The welfare of the affected people is addressed in the recovery phase and will be carried out by the lead Emergency Services agency

For KMRL, the main focus of the recovery phase is to return the site to its previous state. This can only occur after the lead Emergency Services agency or the Kochi City Police has declared the site safe, and no longer a crime scene or disaster scene.

Once deemed safe to do so, the priority of the DMC in the recovery phase is to resume services as quickly as possible. In a terrorism or major crime scenario, there are likely to be longer term business continuity issues for Kochi Metro Rail Limited. These issues are to be discussed Chief Controller in coordination with the SLRRU, who will communicate to the DMC if they require any assistance.

Service Recovery

The specifics of each service recovery will depend on the nature of the incident and may involve the progressive introduction of services until a full level of service can be reached. KMRL has a number of SOP's that detail operational methods in different degraded modes. Various combinations of these can be used.

7.5.4.16 Operations

There are a number of alternatives that can be used individually or in combination to commence a service recovery of services after a disaster these include:

- Recovery of disabled Boat as per the General Rules and SOP Boat Rescue
- Operating short loop services on either side of a contained disaster site as per SOP on Provisional Services and the SOP on Short Loop Services
- Operating on a single line around the contained disaster site as per SOP on Single Line
- Working
- Management of the operation through a degraded mode as detailed in the General Rules

Recovery of operations may also include re-instating certain equipment that had been shut down as a result of a disaster scenario, an example could be the shutting down of OHE. In this case, the reinstatement of equipment would be done in accordance with the General Rules and the procedures for the reinstatement of equipment such as the SOP Powering Up a Section Post Maintenance.

7.5.4.17 Maintenance

The role of maintenance in the recovery revolves around the inspection and repair of assets after a disaster. Maintenance SOPs detail inspection requirements and repair activities for each category of assets. These will be applied as appropriate during the recovery to return the asset to an operable state as quickly as possible.

Systems and Data Recovery

KMRL will maintain backups of all data and will secured it off-site in a protected location. Operation control systems are designed with redundancy with a secondary system which is in a position to relieve a primary system in the event of primary system failure. This reduces the probability of data loss. In the event of a loss of data from both the primary and secondary system, KMRL will use the backups to recover the data with minimal loss. During the response phase, it will be the responsibility of the SLRRU to plan for data recovery.

Staff Recovery

Due to the high intensity nature of disasters during the preparation and response phases, it is often easy to overlook the stresses that these incidents place on staff. The actions of staff are often enhanced by a combination and a sense of duty and adrenaline creating a situation where exhaustion and stress can be managed by the individual in the short term. However, this can create issues during the recovery phase as staff exhaustion can restrict the recovery of operations.

Shift Management

Disaster situations often require staff to work for extended periods particularly during the preparation and response phase. Despite the workload during the phases, it is essential that there are sufficient rested staffs to recover the service once the situation is contained.

During the response phase, when the SLRRU is focused on the incident, it will be the responsibility of the DMC to conduct staff planning for the recovery and to ensure there are sufficient rested staffs available to operate the recovery services.

Counseling

Staffs are often required to deal with extremely stressful situations during a disaster situation and the inability to manage these stressors can lead to post-traumatic stress both in the short and the long term. During the disaster scenario, KMRL will engage with the provider of employee counseling services to provide counseling to staff during the response, recovery and post-incident. This will be managed by the DMC.

An amount of Rs. 30 lakh can be earmarked for Disaster Management purpose.

7.6 STAKEHOLDER CONSULTATION

In order to have a clear understanding of the requirement of the stakeholders, the first step initiated by Antea Group was to identify the important stakeholders, NGOs, senior citizens, Government departments, and public representatives of the project, who can add value to the planning of the project. This helped SPV to initiate arrangements for interactions, meetings, and site visits with the stakeholders. The long- term issues faced by the inhabitants, risk involved in the implementation process, and the benefits that can be derived on implementation of the project were identified and discussed in detail.

The outcome of the interactions helped to:

- Frame the concepts for the activities with the better understanding of the ground realities.
- Improve public trust and confidence with a better understanding of the activities, which are taken up under this project.
- Identify stakeholders, retired government officials who guided in obtaining secondary data and share important reports and legacy data in their possession.
- Identify measures for Institutional strengthening.
- Identify the causes and the actual locations in the project command prone to frequent flooding.

The identified stake holders were differentiated to prioritize, reconcile and balance the stake holders and to closely monitor to maximize the benefits accrued to the project .The stake holders were divided on the basis of whom to be monitored and managed closely, whom to be kept satisfied always and whom to be kept informed about the progress on a regular basis. The major stakeholders are given below in Figure 7.3.

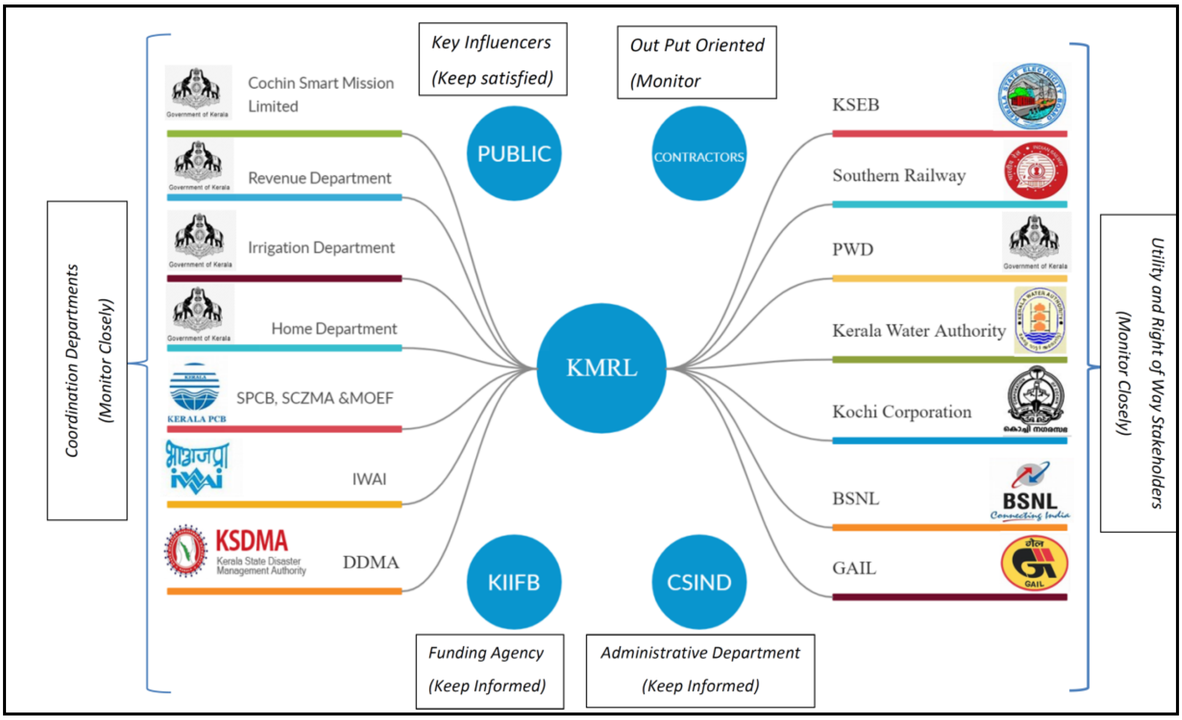


Figure-7.3: Major Stakeholders

KMRL and Antea Group initiated discussions with all the stakeholders to understand the legacy data and to understand the aspirations of each of the stakeholders. The details of various stakeholder consultation conducted are given in Table-7.11.

Table-7.11: Stakeholder meetings conducted

Sl. No.	Meeting details	Departments
1	Stake Holder Meeting with concerned stake holder department officials. Venue: KMRL conference room. 23rd Nov 2019	PWD, Kochi Municipal Corporation, Major Irrigation Dept., Hydrographic Dept, IWAI, BSNL, Revenue, KSEB, IPE Global, CSML, AMRUT & SPV, Antea Group (33 members)
2	Interactive meeting with Cochin Smart Mission Ltd. (CSML). Venue: CSML conference room. 28th November 2019	SPV, CSML and Antea Group. (9 participants)
3	Interactive meeting with Tehsildar Kanayannur Taluk Venue: Kanayannur taluk office. 7th December 2019	SPV, Kanayannur Tehsildar, office staff and Antea Group. (10 participants)
4	Interactive meeting with Kerala State Electricity Board (KSEB) officials. Venue: KMRL conference room. 12th December 2019	SPV, Kanayannur Tehsildar and staff, Antea Group. (16 participants)
5	Joint Site Visit, KSEB main station, Kaloor. Venue: near JLN Metro Station. 13th December 2019	SPV, KSEB officials, Antea Group. (15 participants)
6	Interactive meeting with Kerala Water Authority (KWA) officials. Venue: KMRL conference room. 16th Dec 2019	SPV, KWA officials and Antea Group. (9 participants)
7	Interaction with nearby education institute, Water Institute SCMS, Karukutty. Venue: SCMS, water institute conference room. 19th Dec 2019.	SPV, SCMS, Water Institute staff with Post graduate students, and Antea Group. (12 participants)
8	Interactive with Kerala Voluntary Health Studies, Kottayam (KVHS) (Social impact assessment team). Venue: KMRL conference room. 16th December 2019.	SPV, KVHS team and Antea Group. (8 participants)
9	Joint Sit Visit, KWA STP plant. Venue: Elamkulam, Kochi. 23rd December 2019.	KWA officials and Antea Group. (7 participants)
10	Stake holder meeting with NGO's, senior citizens, public representatives of the project command. Venue: Government Guest House, Kochi. 21st January 2020.	SPV, Stakeholders, Antea Group.

7.7.1 Requirements and Demands of stake holders

The following are the activity-based requirements and demands of stakeholders that have been addressed in this project report.

- **Canal rejuvenation:** Canal dimension estimated to mitigate flood and for restoring navigation. The upper limit of the canal width is fixed based on the village FMB records.
- **Canal bank development:** Canal bank development is conceived with emphasis on reinventing the forgotten waterways and the search of places for entertainment, pleasure, and tourism at the waterfront.
- **Navigation of vessels:** The quantification of boats and the type of vessels to be plied in the canal is based on traffic survey results and environmentally friendly mode of transport included.
- **Sewer networks and sewage treatment facilities:** A catchment area approach (which includes the main canals and the sub canals) undertaken for calculation of sewer loads.
- **Sanitation facilities:** Provision for sanitation facilities to the households that are not connected to the sewer systems. Transitional sanitation facilities also included during the implementation stage of the project.
- **Solid waste management:** A coordinated approach with Kochi Municipal Corporation for solid waste management.
- **Infrastructure property development revenue generation:** Value Capture Financing & Transit Oriented Development model proposed to be tried in IURWTS catchment after the development activities are completed

7.7 RESETTLEMENT AND REHABILITATION POLICY

7.7.1 INTRODUCTION

The objective of the Resettlement and Rehabilitation (R&R) Plan is to enable project planners to take appropriate measures to devise suitable compensation as a part of resettlement and rehabilitation package for the PAFs. The proposed project developments, will lead to acquisition of few buildings, petty shops and land.

The R&R Policy is being adopted by Kochi Metro Rail Limited in order to address any adverse social and economic impacts accrued to identified families or persons in the Affected Area. This Policy has been developed generally in accordance with the requirements of the Right to Fair Compensation & Transparency in Land Acquisition, Rehabilitation & Resettlement Act, 2013 (RTFCTLARRA, 2013) , Rehabilitation and Resettlement, (Kerala), Rules, 2015 (LARR Rules)and the World bank guidelines that are applicable to the Project.

7.7.1 R&R POLICY OF IURWTS Project

Based on the analysis of government provisions and policy, the following resettlement principles are adopted for this Project and RPF will be applicable to IURWTS project and all impacts foreseen/unforeseen issues will be compensated as per RPF :

(i) those who have formal legal rights to land lost in its entirety or in part;

(ii) those who lost the land they occupy in its entirety or in part and have no formal legal rights to such land, but who have claims to such lands that are recognized or recognizable under national/state laws; and

(iii) those who lost the land they occupy in its entirety or in part and have neither formal legal rights nor recognized or recognizable claims to such land.

Cut-off Date: For titleholders, the date of SIA notification [Sec 4(2)] of intended acquisition as per the provisions of RFCTLARR Act will be treated as the cut-off date, and for non-titleholders the start date of project census survey for the subproject will be the cut-off date. There will be adequate notification of cut-off date and measures will be taken to prevent encroachments/squatting after the cut-off date is established.

Non-title holders who settle in the affected areas after the cut-off date will not be eligible for compensation. They however will be given sufficient advance notice (60 days) to vacate the premises and dismantle affected structures prior to project implementation. The project will recognize both licensed and non-licensed vendors, and titled and non-titled households.

The displaced persons will be entitled to the following six types of compensation and assistance packages:

(i) Compensation for the loss of land, crops/ trees at their replacement cost;

(ii) Compensation for structures (residential/ commercial) and other immovable assets at their replacement cost;

(iii) Assistance in lieu of the loss of business/ wage income and income restoration assistance;

(iv) Alternate housing or cash in lieu of house to physically displaces households not having any house site;

(v) Assistance for shifting and provision for the relocation site (if required), and

(vi) Rebuilding and/ or restoration of community resources/facilities.

An Entitlement Matrix has been developed, that summarizes the types of losses and the corresponding nature and scope of entitlements; and is in compliance with National/State Laws and World Bank safeguards ESF 2018 policies. The following entitlement matrix presents the entitlements corresponding to the tenure of the displaced persons and the same has been approved and endorsed by Government of Kerala.

The entitlement matrix proposed for the study is given in Table-7.12.

Table-7.12: Entitlement Matrix

Sl. No.	Impact Category	Entitlements		Implementation Guidelines
PART I. TITLE HOLDERS - Compensation for Loss of Private Property				
1	Loss of Land (agricultural, homestead, commercial or otherwise)	1.1	Compensation for land at Replacement Cost or Land for land, where feasible.	Land will be acquired by the competent authority in accordance with the provisions of RFCTLARR Act, 2013. Replacement cost for land will be, higher of (i) market value as per Indian Stamp Act, 1899 for the registration of sale deed or agreements to sell, in the area where land is situated; or (ii) average sale price for similar type of land, situated in the nearest village or nearest vicinity area, ascertained from the highest 50% of sale deeds of the preceding 3 years; or (iii) consented amount paid for PPPs or private companies. Plus 100% solatium and 12% interest from date of notification to award. The multiplier factor adopted by GoK for land in rural area, based on the distance from urban area to the affected area, will be applied. In case of severance of land, house, manufactory or other building, as per Section 94 (1), the whole land and/or structure shall be acquired, if the owner so desires.
2	Loss of Structure (house, shop, building or immovable property or assets attached to the land)	2.1	Compensation at replacement cost	The market value of structures and other immovable properties will be determined by PWD on the basis of relevant PWD Schedule of Rates (SR) as on date without depreciation.
				Plus 100% solatium

Sl. No.	Impact Category	Entitlements		Implementation Guidelines
				For partly affected structures, the PAP will have the option of claiming compensation for the entire structure, if the remaining portion is unviable.
PART II. REHABILITATION AND RESETTLEMENT – **Both Land Owners and Families Whose livelihoods are Primarily Dependent on Land Acquired**				
3	Loss of Land	3.1	Employment to at least one member per affected family in the project or arrange for a job in such other project as may be required after providing suitable training and skill development in the required field and at a rate not lower than the minimum wages provided for in any other law for the time being in force. or One-time payment of Rs. 5,00,000/- for each affected household or Annuity policy that shall pay not less that Rs. 3000/- per month for 20 years with appropriate indexation to CPIAL	
		3.2	subsistence allowance of Rs. 5,000/- per month for a period of one year from the date of award for those who are displaced.	
		3.3	Transportation assistance of Rs. 50,000/- for affected households who require to relocate due to the Project	
		3.4	One-time assistance of Rs.50,000/- to all	

Sl. No.	Impact Category	Entitlements		Implementation Guidelines
			those who lose a cattle shed	
		3.5	One-time Resettlement Allowance of Rs. 50,000/- for affected household who have to relocate	
		3.6	Additional one-time assistance of Rs. 50,000/- for scheduled caste and scheduled tribe families who are displaced from scheduled areas and who require to relocate due to the project	
4	Loss of Residence	4.1	An alternative house for those who have to relocate, as per IAY specifications in rural areas and a constructed house/flat of minimum 50 sq. m. in urban areas or cash in lieu of house if opted (the cash in lieu of house will be Rs.300,000/-). for those who do not have any homestead land and who have been residing in the affected area continuously for a minimum period of 3-years.	An alternative house for those who have to relocate, as per IAY specifications in rural areas and a constructed house / flat of minimum 50 sq. m. in urban areas or cash in lieu of house if opted (the cash in lieu of house will be Rs.1,48,000/- in line with GoI IAY standards in rural areas and Rs.1,50,000 in case of urban areas). It will be registered on joint title (man and women) The benefits listed above shall also be extended to any affected family which is without homestead land and which has been residing in the area continuously for a period of not less than three years preceding the date of notification of the affected area and which has been involuntarily displaces from such area.
		4.2	Employment to at least one member per affected family in the project or arrange for a job in such other project as may be required after providing suitable training and skill	Preference will be given to women

Sl. No.	Impact Category	Entitlements		Implementation Guidelines
			development in the required field and at a rate not lower than the minimum wages provided for in any other law for the time being in force. or One-time payment of Rs. 5,00,000/- for each affected household or Annuity policy that shall pay Rs. 2000/- per month for 20 years with appropriate indexation to CPIAL	
		4.3	Monthly subsistence allowance of Rs. 5,000/- per month for a period of one year to affected households who require to relocate due to the project	
		4.4	Transportation assistance of Rs. 50,000/- for affected households who require to relocate due to the Project	
		4.5	One-time assistance of Rs. 25,000/- to all those who lose a cattle shed	
		4.7	One-time Resettlement Allowance of Rs. 50,000/- for affected household who have to relocate	
		4.8	Additional one-time assistance of Rs. 50,000/- to scheduled caste and scheduled tribe families who are displaced from scheduled areas and who require to relocate due to the project	

Sl. No.	Impact Category	Entitlements		Implementation Guidelines
		4.9	Right to salvage affected materials	
5	Loss of shop / trade / commercial structure	5.1	Employment to at least one member per affected family in the project or arrange for a job in such other project as may be required after providing suitable training and skill development in the required field and at a rate not lower than the minimum wages provided for in any other law for the time being in force. or One-time payment of Rs.5,00,000/- for each affected household or Annuity policy that shall pay Rs. 2000/- per month for 20 years with appropriate indexation to CPIAL	Preference will be given to women
		5.2	Monthly subsistence allowance of Rs. 5,000/-per month for a period of one year to affected households who require to relocate due to the Project	
		5.3	Transportation assistance of Rs. 50,000/-for affected households who require to relocate due to the Project	
		5.4	One time assistance of Rs. 50,000/- for each affected family of an artisan or self-employed or small trader and who has to relocate	
		5.5	One time Resettlement Allowance of	

Sl. No.	Impact Category	Entitlements		Implementation Guidelines
			Rs.50,000/- for affected household who have to relocate	
		5.6	Additional onetime assistance of Rs.50,000/- to scheduled caste and scheduled tribe families who are displaced from scheduled areas and who require to relocate due to the project	
		5.7	Right to salvage affected materials	
	Employees in commercial establishment	5.8	One time allowance of Rs 6000 for six months for loss of livelihood	
PART III. IMPACT ON TENANTS				
	Commercial	6.1	One time assistance for Rs 200,000	One adult women member of the affected household, whose livelihood is affected, will be entitled for skill development.
	Residential	6.1.1	One time shifting allowance Rs 30,000.	One adult women member of the affected household, whose livelihood is affected, will be entitled for skill development.
PART IV. IMPACT TO SQUATTERS AND ENCROACHERS – Those in the Right of Way or living on Perambok land				
6	Impact to Squatters/encroachers	7.1 7.1.1	Compensation for structure without depreciation An alternative house for those who have to relocate, as per IAY specifications in rural areas and a constructed house/flat of minimum 50 sq. m. in urban areas or cash in lieu of house if opted (the cash in lieu of house will be Rs.300,000/-). for those who do not have any homestead land and who have been residing in the affected area	Only those directly affected squatters who live there will be eligible for all assistance. Structure owners in RoW / Government lands who do not live there and have rented out the structure will be provided compensation for structure and no other assistance will be provided to them. The occupier (squatter-tenant) will be eligible for other assistances

Sl. No.	Impact Category	Entitlements		Implementation Guidelines
			continuously for a minimum period of 3-years.	
		7.1.2	Right to salvage the affected materials	
		7.1.3	Rs 5000 per month for six month.	
		7.2 7.2.1	**Loss of Shop** Compensation at scheduled rates without depreciation for structure with 1-month notice to demolish affected structure	Only those directly affected squatters/encroachers who do business there will be eligible for all assistance. Structure owners in ROW / Government land.
		7.2.2	Right to salvage the affected materials	
		7.2.3	Rs 5000 per month for six month.	
		7.3 7.3.1	**Kiosks / Street Vendors** 1-month advance notice to relocate to nearby place for continuance of economic activity	The PIU and the implementation support NGO / agency will consult such PAPs and assess the requirement of subsistence allowance and rehabilitation grant
		7.3.2	For temporary loss of livelihood during construction period, a monthly subsistence allowance of Rs. 3,000/- will be paid for the duration of disruption to livelihood, but not exceeding 3-months	
		7.4 7.4.1	**Cultivation** 2-month notice to harvest standing crops or market value of compensation for standing crops	
7	Impact to Encroachers	7.5 7.5.1	**Cultivation** 2-month notice to harvest standing crops or market value of compensation for standing crops, if notice is not given	Market value for the loss of standing crops will be decided by the PIU, PWD in consultation with the Agriculture or Horticulture Department

Sl. No.	Impact Category		Entitlements	Implementation Guidelines
PART V. IMPACT TO VULNERABLE HOUSEHOLDS				
8	Vulnerable Households	8.1	One-time assistance of Rs. 25,000/- to DHs who have to relocate	One adult member of the affected household, whose livelihood is affected, will be entitled for skill development. The PIU with support from the NGO will identify the number of eligible vulnerable displaced persons during joint verification and updating of the **RAP** and will conduct training need assessment in consultations with the PAPs so as to develop appropriate training programmes suitable to the PAP's skill and the region. Suitable trainers or local resources will be identified by PIU and NGO In consultation with local training institutes
PART VI. IMPACT DURING CIVIL WORKS				
9	Impact to structure /access to assets/ assets / tree / crops	9.1	The contractor is liable to pay damages to assets / trees / crops in private / public land, caused due to civil works Contractor has to restore access to structures	The PIU will ensure compliance
10	Use of Private Land	10.1	The contractor should obtain prior written consent from the land owner and pay mutually agreed rental for use of private land for storage of material or movement of vehicles and machinery or diversion of traffic during civil works	
PART VII. COMMON PROPERTY RESOURCES				
11	Impact to common property resources such as places of	11.1	Relocation or restoration, if feasible, actual cost upto maximum of Rs 100,000 for	

Sl. No.	Impact Category	Entitlements		Implementation Guidelines
	worship, community buildings, schools, etc.		relocation of place of worship, relocation of all community assets by the contractor	
12	Utilities such as water supply, electricity, etc.	12.1	Will be relocated and services restored prior to commencement of civil works.	The contractor will ensure that utilities are relocated prior to commencement of civil works in that stretch of the project corridor in accordance with the civil works schedule.
PART VII. UNFORESEEN IMPACTS				
Unforeseen impacts encountered during implementation will be addressed in accordance with the principles of RFCTLAR 2013 / World Bank Safeguards Policies 2018.				

7.7.2 DETAILS OF ACQUISITION FOR IURWTS

The impact assessment survey done by the Kerala Voluntary Health Services (KVHS), Kottayam shows that 1641 households (including 207 residential squatters and 50 residential encroachers) and 460 buildings would be affected within the 20.5 meters width of the project canals. Summary of adverse social impact is presented in table-7.13 below:

Table-7.13: Details of Impact for IURWTS

S No	Description	Number
1	Project Affected Families (PAFs)	1641
2	Total Structure Affected	460

Impact on Structures

The study shows that 311 residential structures, 27 commercial structures, 48 residential cum commercial structures and 74 other minor structures would be affected due to this project. Significant impact would be on 311 residential buildings of which majority are in squatter category (207 Nos). Most of these squatters are living in four major colonies. 40 encroachers are also losing their residential structure. Impact on structures are presented in Table-7.14.

Table-7.14: Impact on Structure

Name of Canal	Structure							
	Residential		Commercial		Resi. cum Comm.		Others	Total
	Displaced	Affected	Displaced	Affected	Displaced	Affected		
Thevara	8	0	0	0	0	0	8	16
Thevara-Perendoor	182	0	0	11	0	18	27	238
Edappally	52	0	0	2	0	7	16	77
Chilavanoor	69	0	0	14	0	23	21	127
Market	0	0	0	0	0	0	2	2
Total	**311**	**0**	**0**	**27**	**0**	**48**	**74**	**460**

7.7.3 MEASURES FOR RESETTLEMENT & REHABILITATION

The provisions "Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013" have been taken into consideration. The provisions for Resettlement that would be extended to the families losing homesteads are given in Table-7.15.

Table-7.15: R&R, Land Acquisition and Building Compensation

S No	Description	Amount (Rs.)
1	R&R - Building Construction Package - 7 blocks	78,75,56,556.48
2	Removal of utilities including railway bridges/culverts and demolition	30,00,00,000.00
3	Land Acquisition cost - 7.73 acres (already acquired)	29,61,00,000.00

S No	Description	Amount (Rs.)
4	Buildings Compensation cost for PAP@104 Nos. full building loss @ Rs. 18.08 Lakhs	18,80,00,000.00
5	Buildings Compensation cost for PAF @791 partial loss of building @ Rs 5 Lakh	39,55,00,000.00
	Total	**Rs. 196,72,00,000.00 Say Rs.196.72 Crore**

7.8 SEDIMENT LOAD STUDY

There are 5 rivers namely Achencoil, Pamba, Manimala, Meenachal, and Muvattupuzha reaching the Kochi lagoon and bracing the IURWTS canal on the southern side. None of the rivers have direct flow into the canal system. During monsoon months, the bed load of the sediment transported gets deposited in Kochi lagoon and further carries the suspended sediments, towards the estuary mouth and thereby into the sea.

The rise in water level in the surrounding water bodies of the canal is also experienced inside the canals during the monsoon seasons. All throughout the year the effect of high tide level and low tide water level fluctuations is also experienced inside the canals. On the northern side, a branch of Periyar river flows into Kochi lagoon and as the water flows to the estuary mouth the impact of rise in water level is experienced in the canals on the northern side. The layout of Kochi lagoon with the IURWTS catchment is as given in Figure-7.4.

During the movement of water flow to the sea mouth from the southern and northern side, the impact of the suspended sediment movement will be experienced indirectly into the canals. During extreme climatic events like rise in HTL and LTL above the HFL of the Kochi lagoon, the flow to the sea from the lagoon will get restricted. The rise in water level in the lagoon will also have an impact of sediment movement into the canal systems.

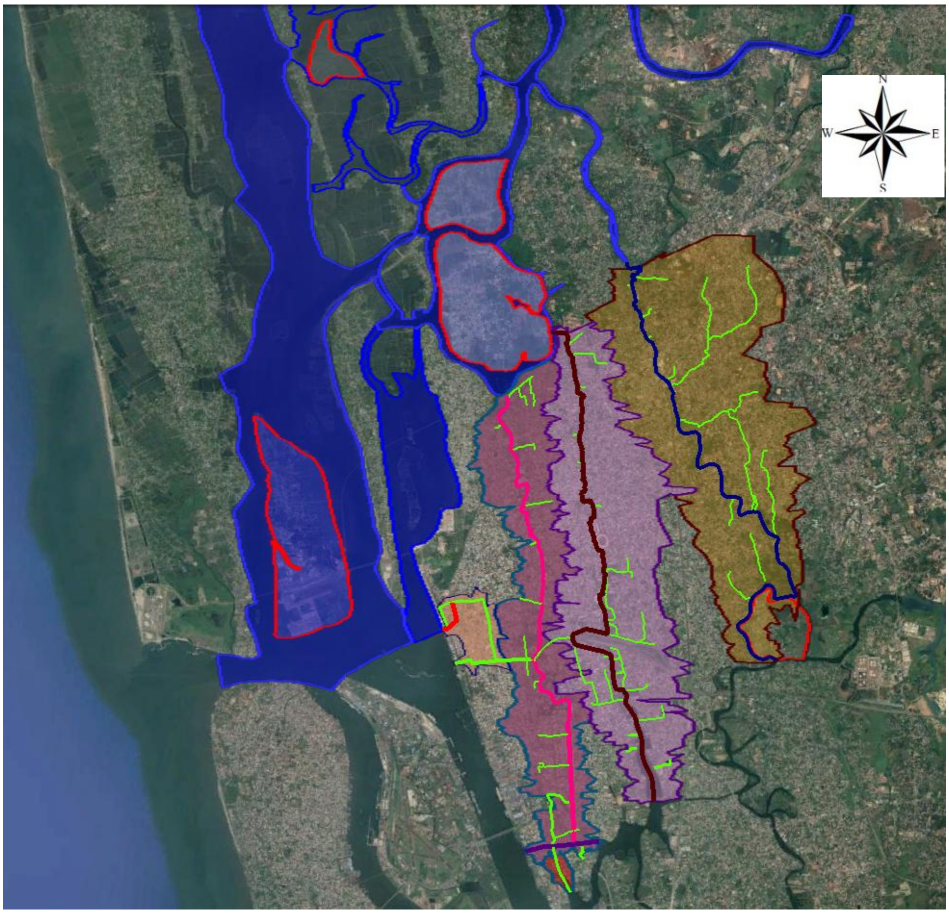


Figure-7.4: Google imagery showing Kochi lagoon around IURWTS canal

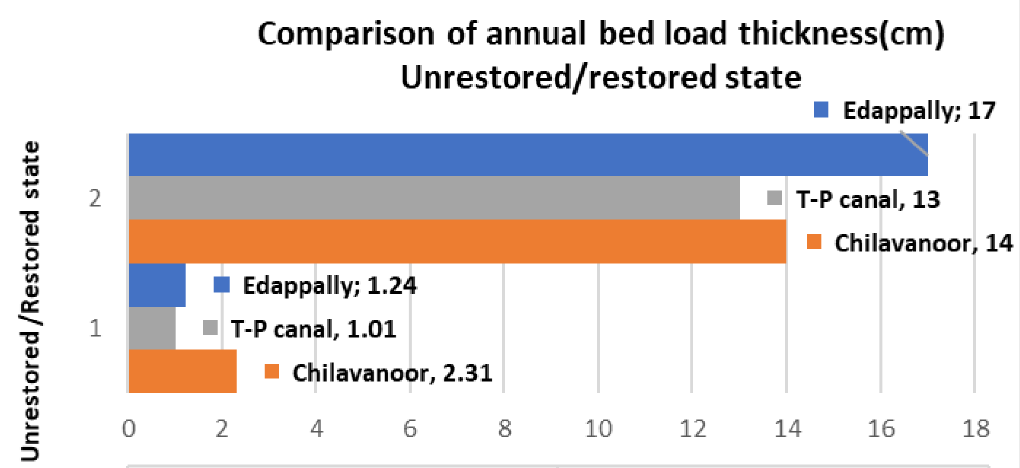
7.8.1 Criteria adopted for estimation of sediment flow in the canals

The rate of sediment flow and bed load deposition annually into the canal has been studied for an adverse condition, Van Rijn (1984) the most comprehensive and popular analytical method derived based on extensive field and laboratory research has been used for predicting transport rate of bed and suspended loads.

7.8.2 Findings

The findings of the study are as follows:

- Soil sample studies of the existing bed soils conducted by KEIL confirms that there are no hazardous materials and hence no sediment remediation measures is required for the bedded materials in the present state in the canals.
- All the 3 canals are in a dilapidated stage and there is no flow of flood waters into the canals in the existing condition except for a certain length at both the ends of the canals. A comparison of annual sediment deposition with the unrestored state and the restored state (when all the bottle necks are removed) i.e. canal widened to 16.5m with a vertical depth maintained uniformly at -0.9m CD for 3 major canals estimated is given as chart in **Figure-7.5*:***.



	1	2
Edappally	1.24	17
T-P canal	1.01	13
Chilavanoor	2.31	14

Annual bed load depth in cm

Figure-7.5: Comparison of annual sediment deposition

- On analysis of the results, it can be seen that in the unrestored condition, Edappally canal sediment load deposition is higher, as the existing bottle necks are less. In the restored condition, based on the proximity to the rivers reaching the surrounding water bodies, Edappally canal is seen to have an annual bedload deposition of 17cm. As the sediment movement into Thevera Perandoor canal is influenced by Thevara canal in the south, bed load deposition is seen to be comparatively lesser than Chilavanoor and Edappally canals as given in Figure-7.5.
- The sediment load rate (Bed and suspended) estimated analytically (Van Regin, 1984) method in restored condition is within reasonable limits and hence in no way will have an impact on the aquatic marine life.

7.8.3 Conclusion and Recommendations

Prediction of the sediment transport rate is one of the most frustrating endeavors in the entire field of sediment dynamics. The analytical estimation of suspended load rate confirms that there will be no impact on the aquatic life (fish, flora, and fauna) after restoration of the canal. Based on location of canals and its influence on the surrounding river catchments, the results of sediment analysis have been arrived, and the following conclusion and recommendations are made:

- Under baseline condition, at various stretches along all the 3 canals studied due to the presence of bottlenecks, waste, and other materials deposited in the canals, there is negligible water flow and practically no silt movement.
- The sediment load movement in the canals is present in the restored condition. The rate of bedload deposition of sediments in the canals is governed by the proximity of the rivers reaching the surrounding water bodies with respect to the canals.
- The average depth of flow to be maintained in the canal is 1.4m for movement of vessels. After accounting for a hull depth of 50cm for the boats designed there will be a free depth of 1m below the bottom of the hull. Hence as per the current rate of bed load sediment accumulation, it is recommended that desilting works will have to be undertaken in the canal after every 2 years.
- In the post implementation stage or during canal operation, bathymetric measurement of the bed load deposition along with periodic water quality sample analysis is to be carried out to estimated seasonal movement of load. This will help to confirm the findings of the study. This will also suggest mid-course measures and extra maintenance required, if any.

7.9 PUBLIC HEARING PROCEEDINGS

7.9.1 GENERAL

The Notice for the public hearing was issued in English (The New Indian Express) and Malayalam (Mathrubhumi, Malayala Manorama) newspapers on 13.02.2021. A copy of the notice for Public Hearing are enclosed as **Appendix-6**, Public Hearing for Integrated Urban Regeneration and Water Transport System (IURWTS) project was conducted by Regional office of Kerala State Pollution Control Board (KSPCB), Ernakulam on 16.03.2021 at 11.00 AM at the Collectorate conference hall, Kakkanad, Dist. Ernakulam.

The public hearing was presided over by Smt.Afsana Perween, I.A.S, District Development Commissioner (DDC) on Behalf of District Collector, Ernakulam. Shri. M.A Baiju, Chief Environmental Engineer, Kerala State Pollution Control Board, Regional Office, Ernakulam welcomed the gathering. The DDC explained the purpose of the hearing and directed Kochi Metro Rail Limited to make a brief description of the project. Nishad Narayanan, Environment Expert assisting made a detailed presentation of the proposed project and the Shri. Stephen Leo, representative of the WAPCOS Limited, the consultant assigned by the Kochi Metro Rail Limited explained the details of the Environmental Impact Assessment Study conducted.

The representatives of the public attending the hearing were requested to express their suggestions, opinions and objections in respect of the project after the presentation.

They were also requested to furnish their objections and suggestions through a written petition either to the District Collector or to the Regional Officer, KSPCB, Ernakulam.

7.9.2 ISSUES RAISED BY THE PARTICIPANTS DURING PUBLIC HEARING

The DDC invited the public to express their views, suggestion and objections if any after the presentation.

The key issues raised during public hearing and response by project proponent are given in Table 7.16.

Table 7.16: Points raised by the participants orally, during Public Hearing

S. No.	Name and Address of participants	Details of representation	Answer given by Project Proponent
1	Sri Sankar Edappally	Raised query on the land requirement and acquisition of land for the canal widening	Replied that a minimum of 8.25 meters on either side from the center line of the canal based on the village records will be acquired and an additional 2m on either side will also be acquired for laying primary sewer lines along the canal.
2	Sri. Jameson Thaipadath	Raised question regarding how KMRL have fixed 16.5m for the canal widening and also asked to clarify the total land required for the complete infra structure development such as jetty construction, green belt, cycle path etc in Edapally Canal and also asked about the no of jetties from Muttar to Chitrapuzha, and depth of canal	• The width of 16.5m was fixed based on the international guidelines for restoring 2 way navigation in the canals. • Informed that total 16.71 hectares of land will be acquired for Edappally canal. Major part of the land for acquisition is Govt. land. • About 4km of stretch in Edappally canal is to be used for beautification starting from pipeline junction up to the confluence point of Edapally thodu and Chitrapuzha. • Since, the project area is included under CRZ Zone, no concrete structures will be constructed. • The bridge construction will be done using corrugated steel plates to reduce construction time. • The bottom level of the canal is final depth fixed at (-) 0.90mCD with respect to the reference levels fixed by Cochin Port Trust. Depth is

S. No.	Name and Address of participants	Details of representation	Answer given by Project Proponent
			fixed at(-) 0.9m CD without entering into the stiff clay layer to prevent the salt water intrusion during tidal effect. • 9 jetties are proposed in Edappally canals between Muttar in the north and Chitrapuzha in the southern end.
3	Sri.Raju Thomas	Raised query on the process of acquisition of land and properties in Edappally thodu since there are many buildings on the right side of canal and future expansion has already been proposed in the NH 66 which falls in the left side of the canal	Already avg 10m width existing in the area. As per the village records 16.5m land to be acquired for widening comes under *Purambokke* (Govt land) very limited area in acquisition part. Maximum acquisition of flats will be avoided , informed that the public can visit the KMRL office at any time and all the records and details related to the project will be made available to the public in this regard
4	Sri.Sebastian M.A- joined through online	Question was to clarify on the capacity of STP at proposed at Vennala in Edappally canal on the southern end. He enquired about the method of calculating the sewage load and the no of residences served by the STP. He also enquired on how sewage will be collected from flats which do not have STP.	• The STPs designed was taking into account the anticipated population of 2051 and following the guidelines of CPHEEO manual. Sewage will be collected through laying sewer lines and collected directly from the houses. • Sewage will be collected through a combination of gravity and pumping system. • Survey will be conducted to identify the flats who have no STPs. Their sewage will be collected for treatment and suitable charges will be levied for the treatment. • The treated sewage effluent will be collected from the flats who have already installed STPs.

The meeting was declared concluded by Chief Environmental Engineer, Regional Office, KSPCB conveyed thanks to the Chairman and all participants.

The copy of public hearing proceedings along with the attendance sheet and The written representations given by various stakeholders and their replies is enclosed as **Appendix-7**.

CHAPTER-8
PROJECT BENEFITS

The project Integrated Urban Regeneration and Water Transport System in Kochi (IURWTS) aim is to restore the city's relationship with canals which were used for navigation until a few decades ago. Now Kochi is facing severe waterlogging and a reason for that is poor maintenance of canals. This is also emphasis an urgent need to rejuvenate the Kochi's canal network. Through IURWTS Government of Kerala is planning to regenerate five major canals and restore them for the people of Kochi.

The five major canals which are covering a total length of 34 km are Edappally Canal (11.23 km), Chilavanoor Canal (11.15 km), Thevara–Perandoor Canal (9.88 km), Thevara Canal (1.41 km), and Market Canal (0.66 km). These canals will be cleaned and free from the pollutants by setting up independent sewage treatment plant and disposal systems, curbing sewage outfalls, reducing the risk of flooding, and retaining and replenishing water by ensuring its smooth flow. The accessibility will be improved by making canals navigable, improving connectivity and enhancing cross-connectivity by making the navigable routes a feeder service to the existing public transport systems.

This project is in line with the overall objective of improvement of transport system of Kochi city and for integration with the Rail Metro and Water Metro to enhance the last mile connectivity. This is proposed to be achieved by canal restoration and urban regeneration of the canal catchment. The Urban Regeneration and Canal Oriented Development (COD) is not considered as a simple form of renovation or rehabilitation of the obsolete and dilapidated canal infrastructure. The restoration of canals and urban regeneration is aimed at restructuring the urban fabric and renewal of the urban economy and thereby overall improvement of city's image.

The proposed project of widening the canal and improve the water transport will boost the tourism and business transport of the commercial capital of Kerala i.e. Kochi.

The major benefits of the proposed project are:

- Improve intermodal connectivity with the Rail Metro and Water Metro by way of restoration of canals.
- Flood mitigation and flood plain management.
- Canal development will create beautifully landscaped canal spaces for leisure and tourism, cute shops, and eateries for creating an illusion of urban vitality along the canal banks and enhanced livelihood opportunities. This would further improve the city's image
- Sanitation facilities and sewage disposal system integrated to serve the inhabitants of the project command.
- Restrict dumping of waste, control encroachments, stop sewage mixing etc.

- Infrastructure / property development along the canals through Value Capture Financing & Transit Oriented Development for generating revenue.
- Improve monitoring of the canal systems, which will reduce to zero waste disposal, mosquito menace, and carbon reduction
- Enhanced utility of the canal waterfront as a natural attraction for social and economic activity for locals and tourists.
- A hassle-free inland water navigation system along the canals to enhance urban mobility and tourism with environmentally friendly ferry vessels, comfort, and innovative jetty terminal facilities.
- Climate change, carbon credits, flood mitigation, boosting of regional economy by tourism, etc.

CHAPTER-9

ENVIRONMENTAL COST BENEFIT ANALYSIS

This chapter is not applicable as it was not recommended at the scoping stage

CHAPTER – 10

ENVIRONMENTAL MANAGEMENT PLAN

10.1 GENERAL

Environmental Management Plan is a plan that seeks to achieve a required end state and describes how activities that have or could have an adverse impact on the environment, will be mitigated, controlled, and monitored.

The EMP will address the environmental impacts during design, construction and operation phases of a project. Due regard must be given to environmental protection during the entire project. In order to achieve this, number of environmental specifications/ recommendations has been made. These are aimed at ensuring that the proponent/contractor maintains adequate control over the project in order to minimize the extent of impact during construction, ensuring appropriate restoration of areas affected by construction, and preventing long term environmental degradation.

Environmental impacts arising due to development activities are the key aspects on EIA study. An equally essential element of this process is to develop measures to eliminate, offset, or reduce adverse impacts to acceptable levels and enhance the beneficial ones during implementation and operation of the projects. The integration of the project planning has been done by clearly defining the environment requirements within an Environment Management Plan (EMP). The Management Action Plan aims at controlling pollution at the source of generation itself to the maximum possible extent with the available and affordable technology followed by treatment measures before they are discharged.

Formulating Environmental Management Plan, which specify mitigation, monitoring activities and indicators to be attached to Annual and periodic activity plans for project implementation. The Environmental Management Plan (EMP) for the proposed project is classified into the following categories:

- EMP During project construction phase
- EMP during project operation phase

10.2 EMP FOR CONSTRUCTION PHASE

The potentially negative impacts of proposed project are expected during construction phases. Good constructions practices are key to minimize, if not eliminate such negative impacts. The measures to be adopted during the construction phase to mitigate the adverse impacts are described in the following paragraphs.

10.2.1 Land Environment

On completion of construction activities, it should be made mandatory for the contractor to annihilate all signs of haul roads, storage areas, temporary structures, labour colonies, etc. Extraneous material and objects should be removed from the site. These aspects will be made mandatory as a part of the contract agreement.

The major impacts on land environment during the construction phase are expected during construction phase only. The borrow pit areas are generally left untreated. During the rainy months these untreated borrow areas get filled up with water and these can serve as potential breeding sites for mosquitoes. As a part of the Environmental Plan, the borrow pits shall be properly levelled, so that no isolated pools or puddles are left over, once the water dries up. A proper system to drain out the rainwater must be installed. The surface roads, which are proposed to be utilised during construction shall be black topped. Adequate provisions should be made for their timely repairs.

On completion of construction activities, the roads should be resurfaced completely. Material excavated during construction will be used for refilling and reclamation purposes.

During construction phase, significant amount of construction material will be required for construction of jetty and other infrastructure. The cutting and filling materials are sufficient to avoid the extra quarry. However, the provision for the same shall be provided in the overall project cost. The construction materials i.e. Steel, Cement, Sand etc; shall be procured from nearest market.

Responsibility: *The contractor shall be responsible to implement the managements measures suggested for land environment during construction phase. These aspects will be made mandatory as a part of the contract agreement.*

10.2.2 Water Environment

During construction phase, total about 132.2 m^3/day of sewage is expected to be generated at all the proposed sites. One community toilet shall be provided for 20 persons at the each site and construction camps. The sewage from the community toilets can be treated in a septic tank with biodigester. The treated effluent can be used for meeting irrigation requirements of areas being afforested under greenbelt development. The total cost required shall be Rs.125.0 lakh. The details are given in Table-10.1.

Table-10.1: Cost estimate for sanitation facilities in labour camps

Item	Unit	Number	Total cost (Rs. lakh)
Community toilet	Rs.50,000/community toilet	150	75.0
Bio digester	Lumpsum		50.0
Total			**125.0**

Responsibility: *The contractor shall be responsible to implement the managements measures suggested for water environment during construction phase. These aspects will be made mandatory as a part of the contract agreement.*

10.2.3 Provision of Free Fuel

As a part of EMP, it is proposed to make a clause mandatory in the contract of every contractor involved in project construction to provide supply of fuel to their labourers, so that trees are not cut for meeting their fuel demands.

The peak labour/technical population will be 2500 for the construction at various sites like 30 jetties, Road Bridges construction, Foot over Bridges, sewerage network and Sewage Treatment Plant etc. The total no. of labour and Technical staff staying at site shall be 625.

The project proponent in association with the state government should make necessary arrangements for distribution of kerosene oil and LPG. This fuel would be supplied at subsidized rates to the local/contract laborers for which provision has been kept in the cost estimate. The total cost required for provisions of fuel has been estimated as **Rs. 49.0 lakh**. The details are given in **Tables-10.2.**

Table-10.2: Cost estimate for LPG distribution

Year	No. of Employees	Annual requirement @1cylinder per four persons per month (No. of cylinders)	Total Cost @Rs.1500 /cylinder (Rs. lakh)	Cost after escalation @ 10%/ year (Rs. lakh)
I	625	156	23.4	23.4
II	625	156	23.4	25.74
Total				**49.14 say 49.0**

Responsibility: *The contractor shall be responsible for free fuel distribution for labourers during construction phase. These aspects will be made mandatory as a part of the contract agreement.*

10.2.4 Control of Impacts deepening on Aquatic Environment

The total quantity of soil to be dredged is 6.95 lakh m^3. The impact on aquatic ecology during the construction phase would be largely confined within the construction period itself. An important factor in minimizing adverse impacts would be optimizing the construction period and avoidance of activities beyond the specified area of implementation. Hence, as a part of the management strategy various activities should be well coordinated and optimized to avoid time and cost over-run.

The recommended measures are given as below:

- To avoid impacts on aquatic environment, the construction specially on water front including desilting and dredging shall not be carried out during the fish breeding season (during April, May)
- The use of a Innovative Dino6 dredger will be used for dredging, which is known to reduce turbidity generation relative to other types of dredger.
- Hopper door seals will be maintained in proper condition to ensure minimum loss of sediment during transport.
- Spillage of fuel / engine oil and lubricants from the construction site are a source of organic pollution which impacts aquatic life, particularly benthos. This shall be prevented by suitable precautions and also by providing necessary mechanisms to trap the spillage.

- The construction activities like desilting, dredging, etc will be carried out in the confined manner to reduce the impacts on aquatic environment.
- The construction waste including debris shall be disposed safely in the designated areas and in no case shall be disposed in the aquatic environment.
- Suitable desilting and dredging methods shall be used to minimise the loss of sediments into the neighbouring water column and cause minimum disturbance to the marine ecology of the area.
- Dredging and construction activities to be scheduled and planned to minimise impacts on fishermen and aquatic ecology.
- Waste consignment notes to be prepared and documented for the disposal of dredged material.
- Disposal of dredged spoils shall be carried out the designated site as per the stipulated guide lines.
- Strict management of the aquatic environment should be followed during the construction phase through waste control, use of minimum disturbance techniques during construction for ensuring minimal changes to the aquatic environment.
- After completion of construction activities, adequate clean-up of the area should be undertaken and all discharged materials should be removed from the site.

10.2.5 Dredge Disposal Plan

The total quantity estimated from deepening is 4,54,013 m^3 and from widening is 2,41,401 m^3, totaling to 6,95,414m^3. Out of the total quantity estimated 20 percent is proposed to be used for canal embankment, landscape works and remaining conveyed to land filling sites. Before transportation, the excavated earth will be deposited over polythene sheets in the 2m width land acquired, on either side at different stretches. The soil will be conveyed after the water content in the soil is drained back into the canal and fit for conveying. The Quantity of the material to be conveyed for disposal is 4,29,681 m^3. The details are given in Table-10.3.

Table-10.3: Details of Quantity of materials to be disposed

S No.	Total deepening quantity (m^3)	Total widening quantity (m^3)	Total quantity available after deduction of 20% as slump (m^3)	Total quantity for bio engineering embankment filling (m^3)	Total quantity Canal beautification (m^3)	Total quantity to be conveyed (70 %) (m^3)
1	4,54,013	2,41,401	5,56,331	36,650	90,000	4,29,681

<u>Quantity to be used for Canal beautification</u>

The quantity that will be required for developing the low lying areas as part of canal beautification proposed is estimated as 90,000 m^3. The width Edappally canal shall be covered for a length of 4.9 km of (from Chitrapuzha to Pipeline jetty) and width of 15 m.

<u>Quantity to be used for filling low lying areas</u>

Embankment using soil bio-engineering measures is proposed at suitable low lying areas on either side of canals, with a base width 1 m , top width 0.7 m and height of 0.7 m. Total quantity that assessed is 36650 m^3.

Usage of remaining soils as soil cover of KEIL Landfill

M/s Kerala Enviro Infrastructure Ltd (KEIL), is operating “Common Treatment, Storage and Disposal Facilities (TSDF) Project with participation of 85 industries in the State, inside FACT – CD Campus, Ambalamedu an industrial hub, situated about 25 Km on the Eastern side of Kochi City. In the KEIL campus, 20 cells are already approved by KSPCB for disposal of 10 lakhs tons of waste. Additionally, there is a landfill expansion to 31 acres of land, which is in development. The Kerala Enviro Infrastructure Limited is in the process of enhancing the capacity of existing Secured Landfill from 10 lacs MT to 27.50 lacs MT at existing Common Hazardous Waste Treatment, Storage and Disposal Facility (CHWTSDF) to meet the long-term future requirement of Hazardous waste Disposal. In this regard, KEIL is in requirement of good quality soil which can be used as the soil cover in the landfill. KEIL has agreed to accept the dredged soil from the canals for their closing operation purpose.

The sediments from the canals of IURWTS were tested by KEIL and found suitable for disposal in their landfill. The distance to KEIL landfill site is given in Table-10.4.

Table-10.4 Distance to KEIL landfill

S. No	Canal	Location	Distance to KEIL Landfill (km)
1	Edappally Canal	Muttar	15.0
2	Chilavanoor Canal	Near Amrita	17.3
3	T-P Canal	Near Proposed STP-Perandoor	20.2
4	Thevara Canal	Near Thevara Market	17.3

The disposal of dredged soil from the canals, the option to use the soil as the soil cover of the landfill of KEIL is selected. The Construction & Demolition Waste shall be treated as per the C&D waste management rules, 2016.

10.2.6 Management of solid waste

During construction and operation phases, the solid wastes generated will contain mainly vegetable matter followed by paper, cardboard, packaging materials, wood boards, polythene, etc. The total solid waste to be generated would be of the order of 0.50 t/day. Adequate facilities for collection and conveyance of municipal wastes generated at the disposal site shall be developed. Dust bins shall be proposed per site for the separate collection of bio-degradable and non-bio-degradable waste. A provision of Rs.94.64 lakh has been earmarked for this purpose. The details are given in Table-10.5.

Table-10.5: Cost Estimates for Solid Waste Management

S. No.	Item	Cost (Rs. lakh)
1.	Provision of dust bins for collection of bio-degradable and non-biodegradable wastes (total 816 dust bin @ 6 dust bin per site @ Rs.3000/dust bin)	24.48

2.	One covered trucks for conveyance of solid waste to Municipal disposal site @ Rs. 50 lakh per truck	50.0
3.	Manpower cost for 8 persons @ Rs. 10,000/ month for 2 years including 10% escalation/year	20.16
	Total	**94.64**

Responsibility: *The contractor in consultation with district administration shall be responsible for implementing the management measures suggested for solid waste management during construction phase. These aspects will be made mandatory as a part of the contract agreement.*

10.2.7 Control of Pollution due to increased vehicles

The movement of vehicles is likely to increase during construction phase and later in the operation phase of the project. Thus, as a control measure, vehicles emitting pollutants above the prescribed standards will not be allowed to ply either in the project construction or in the operation phases. Vehicles and construction equipment will be fitted with internal devices i.e. catalytic converters to reduce CO and HC emissions.

All the roads in the vicinity of the project site and the roads connecting the quarry sites to the construction site are paved or black topped to minimize the entrainment of fugitive emissions. If any of the road stretches cannot be blacktopped or paved due to some reason or the other, then adequate arrangements will be made to spray water on such stretches of the road.

Responsibility: *The contractor in consultation with district administration shall be responsible for implementing the management measures suggested for control of pollution due to increased vehicle during construction phase. These aspects will be made mandatory as a part of the contract agreement.*

10.2.8 Fire Fighting Equipment

It is proposed to place fire extinguishers and fire hydrants in the adequate numbers at suitable locations in the port premises to deal with any emergency situation.

<u>Construction of Camps etc. and placement of fire protection equipments.</u>

It has been planned that all facilities to be constructed shall be fully equipped with the fire protection equipment's as per the standards applicable. The analysis of fire hazard in the construction camps along with mitigation measures, and other facilities is given in Table-10.6.

Table-10.6: Analysis of fire hazard in the construction of these camps, and other facilities

S. No	Stage	Potential hazard	Remedial Measures
1.	Construction of Camps/sites	• Fire prevention and fire fighting not considered in design • Inadequate fire	**By Contractors** • Fire fighting equipments will be placed at all common places (within 15 meters of work place)

		protection measures during construction	• Contract will ensure the placement and maintenance of fire fighting equipments

b). Maintenance of fire protection equipments as the safety measures thorough dedicated EMC

It has been envisaged to set up full-fledged Environment Management Cell (EMC) reporting directly to Head of Project. This department shall also take care of the adequacy of Fire Safety measures set up in all facilities created either owned by KMRL or any of its Contractors. The details of potential hazard and suggested remedial measures is outlined in Table-10.7.

Table-10.7: Details of potential hazard and suggested remedial measures

Potential hazard	Remedial Measures
• Fire incident due to electrical short circuit/ gas Leakage/ Improper handling of flammable liquids/lack of precaution • Improper access to and from the location • In adequate fire fighting arrangements • Lack communication • Lack of Knowledge on fighting fire and handling fire equipment • In adequate Emergency response	• Each camp will be provided with rated estimated trip off circuit breaker will be installed on each block. • All labour and staff are made aware of fire hazard by training, regular campaigns and by placing posters and signs • Flammable liquids will stored at designated storage area . The storage will be well protected, ventilated with adequate provision of fire equipments. • Additionally fire point containing fire buckets, CO_2 extinguishers, fire Extinguisher will be provided at the common place covering labour Camps. • Placement of written posters of preventive measures in each site • Regular inspection of the site by EMC • Placement of placard of emergency numbers to be contacted in case of Emergency

Responsibility

Project In charge is responsible for implementation of plan through his authorized representative on site. Site EMC Team shall monitor the implementation of plan and report noncompliance to site management.

Training and awareness

Training of employees on fire prevention and fire fighting is important to prevent occurrence of fire incident in project area. All employees will be given brief overview of fire prevention, fire fighting procedure and response process at the time EMC Induction training. Project proponent will also carry out regular campaigns on fire prevention around the site. EMC is responsible for providing required training.

An amount of **Rs. 30.00 lakh** has been earmarked for implementing the measures for fire fighting system.

10.2.9 Public Health

The various construction activities may lead to creation of water pools, which provide habitat to Mosquitos. That may lead to various diseases. The water resources project consists of various components and each requires a set of specific management measures. The suggested measures are for controlling of diseases are given as below:

- Adequate drainage system to dispose storm water drainage from the construction camps should be provided.
- Adequate vaccination and immunization facilities should be provided for workers at the construction site.
- Supply of protected water and safe disposal of effluent can eliminate most of the water-borne diseases such as Cholera, Jaundice, etc.

Proposed Health Facilities at Construction sites and Construction camp

It is recommended that necessary medical facilities be developed at the project site during construction phase. It is recommended that the dispensary shall be developed during project construction phase itself near the construction site, so that it can serve the labour population. A well-stocked First Aid kit (administered by medical personnel) shall be maintained at labour camp for each post.

Public Awareness Programmes

It is recommended that a detailed health awareness programme be implemented in the project and the surrounding areas. The objectives of the survey includes:

- Awareness about various diseases and actions to be taken in the course of an epidemic.
- Develop community education massages to provide the community with information about recognizing the illness, how to prevent transmission and when to seek treatment.
- Initiate proper communication with the community as soon as epidemic or public health problem is identified.
- Sensitize communities to constantly sleep under treated mosquito nets
- Distribute treated mosquito nets to communities living in proximity to the lake.

An amount **of Rs.30 lakh** be earmarked for implementation of various measures of public health facilities.

Responsibility: *The contractor in consultation with district administration & health department shall be responsible for implementing the management measures suggested for public health during construction phase. These aspects will be made mandatory as a part of the contract agreement.*

10.2.10 Safety Practices during Construction Phase

The Contractor is required to comply with all the precautions as far as possible for safety of the workers. The contractor will supply all necessary safety appliances such as masks, ear plugs, etc., to the workers and staff. The contractor shall comply with all regulation regarding, working platforms, excavations, trenches and safe means of entry and egress.

In order to guarantee construction safety, efficient lighting and safety signs shall be installed on temporary roads during construction and adequate traffic regulations shall be adopted and implemented for temporary roads.

10.2.11 Occupational health and safety at construction site and labour camps

- Provide personal protective equipment to the labours.
- Ensure the labours are trained to work on the specific project.
- For untrained labour – training should be provided before permission to work on the site.
- The contractor shall provide, if required, erect and maintain necessary (temporary) living accommodation and ancillary facilities during the progress of work for labour to standards and scales approved by the Engineer- In charge.
- Contractor shall follow all relevant provisions of the Factories Act, 1948 and the Building & other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 for construction & maintenance of labor camp.
- Construction camps shall not be proposed within 1000m or sufficiently away from nearest habitation to avoid conflicts and stress over the infrastructure facilities, with the local community. The location, layout and basic facility provision of each labour camp shall be submitted to Engineer prior to their construction.
- Safety and sanitation facility should be provided in the labour camp. Uncontaminated water shall be supplied to the construction workers at labour camps.
- The contractor shall arrange for a readily available first aid unit including an adequate supply of sterilized dressing materials and appliances as per the Factories Rules in every work zone, Availability of suitable transport at all times to take injured or sick person(s) to the nearest hospital
- Always maintain a fully equipped first aid box in the construction camp.

Some of the safety sign boards to be displayed at construction site are as follows:

Responsibility: *The contractor shall be responsible for implementing the management measures suggested for construction phase.*

10.3 EMP FOR IMPLEMENTATION DURING OPERATION PHASE

10.3.1 Control of Air Pollution

During project operation phase, one the major activity would be the emission from the boats. The propulsion of the boats will be diesel-electric. At normal operating speeds, the boats would operate with the help of batteries and there would not be any fuel consumption. The boats will operate on diesel only when batteries are completely discharged. Hence there will be less chance of air pollution. All the DG sets shall be kept as per the CPCB norms to avoid the pollution due to that.

The impacts due to dust emissions could be substantially managed by containment and reduction of emissions. The reduction in the emissions is achieved by continuous spraying of water so that the surface remains moist and entrainment of fugitive emissions is avoided.

Responsibility: *The project proponent shall be responsible for implementing the management measures suggested for control of air pollution during operation phase.*

10.3.2 Control of water pollution

Apart from these regular effluents, plan has been proposed for leaks at workshops and oil spills. To combat oil pollution near the jetties, portable oil skimmers should be available at the berth. A clean sweep oil recovery unit consisting of a power pack and the recovery unit mounted on a system can be utilized for this purpose. The recovery unit generally consists of a recovery drum, collecting trough, screw conveyor, discharge housing and wiper assembly.

In addition, the berths should have chemical dispersants with spray pumps, catamarans for collection of debris and recovery of oil and tanker carriers of 5 kl capacity for recovering sludge/bilge water.

- In case an oil change is undertaken on the engine, the used oil would be collected in suitable containers and stored in the yard. Similarly, if fuel needs to be removed for purposes of maintenance, the same would be stored in containers & returned back to the boat on completion of repairs.
- Bilge water, if any, collected from spaces, could be also transferred to containers.
- Portable transfer pumps for both sludge (fuel and oil) & bilge along with tanks have been provided in the list of yard equipment/ utilities.
- The Oil effluent will be demarcated separately and shall be given to authorized recyclers.

Responsibility: *The project proponent in co-ordination with District Administration, and concerned Port Authorities and departments shall be responsible for implementing the management measures suggested for control of water pollution during operation phase.*

10.3.3 Jetty related wastes

The wastes generated at the jetty in normal operations include domestic effluent, garbage and solid wastes (debris, leftover plastic items, boxes, containers etc). Sufficient number of toilets and bathrooms with biodigestors shall be provided to the operational staff. Bins shall be provided at appropriate locations in the terminals to collect the solid waste.

- Separate bins shall be kept for biodegradable and non-biodegradable.
- The same shall be disposed to the municipal dumping yards.
- The battery and e waste generated shall be disposed of through the authorized vendors.

The solid waste generated in the catchment of the 5 canals has been estimated and the cost involved in collection of the solid waste through innovative methods is estimated. Kochi municipal corporation has already envisaged a proposal for converting the solid waste into energy at Brahmapuram, Kochi. The requirement of daily waste is 250 tons. The project catchment falls within corporation municipality and occupies nearly 50 percent of Kochi municipal corporation area. Hence rather than having a separate plant it is proposed to have a coordinated effort with KMC. The estimate cost for collection of solid waste for the initial 3-year period is estimated as Rs. 3.83 crores and the same is added in the project estimate.

10.3.4 STP& Sewer Lines

The operation and maintenance of 4 STPs and sewer lines shall be done during the operation of the IURWTS project. The following are the major impacts because of the O&M activities:

- Impairment of receiving water quality in surface/sub-surface source due to inadequate /inefficient treatment.

- Contamination of groundwater supplies due to leaching and impact on soil and agriculture
- Problems arising due to bad odour, insects, polluted air, noise pollution, etc.
- Indiscriminate disposal of sludge leading to contamination of land and soil.
- Reduced land values in nearby areas and aesthetics affected.
- The toxic gases are likely to contract communicable diseases from exposure to pathogens present in the sewage
- Leakage and overflow from Water pollution and possibility of mixing with water supply line

Mitigation measures

- Monitor the treated sewage/effluent quality and ensure compliance with PCB standards for effluent disposal into surface water bodies, on land or for the agricultural use.
- Provide buffer zones in the form of green belt around the STP; to be ensured during the design and construction phase itself.
- Prepares a sludge disposal plan and adheres to the same.
- Regular monitoring of sewer line and manholes for visible leakages/ overflows.
- Immediate repair operation for the damaged portion of sewer line.
- De-siltation of blocked sewers/ manholes with sewage pumping machines-storing and disposal at appropriate refusal area after treatment.
- Ensure proper covering of manhole and avoid dumping of solid waste to prevent chocking of sewer line

Responsibility: *The O&M agency and project proponent shall be responsible for implementing the management measures suggested.*

10.3.5 Fire and Safety Management

Full-fledged fire fighting facilities will be provided in the premises to tackle any fire contingency. Regular safety audits will be carried out for improving safety performance. Onsite and offsite Disaster Management Plans shall be developed and mock drills will be conducted at regular intervals to keep the disaster management team in a state of full preparedness.

Fire-fighting arrangements will be made as per the requirements. Basic fire-fighting arrangements consisting of fire hydrants and fire pump will be provided for fire control. The medium for the Fire Hydrant system to fight fire is river water. The system can be used by the in-house trained or fire department personnel in case of emergencies to combat fire. The system will be capable of providing effective water stream / jet required in the advanced stage of fire for cooling the burning surface and the adjacent areas in order to extinguish the fire. Common pumping arrangement is proposed for hydrant system. Sprinklers will be installed not only to control dust pollution but also to guard against self-ignition.

10.3.6 Rain Water Harvesting

The basic design concept is to minimize the discharge of storm water from the terminal to the outside road drain, by providing a series of recharge pits in the drain bed. The entire rain water collected from the terrace and other surface area shall be led to rain water harvesting recharge pits. The dimensions of pits are approximately 1.2 m dia and 1.5 m depth up to water table. The recharge pit with bore holes are provided at a suitable interval and filter media shall be provided depending on the soil conditions pack with Gravel Bed, Pebbles, Sand, etc. to recharge the ground water. The location of the recharge structures is preferably on the open area or on side of the storm water drain etc. The excess runoff shall be diverted to the external storm water drain.

10.3.7 Storm Water Management

The entire storm water from the terminals would be disposed through suitable storm water drainage system with rain water harvesting recharge pits and the surplus water is discharged to the existing storm water drain running outside the premises of the terminals. The effectiveness of the drainage system depends on proper cleaning of all drainage pipes/channels. Regular checking will be done to see that none of the drains are clogged due to accumulation of sludge/sediments. The clogged drains will be cleaned as soon as possible, preferably the same day. The catch-pits linked to the storm water drainage system from the raw material handling areas will be regularly checked and cleaned to ensure their effectiveness. This checking and cleaning will be rigorous during the monsoon season, especially at the time of heavy rains forecast.

10.3.8 Greenbelt Development

Extensive plantation programme will be taken in the project site. This plantation programme will be taken up to upgrade the ecological status of the area and to improve the aesthetic quality of area. The proposed green belt at the project site will form an effective barrier between the plant and the surroundings. Open spaces, where tree plantation may not be possible, will be covered with shrubs and grass to prevent erosion of topsoil. Adequate attention has been paid to plantation of trees, their maintenance and protection based on the geology, soil condition and topography of the site area (Figure 1). In IURWTS project around 5,000 trees will be cut for the project activities. As part of the afforestation program, 10 times the trees cut will be planted. As per the estimate around 22,000 trees will be planted along the canal, around the project facilities such as jetties, STPs and Canal Oriented Development areas. This will contribute to the afforestation program required for this project.

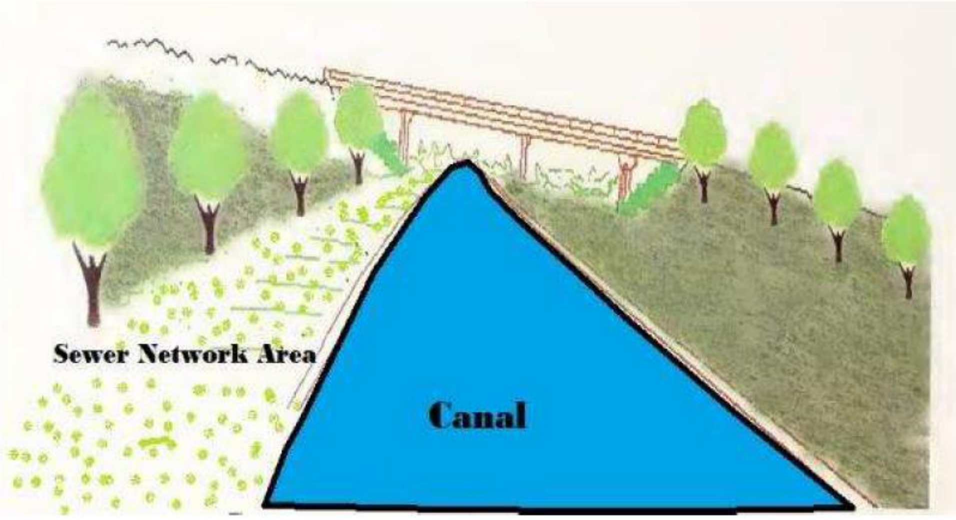


Figure-10.1: Project area with and without Green belt

Green belt will be developed around the four STP sites, 30 Jetties, Areas of Canal oriented Development in Edappally Canal and all available places on the banks of canals after widening and laying the sewer lines. The proposed model of Green Belt proposed are shown in the Figures-10.2 and 10.3. Additionally, whatever space is available around the periphery of the project area will be planned to be utilized for green belt. Other open spaces within the STP plots will be converted to green areas in the form of lawns or flowering plants.

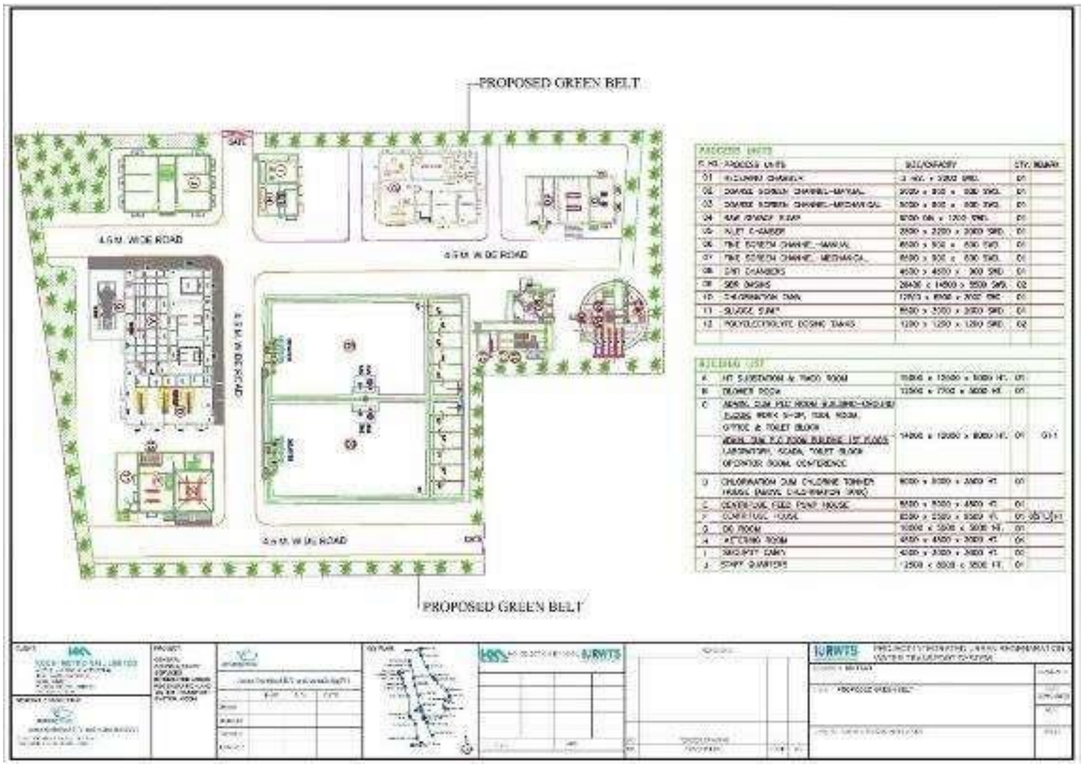


Figure-10.2: Proposed Green belt along STPs

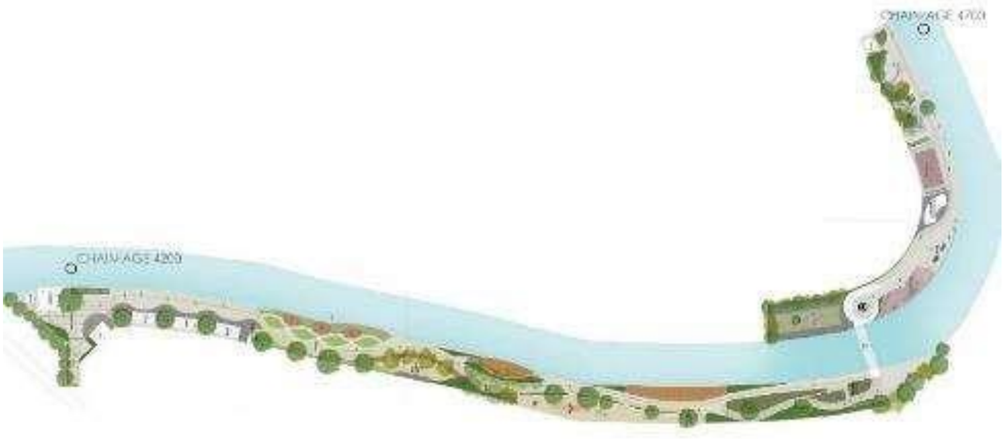


Figure-10.3: A section of the proposed Green Belt for COD

A wide range of plant species will be planted in and around the premises to help capture the odor emissions and noise. This wide range covers plants of fast growing type with thick canopy cover, perennial green nature, native origin, and a large leaf area index.

The following are the considerations given in the proposed green belt.

- Design and development of greenbelt will be in adherence to specific requirements and prevalent climatic conditions.
- SPV shall ensure greenbelt development & maintenance
- SPV shall follow CPCB guidelines for development & maintenance of greenbelt area
- SPV shall ensure regular watering & fertilization of greenbelt area as required timely
- SPV shall ensure re-plantation in greenbelt area depending upon the survival rate of planted vegetation to maintain greenbelt.
- Contractor shall plant trees and shrubs as per the table for developing the greenbelt area.
- Indigenous species with fast growth are only selected or form the base of selection as Green Belt can come in view as fast as possible.
- SPV shall give consideration to local species of trees & shrub for greenbelt development
- The tress shall be planted in three tiers pattern so as to ensure that the entire area gets covered and ensure effective pollution abatement. For this, management shall ensure that plantation of trees shall include mixture of lower, higher, and middle canopy structure, which shall be mixed appropriately / proportionately / uniformly.
- The plantation shall also include fruit bearing trees/ species which shall be uniformly distributed which shall act as dwelling place for Varity of birds and other fauna and

form a breeding ground for them. The tree products should have acceptable characteristics to suit local customs and traditions flowering Herbs & shrubs species.

The canal side green belt and landscape should be developed envisaging a holistic approach to the entire stretch. A concept was evolved so as to maintain visual characteristics and uniformity in terms of landscape along the stretch. In the absence of uniform land availability for the plantations, different schemes may be worked out in tune with the local variations in the design. To achieve

this, the entire stretch of the IURWTS corridors were divided into homogenous landscape sections based on similarity in terms of available width, soil conditions, climate (temperature and rainfall) and topography. A study on the local flora and vegetative cover native to these sections was carried out as part of the field surveys to enable a choice of the suitable species for particular section. Depending on the available ROW, plantation pattern was worked out as follows.

- The first row along the canals and approach road to STPs/Jetties will be of small to medium sized ornamental trees.
- Subsequent rows depending on the availability of width will comprise of ornamental and/or shade bearing species, of more height than those in the first row. In some sections the last row is of shade bearing tall trees.
- Planting of herbaceous species as ground cover, special landscapes, and embankment slopes.
- Turfing with grass, special landscapes, and embankment slopes.

On the completion of plantation, maintenance (soil working, watering, weeding, transplanting etc) of the above sapling will be carried out for at least 5 (five) years from the date of plantation to getting effective result. The maintenance of the plantation area will also be done by the project proponents. The recommended plant species for plantation under Greenbelt Development are given in Table-10.8.

Table-10.8: Plant species recommended for greenbelt development

Scientific Name	**Local Name**
Peltophorum pterocarpum	Copperpod
Casuarina equisetifolia	Cassrina
Swietenia mahogoni	Mahogany
Lagerstroemia speciosa	Jarul
Calophyllum innophyllum	Pinna
Cocus nucifera	Coconut
Acacia auriculiformis	*Earpod wattle*
Cassia fistula	Amaltas
Mimusops elengi	Ilani/ Maulsari
Thespesia populnea	Poovarasu/Cheelanthi

Scientific Name	Local Name
Pongamia pinnata	Karanji
Alstonia scholaris	Ezhilamppala
Shrubs	
Tabernaemontana divaricata	Crape jasmine/Chandni
Tecoma stans	Yellow trumpet
Plumeria rubra	Champa
Calotropis procera	Aka
Nerium indicum	Red kaner
Ixora coccinea	Rugmini
Anona squamosal	Custard apple
Thevetia peruviana	Kulkiphool
Michelia champaca	Swarna Champa

The fencing of single row plantations will be done by using iron /wooden guards. The fencing of multiple row plantations will be done preferably by barbed wire. A four strand barbed wire fencing, with cross strands, stretched on iron/cement poles fixed at a distance of 4 meter from one another; is recommended. Using the appropriate protection measures, the survival rate of sapling should be 90% after raising the plantation of age one year at any stage during contractual period with normal shape and size. The budget also includes maintenance of the executed work. As per CPCB guidelines, various plant species have been suggested for the plantation programme at the project area.

An amount of **Rs. 30.0 lakh** is earmarked for this purpose.

Responsibility: The project proponent in co-ordination with Forest Department, shall be responsible for implementing the Green Belt plan.

10.3.9 Legislative Measures

Government has issued vide G.O.(Rt) No.823/2020/LSGD Dt.04.05.2020 **(Attached as Annexure-VI)** Prohibition of dumping of waste/garbage and draining of sewage into all the canals under Integrated Urban Regeneration & Water Transport System (IURWTS). As per the GO following orders are issued:-

i. Dumping of all type of waste / garbage and draining of sewage to all other canals under Integrated Urban Regeneration & Water Transport System (IURWTS) project viz. Thevara canal, Market canal, Edappally canal and Chilavanoor thodu is hereby prohibited.

ii. Such actions are liable for prosecution under the relevant sections of Kerala Panchayat Raj Act 1994, Kerala Municipality Act 1994, Kerala Irrigation and Water Conservation (Amendment) Act 2018, Police Act as also the other provisions of Indian Penal Code and such other applicable Statutes, rules and Regulations.

iii. The citizens shall not indulge in the dumping of waste/garbage and filth into Thevara canal, Market canal, Edappally canal & Chilavanoor thodu and also that no sewage or human waste is drained into these canals so as to endanger the lives of fellow citizens.

iv. The Secretary, Kochi Municipal Corporation shall publish this order in Newspapers (both English & Malayalam) having vide circulation in Ernakulam District.

v. The District Collector, Ernakulam is authorised to issue detailed instructions to citizens not to indulge in the dumping of waste/garbage and filth and draining of sewage, human waste etc. into these canals quoting the relevant provisions of applicable laws, Statutes and Regulations.

10.3.10 Socio-economic Aspects

The operation phase will provide significant opportunities for employment in skilled, semi-skilled & unskilled categories. About 1000 people will be employed as part of the project. Thus the proposed project would be considerably beneficial to the socio-economic conditions of local area. Beside direct employment, rise in indirect employment and enterprise development due to proposed project would also be significantly beneficial to the economy of local area. These direct & indirect employment would improve employment opportunities. The project will not only improve the socio-economic condition as well as status of health and education in the region. Thus, the project would have a significant positive impact on the overall economy of the area. It was noticed that the people who participated in the public consultation were positively willing towards this project, as it will be a fastest & cheaper way of transport. The only issues or problems are lack of provision of good safety equipment, poor services & low frequency of the ferry boats. As the project envisions provision of these services it is expected to contribute the opportunities for women to access a safe public transport & use to it emancipate their social & economic rights. Thus this project will certainly have positive impacts on the various population groups of that area. Increase in transient population in the project area, migration of workers may cause economic, social and cultural conflicts or displacement of local populations. There are indications that sections of the society that depend on traditional resources (like coir, bamboo, fishery, cashew etc.) for livelihood and the vulnerable sections like Scheduled castes and tribes in the state were left out from development experience.

10.4 IMPLEMENTATION OF EMP

10.4.1 Constitution of Environmental Management Cell

Various control measures have been suggested in the EMP for environmental protection. It is suggested that the KMRL should maintain a full-fledged Environmental Management Cell (EMC) reporting to the top management through the Environment Division of KMRL. The

EMC will closely monitor the environment aspects of the proposed project and identity problems and accordingly, suggest certain measures to mitigate the same. In addition it will also all the statutory requirements in the area of environmental protection.

10.4.2 Summary of Generic and Site-Specific EMP

The summary of EMP for development of IURWTS project including mitigation measures, are given in Table-10.9.

Table-10.9: Generic EMP for IURWTS project

S.No.	Potential Environmental Impacts	Mitigation Measures	Implementing Agency	Monitoring Frequency	Monitoring Institution
Pre-construction Phase					
1.	Establishment of Construction Camp and site office	• Should be identified by the contractor in a central point in consultation with the people. • Layout of construction camp, including indicating various structures to be constructed such as the temporary structures to be put up, site roads, drainage, lighting, equipment storage units and other facilities, should be approved by Engineer-in-charge. • Living units of 30-40 m^2 to each of the labour family with proper ventilation shall be provided • Construction camps should have separate toilets for male and female workers, drinking water, LPG cooking fuel, first aid facilities and waste disposal facilities.	Prospective Contractor	One Time	KMRL
2.	Construction water	Contractor will make his own necessary arrangement for procuring construction water: • In case of community water source, Contractor should carry out consultations with villages/Panchayats and obtain written permission for the utilization of water • In case of private source, Contractor should not utilize the water unless written consent is obtained from other owners of the land parcel. • In case of new bore wells, permits should be obtained as per requirements of State Ground Water Board regulations especially for critical and over-exploited blocks • In case of surface water bodies, necessary permission from concerned department or administrative clearances should be obtained.	Prospective Contractor	One time Regular	KMRL
3.	Storage sites	Contractor shall provide layout and specifications for storage	Prospective	One time	KMRL

S.No.	Potential Environmental Impacts	Mitigation Measures	Implementing Agency	Monitoring Frequency	Monitoring Institution
		of: • Petrol/Oil/Lubricants: Suitable flooring will be provided at the storage places of Petrol/Oil/Lubricants to avoid soil and water contamination due to spillage. Cement: Damp-proof flooring, as per IS codes	Contractor		
4.	Borrow Areas	Shall be identified by the Engineer and list shared in the bid document	Prospective Contractor	One time	KMRL
5.	Disposal sites	• Shall be identified by Engineer and list shared in the bid document • Silt Disposal Plan to be prepared by Contractor and approved by Engineer • Debris Disposal Plan to be prepared by Contractor and approved by Engineer	KMRL	One Time	KMRL
6.	Waste disposal	• The sewage from the toilets can be treated septic tanks with Bio digester. • Municipal solid waste shall be disposed off at nearest municipal solid waste disposal site or landfill after segregation at site.	Prospective Contractor	One time	KMRL
7.	Site Restoration	Contractor to provide restoration plan of sites including borrow areas, construction sites and site office. The plan shall be approved by the Engineer.	Prospective Contractor	One time	KMRL
8.	Natural Habitats/ Wetlands	• Should be identified in consultation with Forest Department and Panchayats • Works in identified areas should be avoided.	KMRL	One time	KMRL
9.	Tree Cutting	• Necessary clearance for cutting of trees should be obtained by Engineer-in-charge prior to start of work from the Forest Department • A joint inspection of Forest Department, KMRL and Panchayats officials should be organized to identify the trees	KMRL	One time	KMRL

S.No.	Potential Environmental Impacts	Mitigation Measures	Implementing Agency	Monitoring Frequency	Monitoring Institution
		to cut for clearing the site. Trees to be cut should be clearly marked.			
Construction Phase					
10.	Construction Camps	• Proper cooking fuel should be provided to the labour residing in the camps. In any case, woods should not be used for cooking. • Proper sanitation facilities should be provided in the construction camps. • Potable drinking water should be provided to the workers. • Water logging conditions should not be allowed inside the camp.	Prospective Contractor	Once in a week	KMRL
11.	Construction Sites	• It should be kept free of water logging • Protective guards should be provided across the areas where workers may fall or could face an impalement hazard. • Keep form and scrap lumber away from work areas, passageways • No loose material should be allowed to leave unattended, and sites should be properly finished after completing the work • Good housekeeping should be maintained at construction sites	Prospective Contractor	Twice in a month	KMRL
12.	Public Safety	• Warning sign boards should be provided along the construction sites in English as well as local language • Trespassing of the construction sites should not be allowed	Prospective Contractor	Twice in a month	KMRL
13.	Occupational Health & Safety	• Safe access to the job sites should be provided to all workers • Passage ways, walkways, should be kept free of materials, scraps or obstructions	Prospective Contractor	Twice in a month	KMRL

S.No.	Potential Environmental Impacts	Mitigation Measures	Implementing Agency	Monitoring Frequency	Monitoring Institution
		• First Aid box should be readily available at construction sites • Contact with nearest nursing homes/clinics/primary health centre should be maintained by the Contractor to deal with any emergency at site • A vehicle should be readily available at construction site to meet emergency situation • The contractor should comply with all the precautions as required for the safety of the workmen as per the International Labour Organization as far as those applicable to this project • The contractor should strictly follow the statutory child labour act • Personal Protective Equipment such as helmets, hand gloves, safety shoes, nose masks, safety goggles should be provided to the workers.			
14.	Disposal of Excavated Soil	• Disposed to KEIL	Prospective Contractor	Once in a week	KMRL
15.	Storage of Construction Materials	• All construction materials should be stored in secured places and following good housekeeping practices • No hazardous material should be allowed to store near the construction sites.	Prospective Contractor	Once in a week	KMRL
16.	Water Pollution	• Solid waste shall be disposed at authorized sites identified in disposal plan • Waste water shall be treated and discharged through soak pits. • SW and GW quality to be tested regularly for any fecal	Prospective Contractor	Twice in a month	KMRL

S.No.	Potential Environmental Impacts	Mitigation Measures	Implementing Agency	Monitoring Frequency	Monitoring Institution
		contamination (at least once a week)			
17.	Soil Pollution	• Measures to prevent accidental spills of oils and other lubricants • Disposal of waste and wastewater shall not be done on open land.	Prospective Contractor	Twice in a month	KMRL
18.	Air Pollution	• Properly functioning construction equipment to minimize exhaust shall be maintained • Idling of machines and equipment shall be minimized • Pollution Free certified vehicles to be allowed • Avoid traffic in populated areas as much as possible • Cover stockpiled silt and trucks hauling silt, sand, and other loose materials or require trucks to maintain at least two feet of freeboard • Sprinkling of water on loose soil, especially during summers, shall be practiced as necessary	Prospective Contractor	Twice in a month	KMRL
19.	Noise Pollution	• Construction equipment, vehicles and machines shall be equipped with noise suppression devices and properly maintained mufflers • Staging of construction equipment and unnecessary idling of equipment within noise sensitive areas to be avoided whenever possible. • Notification, describing noise abatement measures that will be implemented, to be given to residents within 100 m of major noise generating activities. • Regular monitoring of noise levels to be undertaken. In case of exceedance of pre-determined acceptable noise levels, the contractor(s) to stop work and remedy the situation before continuing with works	Prospective Contractor	Twice in a month	KMRL
20.	Green Belt	• Green belt will be developed around the four STP sites, 30	Prospective	One time	KMRL

S.No.	Potential Environmental Impacts	Mitigation Measures	Implementing Agency	Monitoring Frequency	Monitoring Institution
	Development	Jetties, Areas of Canal oriented Development in Edappally Canal and all available places on the banks of canals after widening and laying the sewer lines	Contractor		
21.	Land Acquisition	• Follow Right to Fair Compensation and Transparency in Land Acquisition Rehabilitation and Resettlement Act 2013 and Kerala Rules, 2015. (LARR Rules)	KMRL	Twice in a month	
Operation Phase					
22.	Air Pollution	• All the DG sets shall be kept as per the CPCB norms to avoid the pollution due to that.	KMRL	Twice in a month	PCB
23.	STP/Sewer line	• Monitor the treated sewage/effluent quality and ensure compliance with PCB standards for effluent disposal into surface water bodies, on land or for the agricultural use. • Provide buffer zones in the form of green belt around the STP; to be ensured during the design and construction phase itself. • Prepares a sludge disposal plan and adheres to the same. • Regular monitoring of sewer line and manholes for visible leakages/ overflows. • Immediate repair operation for the damaged portion of sewer line. • De-siltation of blocked sewers/ manholes with sewage pumping machines-storing and disposal at appropriate refusal area after treatment. • Ensure proper covering of manhole and avoid dumping of solid waste to prevent chocking of sewer line	O&M contractor	Twice in a month	KMRL

10.5 CORPORATE ENVIRONMENTAL RESPONSIBILTY (CER)

The proposed project aims to achieve better living conditions and tourism promotion in the canal catchments by focusing on canal-oriented transport development approach. It has been ascertained that the activities proposed in the Integrated Urban Regeneration and Water Transport System (IURWTS) project are economically viable, environmentally sustainable, and socially acceptable. This is proposed to be achieved by canal restoration and urban regeneration of the canal catchment. The Urban Regeneration and Canal Oriented Development (COD) is not considered as a simple form of renovation or rehabilitation of the obsolete and dilapidated canal infrastructure. The restoration of canals and urban regeneration is aimed at restructuring the urban fabric and renewal of the urban economy and thereby overall improvement of city's image.

As per the Corporate Environmental Responsibility (CER) of Ministry of Environment, Forest & Climate Change (MoEF&CC), the activities to be involved are measures for pollution control, environmental protection & control, R&R, compensatory aforestaion etc. The entire project itself is for the pollution control in the 5 major canals in Kochi. As part of the urban regeneration works of the project, 4 STPs is proposed to treat the sewer load generated in the project catchment by providing sewer lines on both sides of the canals. As a transitional facility, biocommunity toilets are proposed at every 500 m along the canals during the project implementation phase. These community toilets would prevent sewage being discharged into the canal. Solid waste management load has been assessed for the catchment and alternate management measures are suggested as part of the project. The total estimate provision for the urban regeneration works shall be Rs.393.13 crores. The details are given in Table-10.10.

Table-10.10: Cost estimate for Urban Regeneration

Project activities	Amount (Rs. in crores)
A full sewer network for the entire catchment with individual household, sewer network connectivity including interceptors, manholes, inspection chamber, pumping stations, etc. is proposed	260.69
Establishment of 4 STPs: The sewer load of the entire project command to be treated over and above the existing and ongoing scheme has been estimated as 31 MLD.	101.96
Sanitation Facilities: The transitional sanitation facilities for population is not covered by the proposed sewage network has been included to prevent sewage being discharged into the canal.	26.65
Solid waste management: Provision for innovative collection for waste to be treated in the Kochi Municipal Corporation's solid waste into energy at Brahmapuram, Kochi.	3.83
Total	**393.13**

10.6 BUDGET FOR EMP

Budget for implementation of Mitigation Measures, Environmental Management Plan is Rs 4.5 crore. The details are given in Table-10.11 below:

Table-10.11: Budget for implementation of Mitigation Measures, Environmental Management Plan

S. No.	Items	Budget (Rs. lakh)
1	Sanitation Facilities in Labour Camps	125.00
2	Air Pollution Control Measures	30.00
3	Provision of Free Fuel	49.0
4	Solid Waste Management	94.64
5	Training and awareness on firefighting	30.0
6	Public Health Facilities	30.0
7	Greenbelt Development	30.0
8	Aquatic Biodiversity Management Plan	60.0
	Total	**Say 448.64 lakhs** **Say 4.5 Crore**

CHAPTER-11

SUMMARY AND CONCLUSIONS

11.1 INTRODUCTION

The project Integrated Urban Regeneration and Water Transport System in Kochi (IURWTS) aim is to restore the city's relationship with canals which were used for navigation until a few decades ago. Now Kochi is facing severe waterlogging and a reason for that is poor maintenance of canals. This is also emphasis an urgent need to rejuvenate the Kochi's canal network. Through IURWTS Government of Kerala is planning to regenerate five major canals and restore them for the people of Kochi.

The five major canals which are covering a total length of 34 km are Edappally Canal (11.23 km), Chilavanoor Canal (11.15 km), Thevara–Perandoor Canal (9.88 km), Thevara Canal (1.41 km), and Market Canal (0.66 km). These canals will be cleaned and free from the pollutants by setting up independent sewage treatment plant and disposal systems, curbing sewage outfalls, reducing the risk of flooding, and retaining and replenishing water by ensuring its smooth flow. The accessibility will be improved by making canals navigable, improving connectivity and enhancing cross-connectivity by making the navigable routes a feeder service to the existing public transport systems. The total cost of the project is Rs. 1528.27 crore

11.2 CONCLUSIONS

The proposed project of widening the canal and improve the water transport will boost the tourism and business transport of the commercial capital of Kerala i.e. Kochi.

The major benefits of the proposed project are:

- Improve intermodal connectivity with the Rail Metro and Water Metro by way of restoration of canals.
- Flood mitigation and flood plain management.
- Canal bank development which includes beautifications, walkways, recreation, and tourism.
- Enhance sewerage network, establish sewage treatment plants, and provide sanitation facilities to the inhabitants of the project catchment and restrict dumping of waste, control encroachments, stop sewage mixing, etc.
- Infrastructure / property development along the canals through Value Capture Financing & Transit Oriented Development for generating revenue.
- Improve monitoring of the canal systems, which will reduce to zero waste disposal, mosquito menace, and carbon reduction
- Providing necessary infrastructure for navigation facilities and vessels.

It can be concluded that the proposed Integrated Urban Regeneration and Water Transport System project is likely to entail certain adverse environmental impacts. However, these impacts have been ameliorated to a large extent by implementing appropriate mitigation measures (Chapter-4). Appropriate management measures too has been suggested and delineated as a part of Environmental Management Plan (EMP) (Chapter-10).

CHAPTER – 12

DECLARATION BY EXPERTS CONTRIBUTING TO THE EIA

I, hereby, certify that I was a part of the EIA team in the following capacity that developed the above EIA.

EIA Coordinator: Name: Dr. Aman Sharma

Aman Sharma

Signature and Date:

Period of involvement:
Contact information: **WAPCOS Limited.**
Plot no 76-C, Institutional Area, Sector-18, Gurgaon, Haryana
Phone: 0124 2397396

The EIA study has been conducted by WAPCOS Ltd., a Government of India Undertaking under the Ministry of Water Resources. WAPCOS Ltd. has the NABET accreditation from Quality Council of India (QCI), for conducting the EIA studies for Ports, Harbour, Breakwater and Dredging Projects and has a full-fledged team of Functional Area Experts and EIA coordinator through which this study has been executed. The list of Experts involved in the EIA study is given in Table-12.1.

Table-12.1: List of Experts involved in the EIA study

S. No.	Name	Functional Area	Signature
1.	Dr. Aman Sharma	EIA Coordinator	Aman Sharma
2.	Mr. A. S. Leo	Dy. EIA Coordinator	A. Stephan Leo
3.	Dr. Aman Sharma	WP	Aman Sharma
4.	Dr. Aman Sharma	SHW	Aman Sharma
5.	Dr. Aman Sharma	HG	Aman Sharma
6.	Mrs. Moumita Mondal Ghosh	HG	
7.	Mr. A. S. Leo	AP	A. Stephan Leo
8.	Dr. S.K. Tyagi	EB	

S. No.	Name	Functional Area	Signature
9.	Mr. S.M. Dixit	AQ	
10.	Mr. S.M. Dixit	Noise	
11.	Mr. R.V. Ramana	Noise	
12.	Mrs. Moumita Mondal Ghosh	LU	
13.	Dr. K.K. Gaur	SE	
14.	Swapan Kumar Bandopadhyay	RH	
15.	Dr. K.P.S Malik	SC	

S. No.	Functional Areas	Team Member	Mentor/FAE
1	WP	Dhaneesh V V	Dr. Aman Sharma
2	WP	Achal Satish Khilnani	Dr. Aman Sharma
3	SC	Deepender	Dr. K.P.S Malik
4	HG	Savvy Singhal	Dr. Aman Sharma

Declaration by the Head of the Accredited Consultant Organization/authorized person

I, Dr. Aman Sharma, hereby, confirm that the above mentioned experts prepared the EIA report entitled “EIA-EMP & SIA Studies for Integrated Urban Regeneration and Water Transport System (IURWTS) Project in Kochi". I also confirm that the consultant organization shall be fully accountable for any misleading information mentioned in this statement.

Signature :

Name : Dr. Aman Sharma

Designation : Chief Executive Director

(Envt., CM & Admn.)

Name of the EIA consultant organization	:	WAPCOS Limited
NABET Certificate No.& Issue Date	:	QCI/NABET/ENV/ACO/20/1500 dated 20.10.2020

ANNEXURE-I

F.No.10-23/2020-IA-III
Government of India
Ministry of Environment, Forest and Climate Change
(IA.III Section)

Indira Paryavaran Bhawan,
Jor Bagh Road, New Delhi - 3

Date: 13 May, 2020

To,

M/s Kochi Metro Rail Limited
Corporate Office, JLN Metro Station,
4th Floor, Kaloor, Ernakulam - 682017, Kerala
E Mail: ajith.nair@kmrl.co.in

Subject: 'Integrated Urban Regeneration and water Transport System (IURWTS)' in Cochin by M/s Kochi Metro Rail Limited - Terms of Reference - reg.

Sir,

This has reference to your proposal No. IA/KL/MIS/144314/2020 dated 20.02.2020, submitted to this Ministry for seeking Terms of Reference (ToR) in terms of the provisions of the Environment Impact Assessment (EIA) Notification, 2006 under the Environment (Protection) Act, 1986.

2. The proposal for grant of Terms of Reference (ToR) to the project 'Integrated Urban Regeneration and water Transport System (IURWTS)' in Cochin by M/s Kochi Metro Rail Limited was considered by the Expert Appraisal Committee (Infra-2) in its 50th meeting held on 22-24 April, 2020.

3. The details of the project, as per the documents submitted by the project proponent, and also as informed during the above said meeting, are under:-

(i) Kochi Metro Rail Limited (KMRL) in line with the directives of the Ministry of Urban Development, Government of India is engaged in the task of developing a seamless multi modal transportation system, focussing on developing a sustainable Integrated Water Transportation System for Kochi City, aiming to integrate the water transport system with other modes of transport including the metro system over a period of time.

(ii) The proposed project envisages the development of the Edappally Canal (11.23 km), Thevara-Perandoor Canal (11.15 km), Chilavanoor Canal (9.88 km), Thevara Canal (1.405 km) and Market Canal (0.664 km) in Kochi. At present all the canals are highly silted and polluted by domestic waste, commercial waste, construction waste, weeds growth and other sources. As a part of the project, the following activities are to be carried out:

- Cleaning of Canals
- Dredging & Cutting
- Bank Protection
- Reconstruction of Cross Structures and Foot Over Bridges
- Sanitary Sewer Line & STPs
- Sanitation Facilities
- Jetties
- Infrastructure Development
- Beautification of canals including Tourism & Sports Park.

(iii) The land required for these projects falls within periphery of the canal. The land belongs to the Government as well as private holders. The project will not affect the natural drainage in the area. The operation of the proposed jetties will provide an impetus to the development of secondary and tertiary activities in the area. The total land requirement for the project is 24.87 ha for all the project activities.

(iv) The total water required for passengers and staff expected as 515 KLD. The source of water is Kerala Water Authority.

(v) Total sewage generation is 180 KL for jetty. Sewage generated at each jetty location will be treated in septic tanks. Boats do not have any toilets nor use fresh water for any purpose, other than engine cooling water. There is no chances of bilge water mixing with oil, which would find a way into the waterway. When the boat is at the yard dry berth for repairs, the crew would use the toilets & wash rooms at the yard.

(vi) For Municipal solid waste bins shall be provided at appropriate locations in the terminals to collect the solid waste. Separate bins shall be kept for biodegradable and non-biodegradable. The same shall be disposed through Municipal waste management system.

(vii) The total electrical demand is estimated to be 1817 KVA. Power will be supplied by Kerala State Electricity Board.

(viii) The entire storm water from the terminals would be disposed through suitable storm water drainage system with rain water harvesting recharge pits and the surplus water is discharged to the existing storm water drain running outside the Terminals premises.

(ix) Investment/Cost of the project will be Rs. 1365 Crore.

(x) Benefits of the project: Better connectivity of islands around Kochi with mainland is a long-standing requirement, Easy access to scenic islands around mainland will lead to socio-economic development of islands connected by KWMP. Project implementation will enhance overall employment opportunities, Continuous need based training programmes proposed will increase the skill and capacity of the involved stakeholders, Substantial reduction of the vehicular traffic and pollution and Safer passenger movement.

(xi) Employment potential: 800 including temporary and permanent employment for construction and operation phase.

4. The project/activity is covered under category 'A' of item 7 (e) i.e. 'Ports, harbours, break waters, dredging' of the schedule to the EIA Notification, 2006 and its subsequent amendments, and requires appraisal at Central level by sectoral EAC.

5. The EAC, in its 50th meeting held during 22-24 April, 2020, after detailed deliberations, recommended the project for grant of Terms of Reference as specified by the Ministry as Standard ToR in April, 2015 for the said project/activity and the additional ToR in addition to Standard ToR for preparation of EIA/EMP report. On the basis of the recommendation of EAC and the submission given by the Project proponent, the Ministry of Environment, Forest and Climate Change hereby accords ToR to the project 'Integrated Urban Regeneration and water Transport System (IURWTS)' in Cochin by M/s Kochi Metro Rail Limited for preparation of the Environment Impact Assessment (EIA) Report and Environment Management Plan (EMP) with the following specific and general conditions in addition to Standard ToR provided at **Annexure**:-

(i) Importance and benefits of the project.

(ii) Submit a copy of layout superimposed on the HTL/LTL map demarcated by an authorized agency on 1:4000 scale.

(iii) Recommendation of the SCZMA.

(iv) Status of NBWL clearance.

(v) Jetties along with their location and capacities; proposed and existing, if any

(vi) Study impacts of dredging on the canal bank.

(vii) Detailed impact analysis of rock dredging, if required.

(viii) Study impacts of dredging and dumping on marine ecology and draw up a management plan through the NIO or any other institute specializing in marine ecology.

(ix) A detailed analysis of the physico-chemical and biotic components in the highly turbid waters round the project site (as exhibited in the Google map shown during the presentation), compare it with the physico-chemical and biotic components in the adjacent clearer (blue) waters both in terms of baseline and impact assessment and draw up a management plan.

(x) Details of emissions, effluents, solid and hazardous waste generation along with their management plans includingwastewater management plan.

(xi) Requirement of water, power/energy, along with their respective sources of supply; status of approval from concerned local authorities, water balance diagram, man-power requirement (regular and contract).

(xii) Details of Environmental Monitoring Plan.

(xiii) Detailed Environmental Management Plan including institutional arrangements.

(xiv) To prepare a detailed biodiversity impact assessment report and management plan through the NIOS or any other institute of repute on marine, brackish water and fresh water ecology and biodiversity. The report shall study the impact on the rivers, estuary and the sea and include the intertidal biotopes, corals and coral communities, molluscs, sea grasses, sea weeds, subtidal habitats, fishes, other marine and aquatic micro, macro and mega flora and fauna including benthos, plankton, turtles , birds etc. as also the productivity. The data collection and impact assessment shall be as per standard survey methods.

(xv) Disaster Management Plan.

(xvi) Flood management plan with worst case scenarios like recent floods in Kerala through modelling study for rivers/estuaries including its connection to sea through national institute.

(xvii) Management of contaminated excavated material from the waterways and its disposal.

(xviii) Layout plan of Greenbelt; proposed and existing.

(xix) Status of litigation pending against the project and/or any direction/order passed by any Court of Law against the project; If so, the details thereof shall also be included. Has the unit received any notice under the Section 5 of Environment (Protection) Act, 1986 or relevant Sections of Air and Water Acts? If so, details thereof and compliance/ATR to the notice(s) and present status of the case.

(xx) Submit an affidavit signed by authorized representative to the effect that there is no violation and no part of the project has been implemented without Environmental Clearance.

(xxi) Plan for Corporate Environment Responsibility (CER), as specified in this Ministry's Office Memorandum No. 22-65/2017-IA.III dated 1st May, 2018, shall be prepared and submitted along with EIA Report.

(xxii) Public hearing is to be conducted. Issues raised during public hearing and commitments made by the project proponent on such issues should be included in final EIA/EMP Report in the form of tabular chart with financial budget for complying with such commitments.

(xxiii) A tabular chart with index for point-wise compliance of above ToRs.

6. The Project proponent shall also take note of the following General Guidelines for preparation of EIA Report and EMP:

(i) The EIA document shall be printed on both sides, as for as possible.

(ii) All documents should be properly indexed, page numbered.

(iii) Period/date of data collection should be clearly indicated.

(iv) Authenticated English translation of all material provided in Regional languages.

(v) The letter/application for EC should quote the MoEF&CC File No. and also attach a copy of the letter prescribing the ToR.

(vi) The copy of the letter received from the Ministry on the ToR prescribed for the project should be attached as an annexure to the final EIA-EMP Report.

(vii) The final EIA-EMP report submitted to the Ministry must incorporate the issues mentioned in ToR and that raised in Public Hearing. The index of the final EIA-EMP report, must indicate the specific chapter and page no. of the EIA-EMP Report where the specific ToR prescribed by the Ministry and the issue raised in the Public Hearing have been incorporated. Questionnaire related to the project (posted on MoEF&CC website) with all sections duly filled in shall also be submitted at the time of applying for EC.

(viii) Grant of ToR does not mean grant of EC.

(ix) The status of accreditation of the EIA consultant with NABET/QCI shall be specifically mentioned. The consultant shall certify that his accreditation is for the sector for which this EIA is prepared.

(x) On the front page of EIA/EMP reports, the name of the consultant/consultancy firm along with their complete details including their accreditation, if any shall be indicated. The consultant while submitting the EIA/EMP report shall give an undertaking to the effect that the prescribed ToRs (ToR proposed by the project proponent and additional ToR given by the MoEF&CC) have been complied with and the data submitted is factually correct (Refer MoEF&CC Office memorandum dated 4th August, 2009).

(xi) While submitting the EIA/EMP reports, the name of the experts associated with/involved in the preparation of these reports and the laboratories through which the samples have been got analysed should be stated in the report. It shall clearly be indicated whether these laboratories are approved under the Environment (Protection) Act, 1986 and the rules made there under (Please refer MoEF&CC Office Memorandum dated 4th August, 2009). The project leader of the EIA study shall also be mentioned.

(xii) All the ToR points as presented before the Expert Appraisal Committee (EAC) shall be covered.

7. The above ToR should be considered for the project 'Integrated Urban Regeneration and water Transport System (IURWTS)' in Cochin by M/s Kochi Metro Rail Limited, in addition to all the relevant information as per the 'Generic Structure of EIA' given in 'Appendix III' and 'IIIA' of the EIA Notification, 2006.

8. The project proponent shall submit the detailed final EIA Report and EMP prepared as per above ToR to the Ministry for considering the proposal for Environmental Clearance within four years as stipulated in amendment notification No. S.O. 751(E) dated 17.02.2020.

9. As per amendment notification No. 648(E) dated 03.03.2016, the Environmental consultant organizations which are accredited for a particular sector and the category of project for that sector with the Quality Council of India (QCI) or National Accreditation Board for Education and Training (NABET) or any other agency as may be notified by the Ministry

of Environment, Forest and Climate Change from time to time shall be allowed to prepare the EIA Report and EMP of a project and appear before the concerned EAC. The consultants involved in preparation of EIA Report would need to include a certificate in this regard in the EIA report and EMP prepared by them and details for data provided by other Organization(s)/ Laboratories including their status of approvals etc.

10. The prescribed Terms of Reference (ToR) would be valid for a period of four years from the date of issue.

11. This issues with the approval of the Competent Authority.

(Dr. Vinod K. Singh)
Scientist E

<u>Copy to:</u>

The Member Secretary, Kerala State Pollution Control Board, Pattom P.O., Thiruvananthapuram - 695 004, Kerala.

Annexure

7(e): STANDARD TERMS OF REFERENCE FOR CONDUCTING ENVIRONMENT IMPACT ASSESSMENT STUDY FOR PORTS, HARBOURS AND INFORMATION TO BE INCLUDED IN EIA/EMP REPORT

i. Reasons for selecting the site with details of alternate sites examined/rejected/ selected on merit with comparative statement and reason/basis for selection. The examination should justify site suitability in terms of environmental angle, resources sustainability associated with selected site as compared to rejected sites. The analysis should include parameters considered along with weightage criteria for short-listing selected site.

ii. Details of the land use break-up for the proposed project. Details of land use around 10 km radius of the project site. Examine and submit detail of land use around 10 km radius of the project site and map of the project area and 10 km area from boundary of the proposed/existing project area, delineating project areas notified under the wild life (Protection) Act, 1972/critically polluted areas as identified by the CPCB from time to time/notified eco-sensitive areas/interstate boundaries and international boundaries. Analysis should be made based on latest satellite imagery for land use with raw images.

iii. Submit the present land use and permission required for any conversion such as forest, agriculture etc. land acquisition status, rehabilitation of communities/ villages and present status of such activities.

iv. Examine and submit the water bodies including the seasonal ones within the corridor of impacts along with their status, volumetric capacity, quality likely impacts on them due to the project.

v. Submit a copy of the contour plan with slopes, drainage pattern of the site and surrounding area.

vi. Submit the details of terrain, level with respect to MSL, filling required, source of filling materials and transportation details etc.

vii. Examine road/rail connectivity to the project site and impact on the existing traffic network due to the proposed project/activities. A detailed traffic and transportation study should be made for existing and projected passenger and cargo traffic.

viii. Submit details regarding R&R involved in the project.

ix. Submit a copy of layout superimposed on the HTL/LTL map demarcated by an authorized agency on 1:4000 scale along with the recommendation of the SCZMA.

x. Submit the status of shore line change at the project site

xi. Details of the layout plan including details of channel, breakwaters, dredging, disposal and reclamation.

xii. Details of handling of each cargo, storage, transport along with spillage control, dust preventive measures. In case of coal, mineral cargo, details of storage and closed conveyance, dust suppression and prevention filters.

xiii. Submit the details of fishing activity and likely impacts on the fishing activity due to the project. Specific study on effects of construction activity and pile driving on marine life.

xiv. Details of oil spill contingency plan.

xv. Details of bathymetry study.

xvi. Details of ship tranquillity study.

xvii. Examine the details of water requirement, impact on competitive user, treatment details, use of treated waste water. Prepare a water balance chart.

xviii. Details of rainwater harvesting and utilization of rain water.

xix. Examine details of Solid waste generation treatment and its disposal.

xx. Details of desalination plant and the study for outfall and intake.

xxi. Examine baseline environmental quality along with projected incremental load due to the proposed project/activities.

xxii. The air quality monitoring should be carried out according to the notification issued on 16th November, 2009.

xxiii. Examine separately the details for construction and operation phases both for Environmental Management Plan and Environmental Monitoring Plan with cost and parameters.

xxiv. Submit details of a comprehensive Risk Assessment and Disaster Management Plan including emergency evacuation during natural and man-made disasters

xxv. Submit details of the trees to be cut including their species and whether it also involves any protected or endangered species. Measures taken to reduce the number of the trees to be removed should be explained in detail. Submit the details of compensatory plantation. Explore the possibilities of relocating the existing trees.

xxvi. Examine the details of afforestation measures indicating land and financial outlay. Landscape plan, green belts and open spaces may be described. A thick green belt should be planned all around the nearest settlement to mitigate noise and vibrations. The identification of species/ plants should be made based on the botanical studies.

xxvii. The Public Hearing should be conducted for the project in accordance with provisions of Environmental Impact Assessment Notification, 2006 and the issues raised by the public should be addressed in the Environmental Management Plan. The Public Hearing should be conducted based on the ToR letter issued by the Ministry and not on the basis of Minutes of the Meeting available on the web-site.

xxviii. A detailed draft EIA/EMP report should be prepared in accordance with the above additional TOR and should be submitted to the Ministry in accordance with the Notification.

xxix. Details of litigation pending against the project, if any, with direction /order passed by any Court of Law against the Project should be given.

xxx. The cost of the Project (capital cost and recurring cost) as well as the cost towards implementation of EMP should be clearly spelt out.

xxxi. Any further clarification on carrying out the above studies including anticipated impacts due to the project and mitigative measure, project proponent can refer to the model ToR available on Ministry website "http://moef.nic.in/Manual/Port and harbour".

*****

ANNEXURE-II
ToR Compliances

Sl. No.	TOR points	Reply
1.	Importance and benefits of the project	This aspect has been covered in Chapter-8 of EIA Report
2.	Submit a copy of layout superimposed on the HTL/LTL map demarcated by an authorized agency on 1:4000 scale	Attached as Annexure-IV
3.	Recommendation of the SCZMA	-
4.	Status of NBWLclearance	Under progress. Application No: FP/KL/Others/5034/2020 Dt.27.04.2020.
5.	Jetties along with their location and capacities; proposed and existing, ifany	Details are given in Section-2.9. The location of the jetties is given in Table-2.3 & Figure-2.2.
6.	Study impacts of dredging on the canal bank.	Only deepening work is envisaged as the part of project. Bank protection measures are suggested as part of the project.
7.	Detailed impact analysis of rock dredging, ifrequired.	No rock dredging is involved in this project.
8.	Study the impact of dredging and dumping on marine ecology and draw up a management plan through the NIO or any other institute specializing in marine ecology	The study was conducted by Department of Marine Biology, Microbiology & Biochemistry, School of Marine Sciences, Cochin University of Science & Technology (CUSAT) during September 2020 to November 2020 and given in Section-7.4 of chapter-7 of EIA Report.
9.	A detailed analysis of the physico-chemical and biotic components in the highly turbid waters round the project site (as exhibited in the Google map shown during the presentation), compare it with the physico-chemical and biotic components in the adjacent clearer (blue) waters both in terms of baseline and impact assessment and draw up a management plan.	The detailed analysis of the physico-chemical and biotic components section 3.14 of chapter-3 of EIA Report.
10.	Details of Emission, effluents, solid waste and hazardous waste generation and their management in the existing and proposed facilities.	The details 4.3 of chapter-4.
11.	Requirement of water, power/energy, along with their respective sources of supply; status of approval from concerned local authorities, water balance diagram, man- power requirement regular and contract).	The details 4.3 of chapter-4. The Consent to Establish from Kerala Pollution control Board Obtained and given in Appendix-4.
12.	Details of Environmental MonitoringPlan.	This details are given in Chapter-6 of EIA Report
13.	Detailed Environmental Management Plan including	This details are given in Chapter-10 of EIA Report. Generic EMP for IURWTS

Sl. No.	TOR points	Reply
	institutionalarrangements.	project along with institutional arrangement given in Table-10.9.
14.	To prepare a detailed biodiversity impact assessment report and management plan through the NIOS or any other institute of repute on marine, brackish water and fresh water ecology and biodiversity. The report shall study the impact on the rivers, estuary and the sea and include the intertidal biotopes, corals and coral communities, molluscs, sea grasses, sea weeds, subtidal habitats, fishes, other marine and aquatic micro, macro and mega flora and fauna including benthos, plankton, turtles, birds etc. as also the productivity. The data collection and impact assessment shall be as per standard survey methods.	Marine Biodiversity study was conducted by Department of Marine Biology, Microbiology & Biochemistry, School of Marine Sciences, Cochin University of Science & Technology (CUSAT) during September 2020 to November 2020and summary is covered in section 3.14 of chapter-3 and Section-7.4 of chapter-7 of EIA Report.
15.	Disaster Management Plan for the above terminal	This aspect has been covered in section 7.5 of chapter-7 of EIA Report.
16.	Flood management plan with worst case scenarios like recent floods in Kerala through modelling study for rivers/estuaries including its connection to sea through nationalinstitute.	This aspect has been covered in section 7.3 of chapter-7 of EIA Report and attached as Annexure-V.
17.	Management of contaminated excavated material from the waterways and its disposal.	Based on analysis of the samples, it can be concluded that the sediments are not toxic in-situ, and will not become so even after the disposal. The analysis report by KEIL is attached as Appendix-5.
18.	Layout plan of existing and proposed Greenbelt	The details of Green belt is covered in the Section-10.3.7 of Chapter-10.
19.	Status of litigation pending against the project and/or any direction/order passed by any Court of Law against the project; If so, the details thereof shall also be included. Has the unit received any notice under the Section 5 of Environment (Protection) Act, 1986 or relevant Sections of Air and Water Acts? If so, details thereof and compliance/ATR to the notice(s) and present status of thecase.	Nil
20.	Submit an affidavit signed by authorized representative to the effect that there is no violation and no part of the project has been implemented without Environmental	Attached as Appendix-1.

Sl. No.	TOR points	Reply
	Clearance.	
21.	Plan for Corporate Environment Responsibility (CER), as specified in this Ministry's Office Memorandum No. 22-65/2017-IA.III dated 1stMay, 2018, shall be prepared and submitted along with EIAReport.	The details of Corporate Environment Responsibility (CER)is covered in the Section-10.5 of Chapter-10.
22.	Public hearing is to be conducted. Issues raised during public hearing and commitments made by the project proponent on such issues should be included in final EIA/EMP Report in the form of tabular chart with financial budget for complying with suchcommitments.	-
23.	A tabular chart with index for point wise compliance of above TORs	Enclosed as Annexure-II

भारतीय गैर न्यायिक

एक सौ रुपये Rs. 100

रु. 100 ONE HUNDRED RUPEES

सत्यमेव जयते

भारत INDIA

INDIA NON JUDICIAL

കേരളം केरल KERALA

CR 085370

AGREEMENT No: KMRL – IURWTS - 04

THIS AGREEMENT entered into on this, the 23rd day of December, Two Thousand and Twenty between,

M/s KERALA ENVIRO INFRASTRUCTURE LIMITED, CIN No U24129KL2005PLC017973, a company registered under the Companies Act, 1956 and having its registered office at FACT-CD Campus, Ambalamedu - 682 303, Kochi, Kerala, India, and currently represented by its CEO, Dr. N Kunjikrishna Pillai hereinafter referred to as "KEIL", which the expression shall, unless otherwise repugnant to the context, shall mean and include all its successors-in-interest, and permitted assignees etc.) of the first part.

and

Kochi Metro Rail Ltd., a Company registered under The Companies Act, 1956 and having its Corporate Office at 4th Floor, JLN Stadium Metro Station, Banerji Road, Ernakulam - 682017, represented by its Director (Projects), Sri. Thiruman Archunan, (hereinafter referred to as 'the KMRL', which the expression shall, unless otherwise repugnant to the context, shall mean and include all its successors-in-interest, and permitted assignees etc.) of the other part

For the purpose of this agreement both KEIL and KMRL are collectively called "Parties" and individually called "Party".

Kochi Metro Rail Ltd Pin-682 017 Kochi

Dr. N.K. PILLAI
Chief Executive Officer
Kerala Enviro Infrastructure Ltd.
Ambalamedu - 682 303

M. P. PADMANABHAN
High Court Stamp Vendor

DISTRICT STAMP DEPOT 11 MAR 2020 ERNAKULAM

Kochi Metro Rail Ltd
Ernakulam

भारतीय गैर न्यायिक

एक सौ रुपये Rs. 100

रु. 100 ONE HUNDRED RUPEES

सत्यमेव जयते

भारत INDIA

INDIA NON JUDICIAL

കേരളം केरल KERALA CR 085371

WHEREAS KEIL is a public limited company which was established on the directive of Supreme Court Monitoring Committee on hazardous waste for treatment and disposal of hazardous waste generated from industries in the state of Kerala. Govt. of Kerala appointed Kerala State Industrial Development Corporation (KSIDC) as nodal agency for setting up a Common Hazardous Waste Treatment, Storage and Disposal Facility (CHWTSDF) for management of hazardous waste in the State of Kerala. KSIDC established KEIL as a Special Purpose Vehicle with participation of 84 industries in the state.

AND WHEREAS, the foremost and the sole objective of KEIL is to prevent Environmental Pollution Hazards and to observe the existing laws on Environmental and Pollution Control.

WHEREAS KMRL is jointly owned by the Government of India and the Government of Kerala and has been formed with the objective of implementing the construction, operation and maintenance of a Mass Rapid Transit system for the city of Kochi by way of a Metro Rail System. KMRL has been appointed as the Special Purpose Vehicle for implementation of the Integrated Urban Regeneration and Water Transport System (IURWTS) Project vide G.O (Ms) No. 07/2018/CSIND dated 12.11.2018, as per the decision taken by the Government of Kerala.

AND WHEREAS KMRL desires to send its dredge spoil, demolition waste and hazardous solid (hereinafter referred to as `HAZARDOUS WASTE') to the KEIL as per the norms of Kerala State Pollution Control Board (hereinafter referred to as "KS-PCB") and the KEIL having requisite facilities in this behalf, agrees to receive the Hazardous Waste sent by KMRL on the terms and conditions stated hereunder, which have been mutually agreed to by and between KEIL and KMRL.

Kochi Metro Rail Ltd Pin-682 017 Kochi

Dr. N. K. PILLAI
Chief Executive Officer
Kerala Enviro Infrastructure Ltd.
Ambalamedu 682 303

DISTRICT STAMP DEPOT ERNAKULAM 11 MAR 2020

M. R. PADMANABHAN
High Court Stamp Vendor
ERNAKULAM

10879 5
24.06.2020

Kochi Metro Rail Ltd
Ernakulam

NOW THEREFORE, THIS AGREEMENT WITNESSES AS FOLLOWS: -

1. DEFINITIONS AND INTERPRETATIONS:

1.1 `TIME' shall be stated in `Hours' and shall mean Indian Standard Time.

1.2 `DAY' means a period of Twelve (12) consecutive hours beginning at 08.00 hours and ending at 20.00 hours.

1.3 `NIGHT' means a period of Twelve (12) consecutive hours beginning at 20.00 hours and ending at 08.00 hours.

1.4 `WEEK' means a period of seven (7) consecutive days beginning from a day.

1.5 `MONTH' means a period beginning at 0800 hours on the first day of calendar month and ending at 0800 hours on the first day of succeeding calendar month.

1.6 `YEAR' means a period of three hundred and sixty five (365) consecutive days or three hundred and sixty six (366) consecutive days when such period includes a twenty ninth (29th) day of February, beginning at 0800 hours from a day.

1.7 `FINANCIAL YEAR' means a period of three hundred and sixty five (365) consecutive days or three hundred and sixty six (366) consecutive days when such period includes a twenty ninth (29th) day of February, beginning at 0800 hours from first April.

1.8 The headings of or titles to the clauses in this AGREEMENT shall not be deemed to be part hereof or be taken into consideration in the interpretation or construction thereof or of the AGREEMENT.

1.9 Words imparting the singular only also include the plural and vice versa, where the context so requires.

1.10 The present agreement is entered in to by KEIL for collection, storage, treatment and disposal of Hazardous waste of its members.

2. PERIOD OF AGREEMENT & MEMBERSHIP FEES:

2.1 The present Agreement shall come into force from the date it is signed or the date when KMRL is able and prepared to send Transportation Vehicles, whichever is later and that the present Agreement shall remain in force for a period of 5 (five) years, effective from any of the above named dates, whichever is applicable.

2.2 KMRL shall take membership in KEIL by payment of a onetime non-refundable membership fee of **Rs 50,000/-** (plus GST) as applicable to non-stakeholder of KEIL, generating more than 5MT/annum of waste.

Dr. N. K. PILLAI
Chief Executive Officer
Kerala Enviro Infrastructure Ltd.
Ambalamedu - 682 303

Kochi Metro Rail Ltd
Pin-682 017
Kochi

3. EXTENSION PERIOD OF AGREEMENT

3.1 If KMRL wishes to send its Hazardous Waste after the expiry of the present Agreement, it shall give four (4) months advance notice to KEIL of its desire of extended period of facility and KEIL shall consider the request and may, in its absolute discretion, offer terms for the fresh agreement.

Both the parties hereto, after reaching an agreement on the offered terms, shall execute a fresh agreement at least three (3) months before the date of expiry of this agreement.

3.2 Both the parties hereto agree that the present Agreement shall automatically come to an end in any of the following eventualities:

I) On expiry of Authorization granted to KMRL and the same having not been renewed or the same having been not granted by KS-PCB.

II) On expiry of the present Agreement, where no fresh agreement is signed and executed between parties hereto as mentioned above.

III) On Authorization to KEIL being cancelled, refused or not granted by KS-PCB.

3.3. Both the parties hereto further agree that in case of the present Agreement coming to an end owing to any of the aforesaid eventuality, it will be the sole responsibility of the Member to handle and treat its Hazardous Waste in accordance with the relevant provisions of law and that KEIL will not be responsible in any manner whatsoever in respect of the Hazardous Waste of the Members.

4. OBLIGATION OF THE MEMBERS:

4.1. While entering into the present Agreement with KEIL, KMRL shall submit the categories of Hazardous Waste and its desire to dispose off the same and that the said categories of Hazardous Waste shall be as per those specified in the Schedule to Hazardous Waste (Management, Handling & Transboundary movement) Rules 2008 as amended from time to time. KMRL shall also give true and correct information related to the description, amount, nature and toxicity of the said Hazardous Waste as and when called upon by KEIL or KS-PCB.

4.2. KMRL shall get the Authorization from KS-PCB permitting KMRL to send its Hazardous Waste to KEIL for disposal and that it shall be the responsibility of KMRL to get the same renewed from time to time, failing which KEIL reserves its right to repudiate the present Agreement.

4.3. For direct disposal of the toxic / hazardous wastes in the landfill, KMRL shall ensure that the waste is free of toxic materials / heavy metals or Phenols, Cyanides and the waste should meet the accepted criteria for the land filling.

4.4. The waste which cannot be accepted for direct land filling will be subject to required treatment like neutralization, solidification, Stabilization or any other chemical treatment. Based on the requirement and depending on the waste characteristic, KEIL will decide the treatment. KMRL has to bear the treatment cost. The treated waste in such case can be disposed off in the landfill.

4.5. The waste should be kept in the containers specially designed for the transportation of hazardous waste.

Dr. N. K. PILLAI
Chief Executive Officer
Kerala Enviro Infrastructure Ltd.
Ambalamedu - 682 303

Kochi Metro Rail Ltd
Pin-682 017
Kochi

4.6. KMRL shall make all the proper and adequate arrangements for keeping accurate records of dredge spoil and shall keep accurate records of each of its products and Hazardous Waste generated thereof and send the compiled records to KEIL on the fifth (5) day of the succeeding MONTH, whereupon the KEIL shall send the same to KS-PCB.

4.7. KMRL shall be required to maintain the record of Hazardous waste to be disposed off in KEIL site. The said records so maintained shall be open for inspection by KEIL or any officer of KS-PCB or any authority of State (Ministry of Environment and Forests) or any officer appointed by them.

4.8. KMRL shall make adequate and necessary arrangements as approved by and to the satisfaction of the KEIL, KS-PCB or other prescribed Authority under Law for collection and storage of its Hazardous Waste in its premises and shall give access to the Transportation Vehicles / Transportation Vehicles of KEIL to its storage facility during day time.

4.9. Before the Hazardous Waste is delivered at KEIL site, KMRL shall ensure that the said Hazardous Waste is packed and transported in a manner suitable for transportation and that KMRL should see that the said waste withstands physical and climatic conditions.

4.10. If and when an accident occurs during the handling / transportation of Hazardous Waste, KMRL availing facility shall immediately report to KEIL and KS-PCB about the accident.

4.11. KMRL shall be bound to accept the rejected Hazardous Waste, if any, and if it fails to do so, his membership will be terminated.

4.12. During wet period of monsoon season, the Hazardous Waste may not be accepted. KMRL shall create proper temporary storage facility which would include leachate facility or any other facility as provided or approved under the provisions of law.

4.13. KMRL shall create required temporary storage facility (minimum 4 months generation) considering the heavy monsoon in Kerala.

4.14. As far as possible the containers are to be filled in full. Proper arrangements have to be made for lifting the containers. It is to be ensured that once the vehicle containing the waste reaches the KEIL factory, after collection of the wastes, it leaves the premises within one hour.

4.15. KMRL is obliged to intimate KEIL to send containers / hook loader and to dispatch a minimum full load of Hazardous Waste within two hours. In case, if KIEL is sending containers / hook loaders, KIEL is obliged to intimate KMRL to dispatch full load of waste within two hours.

4.16. KMRL is obliged to pay in advance transportation /treatment/disposal/analysis charges in cheque (local account) or demand draft or online bank transfer.

4.17. KEIL may by a notice served on KMRL require him to provide such additional information as may be specified in the notice and KMRL shall send the information to KEIL within 15 days from the receipt of the said notice.

4.18. KMRL declares that KMRL alone shall be liable for any action initiated against KMRL under Hazardous Wastes (Management, Handling & Transboundary Movement) Rules,

Dr. N. K. PILLAI
Chief Executive Officer
Kerala Enviro Infrastructure Ltd.
Ambalamedu - 682 303

Kochi Metro Rail Ltd
Pin-682 017
Kochi

2008 or any other Pollution Laws or any other relevant provisions of Law for the time being in force, by KS-PCB or any other Authority.

4.19. KMRL shall comply with the provisions of Environment (Protection) Act, 1986 and the Rules made thereunder as also with the conditions of present agreement and that any breach committed thereunder shall render KMRL not eligible for disposing of Hazardous Waste in KEIL.

5. QUANTITY & QUALITY

5.1. The Hazardous Waste to be sent by KMRL to KEIL shall be as per the categories specified in the schedule to Hazardous Waste (Management, Handling & Transboundary Movement) Rules, 2008 or as per any new amendment or rules under the above Act.

5.2. KMRL shall not send for direct landfilling in any case any Hazardous Waste containing Hexavalent Chromium, heavy metals, phenols, cyanides or any other toxic materials in concentration as specified in the Clause 5.3 or that may be notified by KEIL from time to time. However, such wastes may be accepted for treatment and disposal with extra charges for treatment which can be assessed only after analyzing and evaluating a sample of the waste.

5.3. The following listed wastes will not be accepted by KEIL.

i) Waste which is fluid, slurry, paste or acidic.
ii) Waste which has an obnoxious odour.
iii) Waste which reacts with moisture to produce considerable amount of heat or gases.
iv) Waste which is inflammable. (except for incineration)
v) Waste which contains shock sensitive substances.
vi) Waste which contains volatile substances of significant toxicity.
vii) Waste which contains more than 10 mg / kg chromate in the original sample.
viii) Waste which contains more than 10 mg / Kg. of Water-soluble Arsenic in a 1/10 elute.

5.4. All toxic wastes from pesticide industries shall be incinerated before sending to KEIL site. The waste shall not contain any acidity.

5.5. KEIL may reject the Hazardous Waste in total, if KMRL's above mentioned Hazardous Waste is found not to be in according with the conditions mentioned in clause -5 of this AGREEMENT and the decision of KEIL in rejecting the Hazardous Waste for non-compliance of the provisions of the present clause of this Agreement will be final and it will not be called in question and KMRL shall have to pay the extra amount which shall be charged by KEIL for expenditure incurred in analyzing, transporting and returning the rejected Hazardous Waste.

6. TRANSPORTATION

6.1. Transport of Hazardous Waste shall be in accordance with the provisions of Rules issued by the Central Government under Motor Vehicle Act, 1988 and other guidelines issued from time to time and/or subject to the provisions of law for the time being in force.

6.2. If transportation of materials is arranged by KEIL, the charges will be applicable as mentioned in **Annexure_I** (Detailed Rates for Disposal)

Dr. N. K. PILLAI
Chief Executive Officer
Kerala Enviro Infrastructure Ltd.
Ambalamedu - 682 303

Kochi Metro Rail Ltd
Pin-682 017
Kochi

7. **BILLING AND PAYMENT OF DISPOSAL CHARGES.**

7.1. The sample of the Hazardous waste will be drawn from the supply and will be got analyzed by KEIL Laboratory or Laboratory approved by KEIL. The charges for analysis will be borne by KMRL.

7.2. KMRL shall pay to KEIL the charges for disposing of its Hazardous Waste as may be notified by KEIL by cheque / Demand Draft / online transfer in advance.

7.3. Both the parties here by agree that **Annexure – I** (Detailed Rates for Disposal) form an integral part of this agreement and this agreement together with Annexure – I shall constitute the contract between the parties.

7.4. KEIL shall charge KMRL on the basis of weighment to be done at disposal site. If the Weigh Bridge at disposal site is not working, it will be weighed at outside weigh Bridge approved by KEIL.

7.5. KMRL shall be bound by the analysis results / reports of KEIL for treatment and disposal charges and shall not call the same in question for any reason whatsoever.

8. **DEFAULT**

8.1. If KMRL fails and / or defaults in the discharge of any of his obligations under the present Agreement, KEIL shall have discretion to (i) refuse to accept the Hazardous Waste of KMRL for disposal without assigning any reason, (ii) notify to the KS-PCB the name of KMRL informing about such default and that its Hazardous Waste would not be taken for disposal by KEIL on account of such default, (iii) inform KMRL that its Hazardous Waste would be deemed to cause pollution and that KMRL be liable as polluter under the Pollution Laws.

8.2. KEIL reserves its right to accept or refuse membership. In event of KMRL committing any breach / violation of the conditions of the present Agreement or any provisions of Law / Act / Rules for the time being in force, KEIL reserves its right to suspend / cancel the membership for such period as it deems fit without giving any reasons or prior notice.

8.3. Where an offense under the Environment Protection Act has been committed by KMRL or is attributable to any neglect on the part of KMRL which shall include its Contractor, Partner, etc. and if such Member is guilty of the offense or is liable to be prosecuted against and punished and no suit, prosecution or legal proceeding(s) shall lie against KEIL for the offense committed by its Member. On the other side, if an offense under the Environment Protection Act has been committed by KEIL or is attributable to any neglect on the part of KEIL which shall include its Contractor, Partner, etc. and if such Member is guilty of the offense or is liable to be prosecuted against and punished and no suit, prosecution or legal proceeding(s) shall lie against KMRL for the offense committed by its Member.

8.4. KEIL reserves its right to issue a show cause notice to KMRL if it is of the opinion that KMRL has contravened the provisions of law / conditions of the present Agreement, requiring KMRL to remedy the contravention or as the cause may be, within a specific

Dr. N. K. PILLAI
Chief Executive Officer
Kerala Enviro Infrastructure Ltd.
Ambalamedu - 682 303

Kochi Metro Rail Ltd
Pin-682 017
Kochi

period of time. The said notice served shall specify the measures to be taken by KMRL in remedying the said contravention.

8.5. KEIL shall inform the Kerala State Pollution Control Board / KSIDC of the suspension of any MEMBER.

8.6. The suspension / termination shall be revoked only at sole discretion of KEIL after it is satisfied that its conditions have been met.

9. **TRANSFER OF RIGHTS**

9.1. KEIL may at any time transfer or assign its rights and obligations under the AGREEMENT to any other company or business concern by giving notice in writing to KMRL. Upon such transfer or assignment, only the transferee or assignee shall be liable for the obligations herein contained.

10. **INDEMNITIES:**

10.1. KMRL shall be deemed to be in exclusive possession and control of the said Hazardous Waste and shall be fully liable and responsible for its arrangements, appurtenances and properties before the Transportation Vehicles / Transportation Vehicles of KEIL leave the premises of KMRL. Accordingly KMRL hereby covenants and agrees to fully protect, indemnify and hold KEIL, its employees, agents & successors and assignees harmless against any and all claims, demands, actions, suits, proceedings and judgments and any and all liabilities, costs, expenses, damages or losses arising out of or resulting from or incidental to or in connection therewith, which may be made out against KEIL, whether by KMRL its employees, agents or successors and assignees or by third parties on account of damages or injury to property or loss of life resulting from or arising out of the installation, presence, maintenance or operation or the intake arrangements, appurtenances and properties of KMRL.

10.2. It is also agreed by and between KEIL and KMRL that KEIL is not and shall not be liable in any manner whatsoever due to any negligence and for any reason or otherwise of KMRL, in disposing its Hazardous Waste at the IURWTS project site of KMRL or at any other place.

10.3. KEIL and Members will share any liability arising out of the existence and operation of the facility in proportion to the quantity of waste supplied by each member. Public liability Insurance will be taken for the facility.

11. **FORCE MAJEURE**

11.1. In case of any force majeure, neither parties shall be saddled with any liability - contingent during the force majeure duration.

11.2. Both the parties hereto agree that due to change in any laws related to pollution or due to any directive of any Court or Authority, if KEIL is to incur any additional financial burden consequent upon any alteration and / or modification in the site or because of any other reason, then, in that case KMRL shall be liable to contribute for the same proportionate to its disposal of Hazardous Waste quantity in KEIL site.

Dr. N. K. PILLAI
Chief Executive Officer
Kerala Enviro Infrastructure Ltd.
Ambalamedu - 682 303

Kochi Metro Rail Ltd
Pin-682 017
Kochi

11.3. Both the parties hereto agree that in any event of there being order in form of any injunction, stay or otherwise from any Court, KS-PCB or any other Authority stopping the functioning of the Site or otherwise whereby KEIL becomes unable to accept the Hazardous Waste of KMRL, KEIL shall not be responsible or made responsible and / or

be liable in any manner in that regard and that in such an eventuality, it shall be the responsibility of KMRL to get the needful done in respect of disposal of its Hazardous Waste.

12. PREVIOUS CORRESPONDENCE:

12.1. All discussions and meetings held and correspondence exchanged between KEIL and KMRL in respect of the AGREEMENT and any decisions arrived at therein in the past and before the coming into force of the present AGREEMENT are herein superseded by the present AGREEMENT and no reference of such discussions or meetings or past correspondence shall be entertained by either KEIL or KMRL for interpreting the present AGREEMENT or otherwise.

13. LAWS GOVERNING THE AGREEMENT

13.1. The present Agreement shall be subject to Indian Laws, rules and regulations and notifications etc. issued under such laws.

14. AMENDMENTS:

14.1. KEIL may at any point of time make suitable changes in the present Agreement after serving a notice to KMRL and only with the concurrence of KMRL.

15. TERMINATION OF AGREEMENT

15.1. M/s. KEIL has the unrestricted right to terminate this AGREEMENT and deduct its all pending claims from the deposit paid by KMRL.

15.2. This AGREEMENT can be terminated by either party after giving a written notice of at least 90 days to the other party. If the cancellation is requested by KMRL, the provision relating to minimum charges shall be applicable, also during the notice period.

15.3 As per Section 8 of Hazardous and Other Wastes (Management and Transboundary Movement) Rules 2016, the generators of hazardous waste are authorised to store the hazardous and other wastes for a period not exceeding ninety days and shall maintain a record of sale, transfer, storage, recycling, recovery, pre-processing, co-processing and utilisation of such wastes and make these records available for inspection:

Provided that the State Pollution Control Board may extend the said period of ninety days in following cases, namely:-

(i) small generators (up to ten tonnes per annum) up to one hundred and eighty days of their annual capacity;

(ii) actual users and disposal facility operators up to one hundred and eighty days of their annual capacity,

(iii) occupiers who do not have access to any treatment, storage, disposal facility in the concerned State; or

Dr. N. K. PILLAI
Chief Executive Officer
Kerala Enviro Infrastructure Ltd.
Ambalamedu - 682 303

Kochi Metro Rail Ltd Pin-682 017 Kochi

(iv) the waste which needs to be specifically stored for development of a process for its recycling, recovery, pre-processing, co-processing or utilisation;

(v) in any other case, on justifiable grounds up to one hundred and eighty days.

If KMRL fails to comply with the above stipulation, KEIL has the right to levy minimum charges from KMRL or to terminate their membership in KEIL.

In case after termination of membership, if KMRL desires to shift the waste generated in its unit for disposal in KEIL at a later date, KMRL has to avail a fresh membership completing necessary formalities.

16. **JURISDICTION**

16.1. The arbitration shall be conducted either by the Secretary heading the Law Department of the State Government or by an Addl. Secretary of the Law Department nominated by the Secretary heading the Law Department. The Arbitration shall be conducted as per and in accordance with the Arbitration and Conciliation Act, 1996.

16.2. The place and seat of arbitration shall be Ernakulam.

16.3. The address of the parties hereto unless changed by written notification to be given at least 15 days in advance by registered letter prior to proposed date of change, shall be as follows:

ADDRESSES OF PARTIES:

M/S.KERALA ENVIRO INFRASTRUCTURE LTD.,
(Inside FACT CD Campus)
Ambalamedu – 682 303,
Kochi, Kerala, India.

KOCHI METRO RAIL LIMITED
Corporate Office,
4th Floor, JLN Stadium Metro Station,
Banerji Road, Ernakulam – 682017
Kerala, India

Dr. N. K. PILLAI
Chief Executive Officer
Kerala Enviro Infrastructure Ltd.
Ambalamedu - 682 303

Kochi Metro Rail Ltd
Pin-682 017
Kochi

In **WITNESS WHEREOF,** both the parties hereto have set their hands and signature on the day, month and year first above mentioned.

Signed and delivered
for and on behalf of **KEIL**, First Party

Dr. N. K. PILLAI
Chief Executive Officer
Kerala Enviro Infrastructure Ltd
Ambalamedu - 682 303

KERALA ENVIRO INFRASTRUCTURE LTD. AMBALAMEDU 682 303 T.S.D.F PROJECT

Dr. N Kunjikrishna Pillai

Chief Executive Officer, **KEIL**

Signed and delivered
for and on behalf of the **KMRL**, Second Party

Sri. Thiruman Archunan

Director (Projects), **KMRL**

In the presence of the following witnesses

1. C. Balagopal.
2. Tony James 28/12/2020
3. Cherian George

Kochi Metro Rail Ltd Pin-682 017 Kochi

Annexure – I

Detailed Rates for Disposal

Dr. N. K. PILLAI
Chief Executive Officer
Kerala Enviro Infrastructure Ltd.
Ambalamedu - 682 303

Kochi Metro Rail Ltd
Pin-682 017
Kochi

Disposal Rates at KEIL

Sl No:	Activity	Rate * (Rs. / MT)	Remarks
	Disposal Materials with Ordinary Soil/Silt Properties		
1	Disposal Quantity greater than 500 MT/Annum	nil	
	Disposal Materials with Hazardous Properties		
2	Disposal Quantity less than 500 MT/Annum	1872.00	
3	Disposal Quantity 501 – 2000 MT/Annum	1796.00	
4	Disposal Quantity 2001 – 5000 MT/Annum	1718.00	
5	Disposal Quantity greater than 5000 MT/Annum	1560.00	
6	Transportation Charges (if arranged by KEIL)	8.4 per km per MT	
7	Transportation charges (if arranged by KEIL - Upto 45 Km to and fro – rate per trip basis) one trip per day per vehicle two or more trip per day per vehicle	9502 per trip 4751 per trip	

Note:-

(i) * - To be revised on Annual basis and will be linked to the wholesale price index published by the office of Economic Advisor, Government of India and annual variation in consumer price index published by Labour department, Government of India

(ii) The Commercial charges given as above are the prevailing charges and these are liable to undergo revision based on the decision of the Director Board of KEIL.

Dr. N. K. PILLAI
Chief Executive Officer
Kerala Enviro Infrastructure Ltd.
Ambalamedu - 682 303

Kochi Metro Rail Ltd
Pin-682 017
Kochi

(iii) Regarding transportation charges, if KEIL is arranging the transportation, minimum one truck load (9/12 Ton) or actual weight whichever is higher, will be taken for billing and for shorter distance lump sum rate per trip per vehicle will be charged.

(iv) KMRL shall pay to KEIL the charges for disposing of its Hazardous Waste as may be notified by KEIL by cheque or Demand Draft or Online Transfer in advance.

(v) The concessional slab rates are applicable only after reaching the specified quantity in the immediate previous slab.

Dr. N. K. PILLAI
Chief Executive Officer
Kerala Enviro Infrastructure Ltd.
Ambalamedu - 682 303

Kochi Metro Rail Ltd
Pin-682 017
Kochi

ANNEXURE-IV

RESTRICTED DOCUMENT **REF NO. AU/IRS/RM/208-2020-REV DT 20.12.2021 (19.12.2020)**

PREPARATION OF LOCAL LEVEL COASTAL REGULATION ZONE MAP FOR THE PROPOSED PROJECT "INTEGRATED URBAN REGENERATION AND WATER TRANSPORT SYSTEM (IURWTS)" IN COCHIN, KERALA STATE BY SUPERIMPOSING ON APPROVED CZMP AS PER CRZ NOTIFICATION 2011

For

Proponent
Kochi Metro Rail Limited (KMRL)
JLN Metro Station, 4th Floor,
Kaloor, Ernakulam-682017

Consultant
WAPCOS Limited
76-C, Institutional Area, Sector-18,
Gurgaon – 122 015
Haryana

Prepared by

PROGRESS THROUGH KNOWLEDGE

INSTITUTE OF REMOTE SENSING
ANNA UNIVERSITY, CHENNAI-25

DECEMBER 2021

CONTENTS

Executive Summary

On the request of M/s WAPCOS Limited, 76-C, Institutional Area, Sector-18, Gurgaon – 122 015, Haryana (Consultant for M/s Kochi Metro Rail Limited (KMRL), JLN Metro Station, 4th Floor, Kaloor, Ernakulam-682017), a study was carried out to prepare local level CRZ map in 1:4,000 scale for the proposed project "Integrated Urban Regeneration and Water Transport System (IURWTS)" in Cochin, Kerala State by superimposing on approved CZMP as per CRZ notification, 2011. The satellite imagery of the project area was interpreted for topographic and geomorphic features in the vicinity of the project site. The project site falls in the vicinity of Arabian sea.

The HTL and LTL along with setback lines as per approved CZMP (Map Nos. KL 31, 32, 34 & 35) vide CRZ Notification 2011 were superimposed on to georeferenced cadastral map to prepare a local level CRZ map in 1:4,000 scale. The layout of the proposed project sites in Cochin, Kerala State as provided by the client has also been superimposed on the CRZ maps. The co-ordinates of the HTL derived from approved CZMP at 1:25,000 scale in WGS84 system are presented in the Annexure-I and local level in CRZ maps 1:4,000 scale with the location of project sites as per approved CZMP vide CRZ Notification 2011 are furnished in separately.

The CRZ details of the proposed project components (construction of Sewage Treatment Plant (STP), Jetty, Sewer Line Laying, Canal Bank Beautification, Bridge, Foot Bridge, Reconstruction of Existing Bridge, Walkway, Approach Road and Deepening & Widening of Canals along 5 canals (Chilavanoor canal, Edapally canal, Market canal, Thevara canal and Thevara Perundoor canal) in Cochin City are presented in this report.

Project Data Sheet	
Title	Preparation of local level CRZ map for the proposed project "Integrated Urban Regeneration and Water Transport System (IURWTS)" in Cochin, Kerala State by superimposing on Approved CZMP as per CRZ notification, 2011
Project Ref No.	AU/IRS/RM/208 -2020 DT. 19.12.2020
Funded by	WAPCOS Limited, 76-C, Institutional Area, Sector-18, Gurgaon – 122 015, Haryana (Consultant for Kochi Metro Rail Limited (KMRL), JLN Metro Station, 4th Floor, Kaloor, Ernakulam-682017)
Principal Consultant	Dr.R.Murugasan
Field Survey and Mapping	Mr.S.Inbarasan, Skilled Assistant Grade-I Mr.N.Sathiyanarayanamurthy, Field Assistant Mr.J.Premkumar, Project Staff Mr.V.Chinna Anandh, Project Staff
Report Preparation	Dr.R.Murugasan
Quality Assessment Team	Dr.R.Vidhya, Professor Dr.K.Srinivasa Raju, Professor Mrs.M.Navamuniyammal, Assistant Professor

The Quality Assessment Committee for consultancy projects has scrutinized the local level CRZ map and corresponding text report of the above project on 13.01.2021.The principal consultant of the project has presented the approach adopted and findings of the study to the committee. The committee has evaluated the CRZ Maps and the report for different parameters against the standards prescribed for the mapping. The positional accuracy, attribute accuracy, completeness and semantic accuracy of the output were assessed and found satisfactory. The committee recommends the approval of the maps and associated report.

Dr.R.Murugasan
Principal Consultant

Dr.R.Vidhya **(QAC Member)**	**Dr.K.Srinivasa Raju** **(QAC Member)**	**Mrs.M.Navamuniyammal** **(QAC Member)**

24/1/21

DIRECTOR, IRS

Director
Institute of Remote Sensing
Anna University,
Chennai - 600 025.

List of Tables

List of Tables (Contd...)

1.0 INTRODUCTION

1.1 Coastal Regulation Zone

The coastal zone is the area of interaction between land and sea. The coastal zone of Kerala has a very high concentration of population along with ecologically sensitive areas like mangroves. There is a spurt of developmental activities arising from residential colonies and tourism centres along the coast and in coastal zone. There is a need to protect the coastal environment while ensuring continuing production and development. This zone is extremely vulnerable and has to be managed judiciously striking a balance between ecological and developmental needs.

Government of India has issued a notification during February 1991 for regulating the developments along the coastal stretches of seas, bays, estuaries, creeks, rivers and backwaters which are influenced by tidal action. The land between 500 meters from the High Tide Line (HTL) and the Low Tide Line (LTL) is identified as Coastal Regulation Zone (CRZ). The coastal stretches within CRZ are classified into four categories, namely, Category I (CRZ-I), Category II (CRZ-II), Category III (CRZ-III) and Category IV (CRZ-IV). The notification has also laid down regulations to regulate the various activities in the coastal zone. The Ministry of Environment and Forests, Government of India, has approved a set of CRZ maps on 1:25,000 scale prepared from SPOT satellite imagery. On these maps, zones are demarcated as CRZ I, CRZ II and CRZ III, by Coastal Zone Management Authority.

Coastal Regulation Zone I includes the zone between High Tide Line and Low Tide Line. It also includes the areas that are ecologically sensitive and important, such as national parks/marine parks, sanctuaries, reserve forests, wildlife habitats, mangroves, corals/coral reefs, areas close to breeding and spawning grounds of fish and other marine life, areas of outstanding natural beauty/historically/heritage areas, areas rich in genetic diversity, areas likely to be inundated due to rise in sea level consequent upon global warming and such other areas as may be declared by the Central Government or the concerned authorities at the State/Union Territory level from time to time.

CRZ-II covers the areas that have already been developed up to or close to the shoreline. For this purpose, the "developed area" is referred to as that area within the municipal limits or in other legally designated urban areas which are already substantially built up and have been provided with drainage and approach roads and other infrastructural facilities, such as water supply and sewerage mains.

CRZ-III covers the areas that are relatively undisturbed and those which do not belong to either Category-I or II. These include the coastal zone in the rural areas (developed and undeveloped) and also areas within municipal limits or in other legally designated urban areas which are not substantially built up.

CRZ-IV refers to the coastal stretches in the Andaman and Nicobar, Lakshadweep and small islands other than those designated as CRZ-I, CRZ-II or CRZ-III.

The Ministry of Environment and Forest in the CRZ Notification, 2011 declared the following areas as CRZ and imposed with effect from the date of the notification the restrictions on the setting up and expansion of industries, operations or processes and the like in the CRZ. The areas that are defined as CRZ as per CRZ Notification, 2011 are

(i) The land area from High Tide Line (HTL) to 500 m on the landward side along the sea front.

(ii) CRZ shall apply to the land area between HTL to 100 m or width of the creek whichever is less on the landward side along the tidal influenced water bodies that are connected to the sea and the distance upto which development along such tidal influenced water bodies is to be regulated shall be governed by the distance upto which the tidal effects are experienced which shall be determined based on salinity concentration of 5 parts per thousand (ppt) measured during the driest period of the year and distance upto which tidal effects are experienced shall be clearly identified and demarcated accordingly in the Coastal Zone Management Plans.

(iii) The land area falling between the hazard line and 500 m from HTL on the landward side, in case of seafront and between the hazard line and 100 m line in case of tidal influenced water body. The word 'hazard line' denotes the line demarcated by Ministry of Environment and through the Survey of India taking into account tides, waves, sea level rise and shoreline changes.

(iv) Land area between HTL and Low Tide Line (LTL) which will be termed as the intertidal zone.

(v) The water and the bed area between the LTL to the territorial water limit (12 Nm) in case of sea and the water and the bed area between LTL at the bank to the LTL on the opposite side of the bank, of tidal influenced water bodies.

The Classification of the CRZ is also modified for the purpose of conserving and protecting the coastal areas and marine waters as CRZ - I, CRZ- II, CRZ-III and CRZ-IV. The CRZ-I include the areas that are ecologically sensitive and the geomorphological features which play a role in the maintaining the integrity of the coast like (a) Mangroves(b) Corals and coral reefs and associated biodiversity (c) Sand Dunes (d) Mudflats which are biologically active (e) National parks, marine parks, sanctuaries, reserve forests, wildlife habitats and other protected areas (f) Salt Marshes (g) Turtle nesting grounds (h) Horse shoe crabs habitats (i) Sea grass beds (j) Nesting grounds of birds (k) Areas or structures of archaeological importance and heritage sites and the area between Low Tide Line and High Tide Line. The CRZ-II includes areas that have been developed upto or close to the shoreline. The CRZ-III includes areas that are relatively undisturbed and those do not belong to either CRZ-I or II, which include coastal zone in the rural areas (developed and undeveloped) and also areas within municipal limits or in other legally designated urban areas, which are not substantially built up. The CRZ-IV includes the water area from the Low Tide Line to twelve nautical miles on the seaward side and the water area of the tidal influenced water body from the mouth of the water body at the sea upto the influence of tide which is measured as five parts per thousand during the driest season of the year.

The Ministry of Environment and Forest has also provided guidelines for demarcation of High Tide Line in the CRZ Notification, 2011. As per the guidelines, Cadastral (village) maps in 1:3960 or the nearest scale shall be used as the base maps. HTL and LTL will be demarcated in the cadastral map based on detailed physical verification using coastal geomorphological signatures or features in accordance with the CZM Maps approved by the Central Government. 500 m and 200 m lines shall be demarcated with respect to the HTL.

In order to facilitate the classification of Coastal Regulation Zones, Government of India have approved few agencies/institutions across the country vide Lr. No. J17011/8/92-1A III, dated 10.05.1999 of Ministry of Environment and Forests. Institute of Remote Sensing, Anna University being one of them, has been carrying out HTL and LTL mapping following the guidelines issued by Ministry of Environment & Forests, Government of India.

1.2 Background

M/s WAPCOS Limited, 76-C, Institutional Area, Sector-18, Gurgaon – 122 015, Haryana (Consultant for M/s Kochi Metro Rail Limited (KMRL), JLN Metro Station, 4th Floor, Kaloor, Ernakulam-682017) has requested Institute of Remote Sensing, Anna University to prepare local level CRZ map in 1:4,000 scale for the proposed project "Integrated Urban Regeneration and Water Transport System (IURWTS)" in Cochin, Kerala State by superimposing on approved CZMP as per CRZ notification, 2011. The HTL and LTL for the Sea/Bay/tidal influenced water bodies and ecologically sensitive areas are to be transferred from approved CZMP (Map Nos. KL 31, 32, 34 & 35) at 1:25,000 scale to 1:4,000 scale in the vicinity of the proposed project site. In this context, the proposed project site needs to be evaluated to assess whether it falls under regulations of CRZ Notification, 2011. Hence IRS has taken up the work of superimposing project site on approved CZMP prepared by NCSCM.

1.3 Objectives

The objective of the present study is to examine the site for the proposed project "Integrated Urban Regeneration and Water Transport System (IURWTS)" in Cochin, Kerala State with reference to CRZ Notification, 2011. Keeping in view of the requirements of notification, Institute of Remote Sensing, Anna University under took the project with the following agreed scope of work:

- Transfer of HTL and LTL for Arabian sea / creek indicated in existing approved CZMP as per CRZ Notification, 2011 in the vicinity of the proposed project sites on to georeferenced digital cadastral map.
- Transfer of HTL, LTL for Arabian sea / creek as indicated in approved CZMP in the vicinity of the project site by digitization from approved CZMP at 1:25,000 scale.
- Digitisation of ecologically sensitive entities such as Mangroves, Sand dunes, Turtle breeding grounds etc as indicated on approved CZMP in the vicinity of project site.
- Superimposition of HTL, LTL and ecologically sensitive areas along with the project site on georeferenced cadastral map.
- Preparation of Local Level CRZ Map at 1:4000 scale for the proposed project location.

1.4 Data Products

The satellite images of the study area from web based sources were used for reconnaissance and for analysis of geomorphology of the study area.

Approved CZMP (Map Nos. KL 31, 32, 34 & 35) prepared by NCSCM, MoEFCC, Govt of India as per CRZ Notification 2011 was used as reference for digitization of HTL, LTL and ecologically sensitive area in the vicinity of project site.

1.5 Methodology

The cadastral maps of project site have been used as the base map. The geomorphology of the Coastal Zone has been studied from the temporal medium resolution satellite data. Coastal geomorphologic features and existence of permanent vegetation identified from the satellite imagery were used to transfer the

HTL demarcated by NCSCM on approved CZMP. The approved CZMP was georeferenced using graticules available on the maps.

The cadastral maps of the project area (Cochin City) were digitized from approved CZMP to create a vector dataset of survey polygons in the vicinity of project location. The same is superimposed on satellite imagery to identify the proposed project location. The HTL, LTL and ecologically sensitive areas in the vicinity of project location are digitized from georeferenced approved CZMP. Necessary setback lines (500m / 200 m / 100m / 50 m) from HTL for Arabian Sea / creeks are generated using GIS buffering tool. The zones between LTL, HTL and setback lines are delineated to corresponding CRZ as per CRZ Notification 2011.

2.0 STUDY AREA

2.1 Description of Study Area

The sites for the proposed project "Integrated Urban Regeneration and Water Transport System (IURWTS)" are lying in Cochin City in Kerala State. The proposed project involves the construction of Sewage Treatment Plant (STP), Jetty, Sewer Line Laying, Canal Bank Beautification, Bridge, Foot Bridge, Reconstruction of Existing Bridge, Walkway, Approach Road and Deepening & Widening of Canals. These developments are proposed along 5 canals (Chilavanoor canal, Edapally canal, Market canal, Thevara canal and Thevara Perundoor canal) in Cochin City. The location of proposed developments as provided by the client are shown in CRZ maps.

2.2 Status as per Approved CZMP vide CRZ Notification 2011

The developments proposed along 5 canals (Chilavanoor canal, Edapally canal, Market canal, Thevara canal and Thevara Perundoor canal) in Cochin City in Kerala State are falling in CRZ-IB, CRZ-II, CRZ-IVB and Out of CRZ area as mentioned in Table 1 to Table 25 in para 3,2 of this report as per existing approved CZMP vide CRZ notifications, 2011.

3.0 RESULTS AND CONCLUSIONS

3.1 Results

The cadastral maps of Cochin City in the vicinity of proposed project site were digitized and georeferenced using satellite imagery. The HTL, LTL and ecologically sensitive areas in the vicinity of project site were digitized and superimposed on to cadastral map along with project sites as provided by the client. The project sites were superimposed on to georeferenced cadastral map of Cochin City using coordinates provided by the client. Setback lines (50m/100m/200m/500m) from HTL were generated using GIS to demarcate various CRZ zones as defined in CRZ notification 2011. The HTL co-ordinates in WGS 84 system derived from approved CZMP (Map Nos. KL 31, 32, 34 & 35) are presented in Annexure I. The local level CRZ maps in 1:4,000 scale for the proposed developments along 5 canals (Chilavanoor canal, Edapally canal, Market canal, Thevara canal and Thevara Perundoor canal) in Cochin City, Kerala State by superimposing on approved CZMP as per CRZ notification, 2011 are furnished separately.

3.2 Conclusions

(i) The CRZ details of proposed developments along Chilavanoor canal by superimposing on approved CZMP as per CRZ notification, 2011 are given below (Table 1 to Table 5).

Table 1 CRZ details of proposed deepening and widening (along Chilavanoor canal)

Sl.No.	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
1	CRZ - II	8,762.9	71,367.1
	CRZ - IB	34.9	
	CRZ - IVB	4,703.5	
	Out of CRZ	57,865.8	

PRINCIPAL CONSULTANT

DIRECTOR, IRS

Director
Institute of Remote Sensing
Anna University,
Chennai - 600 025.

Table 2 CRZ details of proposed Jetties (Chilavanoor canal)

Sl.No.	Name of Jetty	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
1	Edappalli Raghavan Pillai Road	Out of CRZ	565.6	565.6
2	Kathrikadavu	Out of CRZ	422.5	422.5
3	Keerthi Nagar	Out of CRZ	568.6	568.6
4	Near Elamakulam Metro Station	CRZ - II	105.5	968.6
		CRZ - IB	863.1	
5	Near JLN Stadium	Out of CRZ	333.3	333.3
6	Near JLN Metro Station	Out of CRZ	176.7	176.7
7	Near National Public School	Out of CRZ	271.7	271.7
8	Jetty SCB Road	CRZ - II	670.4	691.5
		CRZ - IB	21.1	

Table 3 CRZ details of proposed STP location (along Chilavanoor canal)

Sl.No.	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
1	CRZ - II	18,317.1	29,808.9
	CRZ - IB	1,035.4	
	Out of CRZ	10,456.4	

Table 4 CRZ details of proposed sewer line laying area (along Chilavanoor canal)

Sl.No.	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
1	CRZ - II	18,601.4	54,857.3
	CRZ - IB	1,642.8	
	CRZ - IVB	5,944.7	
	Out of CRZ	28,668.4	

PRINCIPAL CONSULTANT

24/1/24

DIRECTOR, IRS

Director
Institute of Remote Sensing
Anna University,
Chennai - 600 025.

Table 5 CRZ details of proposed bridge, foot bridge and existing to be reconstructed (along Chilavanoor canal)

Sl.No.	Proposed bridge / foot bridge / existing to be reconstructed	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
1	Elamakulam Bridge	CRZ - II	357.0	1,137.2
		CRZ - IB	401.9	
		CRZ - IVB	378.3	
2	RCC Road Bridge Geroge Edan Road	Out of CRZ	13.5	13.5
3	BTS Road	Out of CRZ	31.2	31.2
4	Raghavan Pillai Road	CRZ - II	97.4	97.4
5	Chilavanoor Bridge	CRZ - II	49.6	419.5
		CRZ - IVB	369.9	
6	Foot Bridge 2	Out of CRZ	12.4	12.4
7	Foot Over Bridge 12	CRZ - II	17.5	50.9
		CRZ - IVB	33.4	
8	Foot Over Bridge 13	CRZ - II	8.3	25.5
		CRZ - IVB	17.2	
9	Foot Over Bridge 14	CRZ - IVB	50.9	50.9
10	SCB Road Bridge	CRZ - II	63.7	102.5
		CRZ - IVB	38.8	
11	Private Road Bridge	CRZ - II	4.1	19.5
		CRZ - IVB	15.4	
12	St.Sebastien Road Bridge	CRZ - II	4.8	32.5
		CRZ - IVB	27.7	
13	VV Road Freinds Ave Road Bridge	CRZ - IVB	25.2	25.2
14	Railnagar Bridge-2	CRZ - II	66.3	81.0
		CRZ - IVB	14.7	
15	Railnagar Bridge-1	Out of CRZ	43.1	43.1
16	Panorama Residency Road Bridge	Out of CRZ	50.9	50.9
17	Railway Quarters Bridge	Out of CRZ	54.6	54.6
18	Karanakoodam Bridge 1	Out of CRZ	102.4	102.4
19	Karanakoodam Bridge 2	Out of CRZ	69.3	69.3
20	Skyline Bridge	Out of CRZ	75.0	75.0
21	Ima House Bridge	Out of CRZ	66.9	66.9
22	Vyloppilly Lane Bridge	Out of CRZ	30.8	30.8
23	Kent Construction Bridge	Out of CRZ	61.9	61.9
24	Foot Bridge 10	Out of CRZ	18.8	18.8
25	Noel Builders Bridge	Out of CRZ	67.6	67.6

PRINCIPAL CONSULTANT

DIRECTOR, IRS

Director
Institute of Remote Sensing
Anna University,
Chennai - 600 025.

Table 5 (Contd…) CRZ details of proposed bridge, foot bridge and existing to be reconstructed (along Chilavanoor canal)

Sl.No.	Proposed bridge / foot bridge / existing to be reconstructed	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
26	Stadium Complex Gate Bridge	Out of CRZ	23.8	23.8
27	Stadium Gate Bridge	Out of CRZ	34.1	34.1
28	Greenz Villa Bridge	Out of CRZ	19.1	19.1
29	National Public School Road Bridge	Out of CRZ	19.1	19.1
30	Pottakuzhy-Mamngalam Road	Out of CRZ	38.5	38.5
31	Keerthi Nagar Road,Bridge	Out of CRZ	26.8	26.8
32	Foot Bridge 6	Out of CRZ	4.9	4.9
33	RCC Road Bridge	Out of CRZ	37.7	37.7
34	RCC Foot Bridge 7	Out of CRZ	2.3	2.3
35	Keerthi Nagar Extension Bridge	Out of CRZ	21.5	21.5
36	Steel Road Bridge	Out of CRZ	17.6	17.6
37	Foot Bridge 5	Out of CRZ	8.1	8.1
38	Foot Bridge 4	Out of CRZ	36.8	36.8
39	Foot Bridge 3	Out of CRZ	8.9	8.9
40	Anganawadi Foot Bridge	Out of CRZ	5.5	5.5
41	Foot Bridge 1	Out of CRZ	11.7	11.7

(ii) The CRZ details of proposed developments along Edapally canal in Cochin City, Kerala State by superimposing on approved CZMP as per CRZ notification, 2011 are given below (Table 6 to Table 11).

Table 6 CRZ details of proposed Jetties (Edapally canal)

Sl. No.	Name of Jetty	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
1	Muttar Jetty	Out of CRZ	1,876.5	1,876.5
2	Jetty near Pipe Line Bridge	Out of CRZ	736.5	736.5
3	Jetty near Kuzhivelipalam	CRZ - II	591.4	591.4
4	Jetty near Indiraji Bridge	Out of CRZ	1,655.6	1,655.6
5	SPV Office and Jetty near Chembokadavu Bridge	Out of CRZ	4,167.2	4,167.2
6	Jetty Edappaly near LuluMall	Out of CRZ	621.2	621.2
7	Jetty near Chembumukku Bridge	Out of CRZ	819.3	819.3
8	Jetty near Palachuvadu Bridge	CRZ - II	3,133.8	6,796.4
		Out of CRZ	3,662.6	
9	Jetty near Arakkadavu Bridge	CRZ - II	1,345.3	1,464.7
		CRZ - IVB	119.4	

PRINCIPAL CONSULTANT

DIRECTOR, IRS

Director
Institute of Remote Sensing
Anna University,
Chennai - 600 025.

Table 7 CRZ details of proposed deepening and widening (along Edapally canal)

Sl.No.	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
1	CRZ - II	1,975.9	34,594.5
	CRZ - IVB	579.5	
	Out of CRZ	32,039.1	

Table 8 CRZ details of proposed STP location (along Edapally canal)

Sl.No	Description	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
1	STP @ Muttar	Out of CRZ	11,789.5	11,789.5
2	Vennala STP	CRZ - II	7,304.6	17,482.4
		Out of CRZ	10,177.8	

Table 9 CRZ details of proposed sewer line laying area (along Edapally canal)

Sl.No.	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
1	CRZ - IB	1,104.7	49,817.2
	CRZ - II	15,461.9	
	CRZ - IVB	8,404.6	
	Out of CRZ	24,846.0	

PRINCIPAL CONSULTANT

24/12/21

DIRECTOR, IRS

Director
Institute of Remote Sensing
Anna University,
Chennai - 600 025.

Table 10 CRZ details of proposed bridge, foot bridge and existing to be reconstructed (along Edapally canal)

Sl.No.	Proposed bridge / foot bridge / existing to be reconstructed	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
1	Arkkakadavu Bridge	CRZ - II	131.9	546.8
		CRZ - IVB	414.9	
2	Chembookadav Bridge	Out of CRZ	110.4	110.4
3	Chembumukku Bridge	Out of CRZ	434.8	434.8
4	Foot Over Bridge 4	CRZ - II	14.8	25.1
		CRZ - IVB	10.3	
5	Foot Over Bridge 5	CRZ - II	3.7	47.2
		CRZ - IVB	43.5	
6	Foot Over Bridge 6	CRZ - II	1.0	47.2
		CRZ - IVB	46.2	
7	Foot Over Bridge 7	Out of CRZ	47.2	47.2
8	Indraji Bridge	Out of CRZ	162.1	162.1
9	Kuzhuvelippalam Bridge	CRZ - II	2.8	152.2
		CRZ - IB	6.9	
		CRZ - IVB	142.5	
10	Lulu Mall Parking Bridge	Out of CRZ	241.4	241.4
11	Marottichodu Bridge	Out of CRZ	273.1	273.1
12	Muttarkadavu Bridge	Out of CRZ	28.4	28.4
13	Oriental Timber Bridge	Out of CRZ	52.5	52.5
14	Palachuvadu Bridge	CRZ - II	13.4	192.7
		CRZ - IVB	179.3	
15	Pipe Line Road Bridge	Out of CRZ	142.5	142.5
16	Foot Over Bridge 1	CRZ - II	18.4	18.5
		CRZ - IB	0.1	
17	Foot Over Bridge 2	CRZ - IB	8.8	47.2
		CRZ - IVB	38.4	
18	Foot Over Bridge 3	CRZ - II	18.1	57.0
		CRZ - IVB	38.9	
19	Puravankara Iron Bridge 1	Out of CRZ	150.7	150.7
20	Puravankara PVT Bridge 2	Out of CRZ	2,170.7	2,170.7

PRINCIPAL CONSULTANT

DIRECTOR, IRS

Director
Institute of Remote Sensing
Anna University,
Chennai - 600 025.

Table 11 CRZ details of proposed Edapally canal bank beautification

Sl.No.	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
1	CRZ - II	42,730.0	68,770.1
	CRZ - IB	283.6	
	CRZ - IVB	10,977.9	
	Out of CRZ	14,778.6	

(iii) The CRZ details of proposed developments along Market canal in Cochin City, Kerala State by superimposing on approved CZMP as per CRZ notification, 2011 are given below (Table 12 to Table 13).

Table 12 CRZ details of proposed walkway in Market canal

Sl.No.	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
1	CRZ - II	1,400.2	1,897.6
	CRZ - IB	472.1	
	CRZ - IVB	25.3	

Table 13 CRZ details of proposed bridge, foot bridge and existing to be reconstructed (along Market canal)

Sl.No.	Proposed bridge / foot bridge / existing to be reconstructed	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
1	Marine Drive Bridge	CRZ - IB	48.0	111.6
		CRZ - II	63.6	
2	Shanmughom Road	CRZ - IB	443.6	517.2
		CRZ - II	73.6	
3	Broadway Road	CRZ - IB	117.4	120.7
		CRZ - II	3.3	
4	Ernakulam Market Canal Bridge	CRZ - IB	29.2	40.9
		CRZ - II	11.7	

PRINCIPAL CONSULTANT

DIRECTOR, IRS
Director
Institute of Remote Sensing
Anna University,
Chennai - 600 025.

(iv) The CRZ details of proposed developments along Thevara canal in Cochin City, Kerala State by superimposing on approved CZMP as per CRZ notification, 2011 are given below (Table 14 to Table 17).

Table 14 CRZ details of proposed Jetties (Thevara canal)

Sl.No.	Name of Jetty	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
1	Thevara Market Jetty	CRZ - II	53.9	80.3
		CRZ - IVB	26.4	
2	Kallupalam Jetty	CRZ - II	187.0	381.1
		CRZ - IVB	0.2	
		Out of CRZ	193.9	

Table 15 CRZ details of proposed sewer line laying area (along Thevara canal)

Sl.No.	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
1	CRZ - IB	586.7	14,132.0
	CRZ - II	10,814.2	
	CRZ - IVB	2,695.3	
	Out of CRZ	35.8	

Table 16 CRZ details of proposed bridge, foot bridge and existing to be reconstructed (along Thevara canal)

Sl. No.	Proposed bridge / foot bridge / existing to be reconstructed	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
1	Kallupalam Bridge	CRZ - II	9.4	45.4
		CRZ - IVB	36.0	
2	Konthuruthy Road Bridge	Out of CRZ	286.4	286.4
3	Pandit Karuppan Road Bridge	CRZ - II	259.3	553.1
		CRZ - IVB	185.0	
		Out of CRZ	108.8	
4	Proposed Foot Bridge 1	CRZ - II	209.4	286.4
		CRZ - IB	60.9	
		CRZ - IVB	16.1	
5	Proposed Foot Bridge 2	CRZ - II	173.8	286.4
		CRZ - IB	74.2	
		Out of CRZ	38.4	
6	Proposed Road Bridge	CRZ - II	64.3	221.7
		CRZ - IVB	157.4	

PRINCIPAL CONSULTANT

DIRECTOR, IRS
Director
Institute of Remote Sensing
Anna University,
Chennai - 600 025.

Table 17 CRZ details of proposed approach road (along Thevara canal)

Sl.No.	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
1	CRZ - II	690.4	963.7
	Out of CRZ	273.3	

(v) The CRZ details of proposed developments along Thevara Perundoor canal in Cochin City, Kerala State by superimposing on approved CZMP as per CRZ notification, 2011 are given below (Table 18 to Table 22).

Table 18 CRZ details of proposed Jetties (Thevara Perundoor canal)

Sl.No.	Name of Jetty	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
1	Jetty Opposite to Chinmaya Vidyalaya	CRZ - II	14.8	84.7
		CRZ - IVB	69.9	
2	Jetty near Yuvajana Samajam Road	CRZ - II	257.8	257.8
3	Panampally Nagar near Lag	CRZ - II	217.2	410.4
		Out of CRZ	193.2	
4	Jetty near Kadavanthara Metro Station	Out of CRZ	421.0	421.0
5	Jetty near P&T Colony	Out of CRZ	705.3	705.3
6	Jetty near Ksrtc	Out of CRZ	779.3	779.3
7	Jetty near Kaloor Metro	Out of CRZ	568.7	568.7
8	Jetty near Pottakuzhy Bridge	CRZ - II	390.7	1,002.8
		CRZ - IVB	10.2	
		Out of CRZ	601.9	
9	Jetty near Karshaka Road	CRZ - II	797.9	797.9
10	Jetty Perandoor	CRZ - II	250.9	314.3
		CRZ - IVB	63.4	

Table 19 CRZ details of proposed deepening and widening (along Thevara Perundoor canal)

Sl.No.	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
1	CRZ - II	1,925.9	35,861.2
	CRZ - IB	1.9	
	CRZ - IVB	1,736.0	
	Out of CRZ	32,197.4	

PRINCIPAL CONSULTANT

DIRECTOR, IRS

Director
Institute of Remote Sensing
Anna University,
Chennai - 600 025.

Table 20 CRZ details of proposed STP location (along Thevara Perundoor canal)

Sl.No.	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
1	CRZ - II	3,921.5	4,037.6
	CRZ - IVB	116.1	

Table 21 CRZ details of proposed sewer line laying area (along Thevara Perundoor canal)

Sl.No.	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
1	CRZ - II	13,902.0	37,455.6
	CRZ - IB	16.3	
	CRZ - IVB	6,005.3	
	Out of CRZ	17,532.0	

Table 22 CRZ details of proposed bridge, foot bridge and existing to be reconstructed (along Thevara Perundoor canal)

Sl.No.	Proposed bridge / foot bridge / existing to be reconstructed	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
1	Anamthuruthu Road Bridge	CRZ - II	47.0	165.2
		CRZ - IVB	118.2	
2	Chemmani Road Bridge	Out of CRZ	46.5	46.5
3	Church Road Bridge	Out of CRZ	62.0	62.0
4	Concrete Foot Bridge 1	Out of CRZ	17.2	17.2
5	Concrete Foot Bridge 2	Out of CRZ	13.7	13.7
6	Concrete Slab Foot Bridge	Out of CRZ	11.9	11.9
7	Elders Forum Road Bridge	CRZ - II	67.8	71.4
		CRZ - IVB	3.6	
8	Foot Bridge 1	Out of CRZ	73.0	73.0
9	Foot Bridge 2	Out of CRZ	46.2	46.2

PRINCIPAL CONSULTANT

DIRECTOR, IRS

Director
Institute of Remote Sensing
Anna University,
Chennai - 600 025.

Table 22 (Contd...) CRZ details of proposed bridge, foot bridge and existing to be reconstructed (along Thevara Perundoor canal)

Sl.No.	Proposed bridge / foot bridge / existing to be reconstructed	CRZ-Classification	Area in Sq.m	Total Area in Sq.m
10	Foot Bridge 3	Out of CRZ	9.7	9.7
11	Foot Bridge 4	Out of CRZ	12.2	12.2
12	Foot Bridge 5	Out of CRZ	18.4	18.4
13	Iron Foot Bridge 1	Out of CRZ	13.5	13.5
14	Iron Foot Bridge 2	CRZ - II	1.8	32.4
		CRZ - IVB	30.6	
15	Kadavanthra Market Bridge	Out of CRZ	114.1	114.1
16	Kaloor Manappattiparambu Bridge	Out of CRZ	120.8	120.8
17	Karshaka Road Bridge	Out of CRZ	131.8	131.8
18	Kochu Kadavanthra Road Bridge	CRZ - II	38.5	151.7
		CRZ - IVB	113.2	
19	Panampilly Nagar-Girinagar Road Bridge	CRZ - IVB	81.2	81.2
20	Panampilly Nagar-Vidhya Nagar Road Bridge	CRZ - II	6.2	73.0
		CRZ - IVB	66.8	
21	Panampilly Nagar Link Road Bridge	CRZ - II	2.9	61.6
		CRZ - IVB	58.7	
22	Pottakuzhy Road Bridge	CRZ - II	155.3	312.1
		CRZ - IVB	156.8	
23	Rbi Quaters Road Bridge	Out of CRZ	56.8	56.8
24	Refinery Pipeline Bridge	Out of CRZ	29.5	29.5
25	Road Bridge	Out of CRZ	55.0	55.0
26	Sahodaran Ayyappan Road Bridge	Out of CRZ	365.4	365.4
27	Salim Rajan Road Bridge	Out of CRZ	419.0	419.0
28	Sasthri Nagar Bridge	CRZ - II	17.9	108.0
		CRZ - IVB	90.1	
29	Sebastan Road Bridge	Out of CRZ	31.1	31.1
30	Shastha Temple Road Bridge	Out of CRZ	93.3	93.3
31	St Augustines School Road Bridge	Out of CRZ	55.0	55.0
32	Steel Foot Bridge 1	Out of CRZ	46.1	46.1
33	Steel Foot Bridge 2	Out of CRZ	46.1	46.1
34	Steel Foot Bridge 3	Out of CRZ	24.2	24.2
35	Thammanam-Pulleppady Road Bridge	Out of CRZ	67.2	67.2

PRINCIPAL CONSULTANT

DIRECTOR, IRS

24/12/21

Director
Institute of Remote Sensing
Anna University,
Chennai - 600 025.

ANNEXURE – I

TABLE 23 COORDINATES OF HTL REFERENCE POINTS

Reference System: WGS 84 Datum

HTL Points	Latitude	Longitude
1	10° 2' 20.175" N	76° 17' 20.569" E
2	10° 2' 23.268" N	76° 17' 26.418" E
3	10° 2' 28.997" N	76° 17' 30.672" E
4	10° 2' 34.433" N	76° 17' 28.282" E
5	10° 2' 35.275" N	76° 17' 29.757" E
6	10° 2' 22.851" N	76° 17' 29.943" E
7	10° 2' 18.332" N	76° 17' 19.640" E
8	10° 2' 0.160" N	76° 17' 19.581" E
9	10° 1' 53.874" N	76° 17' 22.816" E
10	10° 1' 53.919" N	76° 17' 29.309" E
11	10° 1' 46.965" N	76° 17' 30.246" E
12	10° 1' 54.031" N	76° 17' 38.617" E
13	10° 1' 44.013" N	76° 17' 31.772" E
14	10° 1' 42.024" N	76° 17' 41.190" E
15	10° 1' 43.025" N	76° 17' 46.866" E
16	10° 1' 40.556" N	76° 17' 34.008" E
17	10° 1' 32.884" N	76° 17' 36.538" E
18	10° 1' 24.465" N	76° 17' 38.799" E
19	10° 1' 18.423" N	76° 17' 39.911" E
20	10° 1' 15.627" N	76° 17' 42.413" E
21	10° 1' 10.729" N	76° 17' 42.775" E
22	10° 1' 21.232" N	76° 17' 39.555" E
23	10° 1' 30.144" N	76° 17' 36.663" E
24	10° 1' 42.439" N	76° 17' 31.206" E
25	10° 1' 52.389" N	76° 17' 23.920" E
26	10° 1' 42.416" N	76° 17' 23.919" E
27	10° 1' 25.843" N	76° 17' 2.894" E
28	10° 1' 14.531" N	76° 16' 57.837" E
29	10° 1' 0.097" N	76° 16' 54.372" E
30	10° 0' 49.827" N	76° 17' 2.127" E
31	10° 0' 44.394" N	76° 17' 12.424" E
32	10° 0' 35.623" N	76° 17' 6.802" E
33	10° 0' 28.799" N	76° 17' 7.636" E
34	10° 0' 19.447" N	76° 17' 7.946" E
35	10° 0' 15.977" N	76° 17' 14.509" E
36	10° 0' 9.397" N	76° 17' 12.946" E
37	10° 0' 3.464" N	76° 17' 14.921" E
38	10° 0' 6.767" N	76° 17' 11.685" E
39	10° 0' 13.428" N	76° 17' 13.507" E
40	10° 0' 20.411" N	76° 17' 13.554" E

ANNEXURE – I

TABLE 25 COORDINATES OF HTL REFERENCE POINTS (CONTD...)

Reference System: WGS 84 Datum

HTL Points	Latitude	Longitude
41	10° 0' 22.920" N	76° 17' 6.257" E
42	10° 0' 32.401" N	76° 17' 6.720" E
43	10° 0' 39.067" N	76° 17' 2.314" E
44	10° 0' 46.427" N	76° 17' 1.196" E
45	10° 0' 53.313" N	76° 16' 56.461" E
46	10° 1' 2.244" N	76° 16' 51.787" E
47	10° 1' 12.147" N	76° 16' 55.417" E
48	10° 1' 16.441" N	76° 16' 45.350" E
49	10° 1' 22.372" N	76° 16' 39.425" E
50	10° 1' 26.282" N	76° 16' 32.965" E
51	10° 1' 27.686" N	76° 16' 3.894" E
52	10° 1' 19.153" N	76° 16' 5.730" E
53	10° 1' 15.254" N	76° 16' 12.222" E
54	10° 1' 10.270" N	76° 16' 14.914" E
55	10° 1' 3.662" N	76° 16' 16.452" E
56	10° 0' 57.631" N	76° 16' 19.244" E
57	10° 0' 51.976" N	76° 16' 21.607" E
58	10° 0' 45.702" N	76° 16' 23.786" E
59	10° 0' 40.218" N	76° 16' 22.003" E
60	10° 0' 35.523" N	76° 16' 26.509" E
61	10° 0' 26.884" N	76° 16' 27.096" E
62	10° 0' 20.723" N	76° 16' 31.044" E
63	10° 0' 14.132" N	76° 16' 31.988" E
64	10° 0' 4.679" N	76° 16' 35.445" E
65	9° 59' 59.117" N	76° 16' 34.047" E
66	9° 59' 53.005" N	76° 16' 36.059" E
67	9° 59' 48.500" N	76° 16' 33.894" E
68	9° 59' 57.094" N	76° 16' 33.319" E
69	10° 0' 1.387" N	76° 16' 22.436" E
70	9° 59' 54.625" N	76° 16' 22.414" E
71	9° 59' 47.078" N	76° 16' 19.767" E
72	9° 59' 40.654" N	76° 16' 22.747" E
73	9° 59' 36.754" N	76° 16' 22.219" E
74	9° 59' 34.480" N	76° 16' 23.549" E
75	9° 59' 32.023" N	76° 16' 18.216" E
76	9° 59' 30.293" N	76° 16' 11.731" E
77	9° 59' 31.667" N	76° 16' 14.911" E
78	9° 59' 37.972" N	76° 16' 21.504" E
79	9° 59' 43.004" N	76° 16' 21.702" E
80	9° 59' 43.409" N	76° 16' 17.316" E

ANNEXURE – I

TABLE 25 COORDINATES OF HTL REFERENCE POINTS (CONTD...)

Reference System: WGS 84 Datum

HTL Points	Latitude	Longitude
81	9° 59' 38.522" N	76° 16' 11.481" E
82	9° 59' 33.922" N	76° 16' 7.454" E
83	9° 59' 26.124" N	76° 16' 10.329" E
84	9° 59' 19.234" N	76° 16' 13.873" E
85	9° 59' 11.498" N	76° 16' 17.493" E
86	9° 59' 15.696" N	76° 16' 23.634" E
87	9° 59' 21.506" N	76° 16' 22.297" E
88	9° 59' 19.763" N	76° 16' 27.590" E
89	9° 59' 13.236" N	76° 16' 21.661" E
90	9° 59' 6.681" N	76° 16' 20.244" E
91	9° 58' 59.826" N	76° 16' 23.805" E
92	9° 58' 51.890" N	76° 16' 27.917" E
93	9° 58' 52.077" N	76° 16' 35.154" E
94	9° 58' 59.060" N	76° 16' 36.202" E
95	9° 59' 5.042" N	76° 16' 34.387" E
96	9° 58' 55.885" N	76° 16' 37.851" E
97	9° 58' 48.282" N	76° 16' 31.748" E
98	9° 58' 41.660" N	76° 16' 33.140" E
99	9° 58' 36.267" N	76° 16' 35.682" E
100	9° 58' 28.782" N	76° 16' 38.976" E
101	9° 58' 30.331" N	76° 16' 44.411" E
102	9° 58' 29.426" N	76° 16' 50.751" E
103	9° 58' 30.483" N	76° 16' 55.817" E
104	9° 58' 31.225" N	76° 16' 47.961" E
105	9° 58' 23.252" N	76° 16' 41.222" E
106	9° 58' 13.829" N	76° 16' 45.110" E
107	9° 58' 3.372" N	76° 16' 50.030" E
108	9° 57' 54.012" N	76° 16' 54.566" E
109	9° 57' 46.398" N	76° 16' 58.077" E
110	9° 57' 40.117" N	76° 17' 1.897" E
111	9° 57' 31.715" N	76° 17' 4.685" E
112	9° 57' 24.207" N	76° 17' 8.476" E
113	9° 57' 15.797" N	76° 17' 13.295" E
114	9° 57' 7.824" N	76° 17' 16.212" E
115	9° 56' 59.512" N	76° 17' 20.206" E
116	9° 56' 49.031" N	76° 17' 24.074" E
117	9° 56' 39.862" N	76° 17' 31.151" E
118	9° 56' 39.759" N	76° 17' 37.341" E
119	9° 56' 41.762" N	76° 17' 45.379" E
120	9° 56' 45.587" N	76° 17' 48.840" E

ANNEXURE – I

TABLE 25 COORDINATES OF HTL REFERENCE POINTS (CONTD...)
Reference System: WGS 84 Datum

HTL Points	Latitude	Longitude
121	9° 56' 52.304" N	76° 17' 47.055" E
122	9° 56' 56.653" N	76° 17' 46.121" E
123	9° 56' 56.456" N	76° 17' 43.294" E
124	9° 57' 0.428" N	76° 17' 46.200" E
125	9° 57' 6.062" N	76° 17' 45.310" E
126	9° 57' 11.837" N	76° 17' 42.732" E
127	9° 57' 13.576" N	76° 17' 47.413" E
128	9° 57' 10.804" N	76° 17' 52.930" E
129	9° 57' 10.944" N	76° 17' 57.784" E
130	9° 57' 18.143" N	76° 17' 56.719" E
131	9° 57' 26.171" N	76° 17' 55.625" E
132	9° 57' 32.317" N	76° 17' 54.770" E
133	9° 57' 31.459" N	76° 17' 48.959" E
134	9° 57' 30.475" N	76° 17' 38.601" E
135	9° 57' 30.925" N	76° 17' 44.476" E
136	9° 57' 35.448" N	76° 17' 54.241" E
137	9° 57' 44.281" N	76° 17' 52.922" E
138	9° 57' 55.052" N	76° 17' 51.440" E
139	9° 57' 48.680" N	76° 17' 52.860" E
140	9° 57' 39.640" N	76° 17' 54.233" E
141	9° 57' 29.290" N	76° 17' 55.731" E
142	9° 57' 21.596" N	76° 17' 56.787" E
143	9° 57' 7.408" N	76° 17' 58.848" E
144	9° 56' 58.322" N	76° 18' 0.079" E
145	9° 56' 50.825" N	76° 18' 1.141" E
146	9° 56' 46.486" N	76° 18' 1.189" E
147	9° 56' 55.065" N	76° 18' 0.042" E
148	9° 57' 3.317" N	76° 17' 58.881" E
149	9° 57' 8.947" N	76° 17' 55.010" E
150	9° 57' 13.091" N	76° 17' 49.773" E
151	9° 57' 13.069" N	76° 17' 42.982" E
152	9° 57' 8.185" N	76° 17' 45.955" E
153	9° 57' 2.456" N	76° 17' 45.845" E
154	9° 56' 55.791" N	76° 17' 47.343" E
155	9° 56' 49.307" N	76° 17' 48.006" E
156	9° 56' 49.501" N	76° 17' 54.581" E
157	9° 56' 50.259" N	76° 17' 55.951" E
158	9° 56' 46.102" N	76° 17' 49.251" E
159	9° 56' 42.334" N	76° 17' 48.111" E
160	9° 56' 42.910" N	76° 17' 52.692" E

ANNEXURE – I

TABLE 25 COORDINATES OF HTL REFERENCE POINTS (CONTD...)

Reference System: WGS 84 Datum

HTL Points	Latitude	Longitude
161	9° 56' 43.895" N	76° 17' 57.994" E
162	9° 56' 44.760" N	76° 18' 2.277" E
163	9° 56' 46.160" N	76° 18' 9.716" E
164	9° 56' 47.870" N	76° 18' 19.655" E
165	9° 56' 53.213" N	76° 18' 27.704" E
166	9° 57' 1.871" N	76° 18' 31.016" E
167	9° 57' 8.969" N	76° 18' 28.980" E
168	9° 57' 14.499" N	76° 18' 24.635" E
169	9° 57' 19.670" N	76° 18' 20.473" E
170	9° 57' 27.783" N	76° 18' 18.442" E
171	9° 57' 38.190" N	76° 18' 15.386" E
172	9° 57' 43.431" N	76° 18' 13.087" E
173	9° 57' 30.439" N	76° 18' 18.522" E
174	9° 57' 27.236" N	76° 18' 21.689" E
175	9° 57' 22.719" N	76° 18' 23.560" E
176	9° 57' 18.135" N	76° 18' 22.969" E
177	9° 57' 20.316" N	76° 18' 27.069" E
178	9° 57' 19.114" N	76° 18' 30.401" E
179	9° 57' 16.840" N	76° 18' 23.902" E
180	9° 57' 11.240" N	76° 18' 25.987" E
181	9° 57' 8.475" N	76° 18' 31.711" E
182	9° 57' 9.367" N	76° 18' 38.668" E
183	9° 57' 11.097" N	76° 18' 45.674" E
184	9° 57' 16.060" N	76° 18' 48.557" E
185	9° 57' 22.773" N	76° 18' 42.606" E
186	9° 57' 31.542" N	76° 18' 38.723" E
187	9° 57' 39.670" N	76° 18' 35.376" E
188	9° 57' 46.961" N	76° 18' 34.838" E
189	9° 57' 53.189" N	76° 18' 34.721" E
190	9° 58' 0.763" N	76° 18' 31.676" E
191	9° 58' 5.116" N	76° 18' 26.726" E
192	9° 58' 11.881" N	76° 18' 21.738" E
193	9° 58' 15.389" N	76° 18' 23.305" E
194	9° 58' 24.771" N	76° 18' 17.360" E
195	9° 58' 32.399" N	76° 18' 15.818" E
196	9° 58' 41.350" N	76° 18' 14.136" E
197	9° 58' 28.144" N	76° 18' 17.013" E
198	9° 58' 21.221" N	76° 18' 22.861" E
199	9° 58' 30.508" N	76° 18' 23.315" E
200	9° 58' 38.646" N	76° 18' 20.376" E

ANNEXURE – I

TABLE 25 COORDINATES OF HTL REFERENCE POINTS (CONTD...)

Reference System: WGS 84 Datum

HTL Points	Latitude	Longitude
201	9° 58' 36.082" N	76° 18' 21.917" E
202	9° 58' 25.376" N	76° 18' 23.429" E
203	9° 58' 21.567" N	76° 18' 30.685" E
204	9° 58' 17.845" N	76° 18' 33.912" E
205	9° 58' 14.125" N	76° 18' 27.016" E
206	9° 58' 8.900" N	76° 18' 32.871" E
207	9° 58' 3.544" N	76° 18' 34.158" E
208	9° 58' 0.464" N	76° 18' 38.678" E
209	9° 57' 53.491" N	76° 18' 39.711" E
210	9° 57' 48.381" N	76° 18' 43.616" E
211	9° 57' 39.480" N	76° 18' 43.296" E
212	9° 57' 37.336" N	76° 18' 54.412" E
213	9° 57' 32.275" N	76° 18' 48.355" E
214	9° 57' 17.451" N	76° 18' 53.553" E
215	9° 57' 15.994" N	76° 18' 59.348" E
216	9° 57' 17.917" N	76° 19' 7.779" E
217	9° 57' 19.165" N	76° 19' 17.275" E
218	9° 57' 19.722" N	76° 19' 24.953" E
219	9° 57' 23.338" N	76° 19' 35.384" E
220	9° 57' 28.509" N	76° 19' 43.359" E
221	9° 57' 35.461" N	76° 19' 43.964" E
222	9° 57' 39.176" N	76° 19' 32.969" E
223	9° 57' 40.861" N	76° 19' 18.298" E
224	9° 57' 49.836" N	76° 19' 10.532" E
225	9° 57' 57.810" N	76° 19' 11.019" E
226	9° 58' 2.043" N	76° 19' 17.500" E
227	9° 58' 5.135" N	76° 19' 21.248" E
228	9° 58' 11.009" N	76° 19' 20.132" E
229	9° 58' 13.567" N	76° 19' 22.449" E
230	9° 58' 18.829" N	76° 19' 23.637" E
231	9° 58' 21.386" N	76° 19' 17.361" E
232	9° 58' 19.801" N	76° 19' 11.857" E
233	9° 58' 22.042" N	76° 19' 14.147" E
234	9° 58' 24.132" N	76° 19' 16.553" E
235	9° 58' 23.881" N	76° 19' 13.792" E
236	9° 58' 27.556" N	76° 19' 14.790" E
237	9° 58' 32.070" N	76° 19' 13.097" E
238	9° 58' 37.654" N	76° 19' 10.091" E
239	9° 58' 43.794" N	76° 19' 5.555" E
240	9° 58' 47.437" N	76° 19' 2.288" E

ANNEXURE – I

TABLE 25 COORDINATES OF HTL REFERENCE POINTS (CONTD...)

Reference System: WGS 84 Datum

HTL Points	Latitude	Longitude
241	9° 58' 51.728" N	76° 19' 1.742" E
242	9° 58' 45.672" N	76° 19' 4.126" E
243	9° 58' 40.627" N	76° 19' 8.188" E
244	9° 58' 33.946" N	76° 19' 12.337" E
245	9° 58' 29.223" N	76° 19' 14.479" E
246	9° 58' 21.611" N	76° 19' 18.492" E
247	9° 58' 22.235" N	76° 19' 24.020" E
248	9° 58' 22.327" N	76° 19' 27.841" E
249	9° 58' 20.060" N	76° 19' 22.793" E
250	9° 58' 14.230" N	76° 19' 25.701" E
251	9° 58' 16.803" N	76° 19' 29.586" E
252	9° 58' 22.501" N	76° 19' 29.815" E
253	9° 58' 28.691" N	76° 19' 28.835" E
254	9° 58' 32.502" N	76° 19' 28.304" E
255	9° 58' 37.169" N	76° 19' 28.165" E
256	9° 58' 40.787" N	76° 19' 27.868" E
257	9° 58' 41.190" N	76° 19' 23.869" E
258	9° 58' 45.482" N	76° 19' 19.361" E
259	9° 58' 50.225" N	76° 19' 16.964" E
260	9° 58' 55.190" N	76° 19' 14.565" E
261	9° 58' 59.091" N	76° 19' 12.196" E
262	9° 59' 3.496" N	76° 19' 9.419" E
263	9° 59' 0.916" N	76° 19' 15.065" E
264	9° 58' 51.800" N	76° 19' 16.560" E
265	9° 58' 43.295" N	76° 19' 20.891" E
266	9° 58' 42.306" N	76° 19' 25.228" E
267	9° 58' 40.860" N	76° 19' 33.199" E
268	9° 58' 40.728" N	76° 19' 40.071" E
269	9° 58' 41.626" N	76° 19' 46.607" E
270	9° 58' 45.754" N	76° 19' 54.595" E
271	9° 58' 45.296" N	76° 19' 48.651" E
272	9° 58' 48.187" N	76° 19' 40.526" E
273	9° 58' 54.941" N	76° 19' 36.825" E
274	9° 58' 58.920" N	76° 19' 34.952" E
275	9° 59' 3.073" N	76° 19' 30.234" E
276	9° 59' 7.982" N	76° 19' 30.306" E
277	9° 59' 11.357" N	76° 19' 34.885" E
278	9° 59' 17.371" N	76° 19' 36.121" E
279	9° 59' 25.344" N	76° 19' 30.528" E
280	9° 59' 25.746" N	76° 19' 38.719" E

ANNEXURE – I

TABLE 25 COORDINATES OF HTL REFERENCE POINTS (CONTD…)

Reference System: WGS 84 Datum

HTL Points	Latitude	Longitude
281	9° 59' 32.339" N	76° 19' 44.570" E
282	9° 59' 42.399" N	76° 19' 40.301" E
283	9° 59' 49.401" N	76° 19' 38.789" E
284	9° 59' 38.803" N	76° 19' 46.305" E
285	9° 59' 36.410" N	76° 19' 56.627" E
286	9° 59' 26.696" N	76° 19' 53.069" E
287	9° 59' 27.168" N	76° 20' 1.670" E
288	9° 59' 34.563" N	76° 20' 0.345" E
289	9° 59' 42.858" N	76° 19' 56.768" E
290	9° 59' 52.821" N	76° 19' 49.693" E
291	10° 0' 2.959" N	76° 19' 44.325" E
292	10° 0' 12.635" N	76° 19' 37.900" E
293	10° 0' 12.556" N	76° 19' 25.348" E
294	10° 0' 22.727" N	76° 19' 24.334" E
295	10° 0' 20.941" N	76° 19' 15.464" E
296	10° 0' 17.168" N	76° 19' 25.367" E
297	10° 0' 16.183" N	76° 19' 34.802" E
298	10° 0' 8.092" N	76° 19' 41.711" E
299	10° 0' 1.433" N	76° 19' 50.825" E
300	9° 59' 46.554" N	76° 19' 52.986" E
301	9° 59' 32.456" N	76° 20' 2.508" E
302	9° 59' 38.101" N	76° 20' 3.894" E
303	9° 59' 21.508" N	76° 20' 6.065" E
304	9° 59' 11.445" N	76° 20' 0.929" E
305	9° 59' 15.219" N	76° 19' 50.071" E
306	9° 59' 23.340" N	76° 19' 54.016" E
307	9° 59' 23.847" N	76° 20' 1.903" E
308	9° 59' 14.689" N	76° 19' 53.958" E
309	9° 59' 23.545" N	76° 19' 47.784" E
310	9° 59' 30.089" N	76° 19' 45.882" E
311	9° 59' 22.461" N	76° 19' 38.361" E
312	9° 59' 10.036" N	76° 19' 38.396" E
313	9° 59' 2.982" N	76° 19' 33.320" E
314	9° 58' 56.361" N	76° 19' 42.002" E
315	9° 58' 48.130" N	76° 19' 44.221" E
316	9° 58' 48.430" N	76° 20' 1.794" E
317	9° 58' 43.186" N	76° 19' 55.319" E
318	9° 58' 38.854" N	76° 19' 43.772" E
319	9° 58' 37.523" N	76° 19' 32.762" E
320	9° 58' 29.323" N	76° 19' 31.395" E

ANNEXURE – I

TABLE 25 COORDINATES OF HTL REFERENCE POINTS (CONTD...)
Reference System: WGS 84 Datum

HTL Points	Latitude	Longitude
321	9° 58' 20.289" N	76° 19' 32.270" E
322	9° 58' 10.590" N	76° 19' 25.025" E
323	9° 58' 11.214" N	76° 19' 35.846" E
324	9° 58' 9.371" N	76° 19' 45.235" E
325	9° 58' 0.352" N	76° 19' 49.725" E
326	9° 57' 52.926" N	76° 19' 42.286" E
327	9° 57' 51.582" N	76° 19' 37.499" E
328	9° 58' 2.330" N	76° 19' 44.283" E
329	9° 58' 7.062" N	76° 19' 45.887" E
330	9° 58' 8.495" N	76° 19' 32.822" E
331	9° 58' 5.107" N	76° 19' 24.351" E
332	9° 57' 57.144" N	76° 19' 32.731" E
333	9° 57' 45.813" N	76° 19' 34.209" E
334	9° 57' 49.204" N	76° 19' 29.482" E
335	9° 57' 58.380" N	76° 19' 28.171" E
336	9° 57' 57.276" N	76° 19' 21.553" E
337	9° 57' 51.904" N	76° 19' 15.811" E
338	9° 57' 42.415" N	76° 19' 19.722" E
339	9° 57' 43.054" N	76° 19' 32.690" E
340	9° 57' 41.191" N	76° 19' 39.909" E
341	9° 57' 36.659" N	76° 19' 48.075" E
342	9° 57' 29.710" N	76° 19' 50.866" E
343	9° 57' 22.120" N	76° 19' 41.707" E
344	9° 57' 16.027" N	76° 19' 51.176" E
345	9° 57' 17.427" N	76° 19' 53.891" E
346	9° 57' 22.934" N	76° 19' 54.824" E
347	9° 57' 26.806" N	76° 19' 57.834" E
348	9° 57' 27.231" N	76° 20' 1.420" E
349	9° 57' 23.594" N	76° 20' 1.421" E
350	9° 57' 13.495" N	76° 20' 3.295" E
351	9° 57' 3.805" N	76° 20' 4.846" E
352	9° 56' 58.900" N	76° 20' 4.362" E
353	9° 57' 8.617" N	76° 20' 1.726" E
354	9° 57' 10.362" N	76° 19' 52.763" E
355	9° 57' 15.123" N	76° 19' 45.111" E
356	9° 57' 22.397" N	76° 19' 39.198" E
357	9° 57' 19.524" N	76° 19' 30.540" E
358	9° 57' 16.954" N	76° 19' 13.140" E
359	9° 57' 13.276" N	76° 18' 56.710" E
360	9° 57' 3.880" N	76° 18' 55.469" E

ANNEXURE – I

TABLE 25 COORDINATES OF HTL REFERENCE POINTS (CONTD...)

Reference System: WGS 84 Datum

HTL Points	Latitude	Longitude
361	9° 56' 54.946" N	76° 18' 59.525" E
362	9° 56' 45.339" N	76° 19' 2.098" E
363	9° 56' 39.935" N	76° 19' 4.702" E
364	9° 56' 39.572" N	76° 19' 12.204" E
365	9° 56' 39.394" N	76° 19' 19.540" E
366	9° 56' 37.410" N	76° 19' 10.497" E
367	9° 56' 36.183" N	76° 19' 7.675" E
368	9° 56' 38.438" N	76° 19' 4.730" E
369	9° 56' 40.250" N	76° 18' 57.319" E
370	9° 56' 42.450" N	76° 18' 51.108" E
371	9° 56' 46.080" N	76° 18' 50.118" E
372	9° 56' 45.046" N	76° 18' 56.524" E
373	9° 56' 40.491" N	76° 18' 53.771" E
374	9° 56' 45.518" N	76° 18' 59.758" E
375	9° 56' 48.769" N	76° 18' 58.426" E
376	9° 56' 52.064" N	76° 18' 53.938" E
377	9° 56' 53.205" N	76° 18' 46.116" E
378	9° 56' 56.695" N	76° 18' 44.540" E
379	9° 57' 3.946" N	76° 18' 44.784" E
380	9° 57' 9.742" N	76° 18' 43.191" E
381	9° 57' 8.061" N	76° 18' 35.465" E
382	9° 56' 59.810" N	76° 18' 33.838" E
383	9° 56' 51.756" N	76° 18' 42.212" E
384	9° 56' 46.234" N	76° 18' 42.681" E
385	9° 56' 39.289" N	76° 18' 43.983" E
386	9° 56' 35.958" N	76° 18' 41.048" E
387	9° 56' 36.845" N	76° 18' 36.444" E
388	9° 56' 35.260" N	76° 18' 33.114" E
389	9° 56' 36.909" N	76° 18' 29.157" E
390	9° 56' 36.633" N	76° 18' 25.622" E
391	9° 56' 39.929" N	76° 18' 26.466" E
392	9° 56' 37.972" N	76° 18' 21.492" E
393	9° 56' 36.467" N	76° 18' 16.356" E
394	9° 56' 46.399" N	76° 18' 13.812" E
395	9° 56' 44.848" N	76° 18' 6.083" E
396	9° 56' 42.310" N	76° 17' 58.662" E
397	9° 56' 41.933" N	76° 17' 50.675" E
398	9° 56' 40.206" N	76° 17' 52.853" E
399	9° 56' 40.728" N	76° 17' 42.591" E
400	9° 56' 37.683" N	76° 17' 33.475" E

ANNEXURE – I

TABLE 25 COORDINATES OF HTL REFERENCE POINTS (CONTD...)

Reference System: WGS 84 Datum

HTL Points	Latitude	Longitude
401	9° 56' 35.108" N	76° 17' 32.909" E
402	9° 59' 05.492" N	76° 15' 55.029" E
403	9° 58' 57.761" N	76° 16' 04.940" E
404	9° 59' 05.032" N	76° 16' 04.312" E
405	9° 59' 16.809" N	76° 16' 01.881" E
406	9° 59' 26.190" N	76° 16' 0.035" E
407	9° 59' 37.279" N	76° 15' 56.770" E
408	9° 59' 46.939" N	76° 15' 54.331" E
409	9° 59' 46.574" N	76° 16' 4.979" E
410	9° 59' 52.145" N	76° 16' 9.532" E
411	9° 59' 58.943" N	76° 16' 10.151" E
412	10° 0' 04.384" N	76° 16' 08.241" E
413	10° 0' 12.739" N	76° 16' 05.224" E
414	10° 0' 14.400" N	76° 15' 59.150" E
415	10° 0' 08.066" N	76° 16' 01.195" E
416	10° 0' 0.723" N	76° 16' 02.957" E
417	9° 59' 52.100" N	76° 16' 03.585" E

PRINCIPAL CONSULTANT

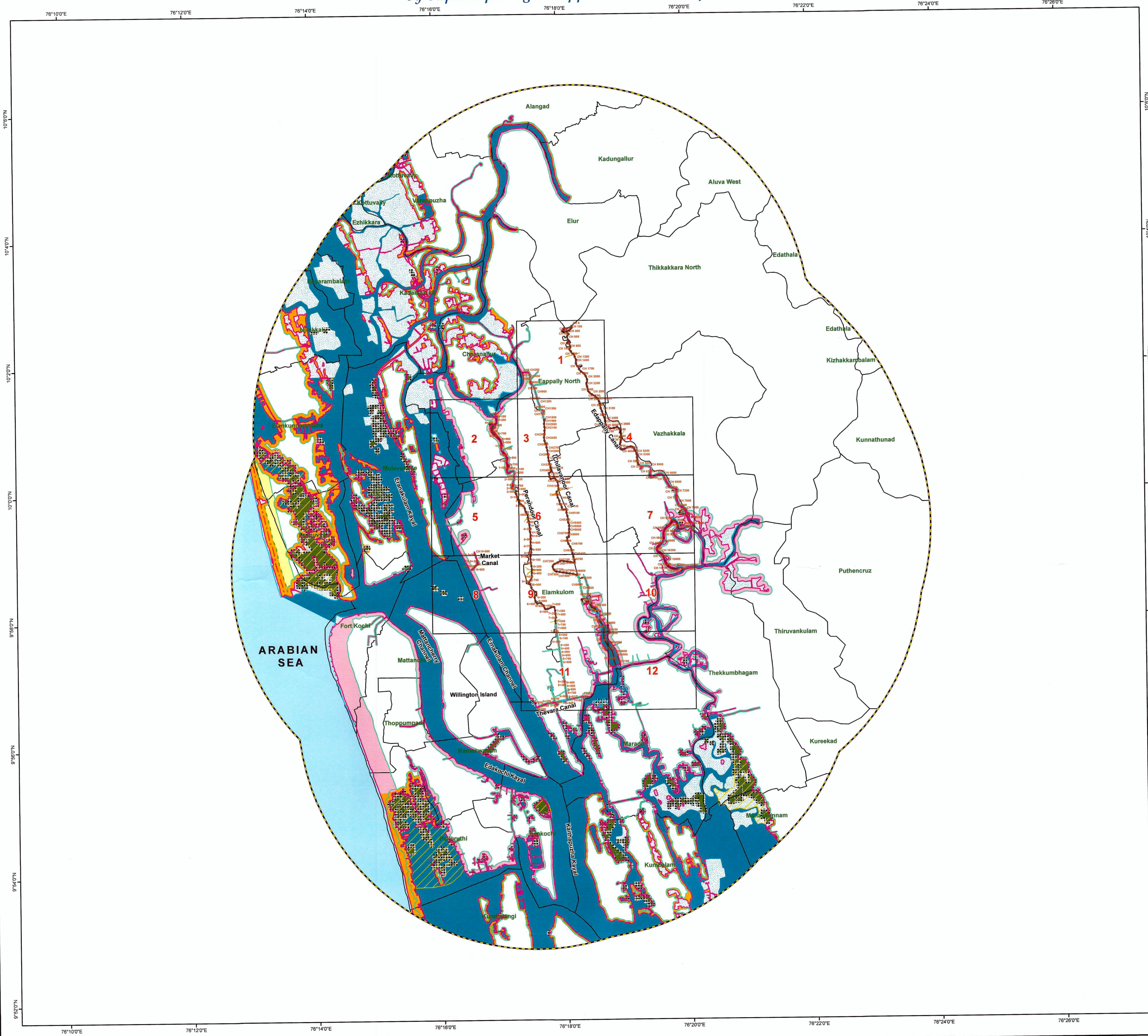
24/11/21

DIRECTOR, IRS

Director
Institute of Remote Sensing
Anna University,
Chennai - 600 025.

Preparation of Local Level Coastal Regulation Zone Map for the Proposed Project "Integrated Urban Regeneration and Water Transport System (IURWTS)" in Cochin, Kerala State by Superimposing on Approved CZMP as per CRZ Notification 2011

INDEX MAP



LEGEND

SOURCE : APPROVED CZMP (MAP NO : KL 31, 32, 34 & 35) AS PER CRZ NOTIFICATION 2011

- LOW TIDE LINE (LTL)
- HIGH TIDE LINE (HTL)
- 100m LINE IN CRZ - III AREA
- 200m CRZ LINE - NDZ
- CRZ BOUNDARY (500m FOR SEA, 100m FOR BAY, 50m FOR BACKWATER ISLAND, 100m OR WIDTH OF THE CREEK WHICHEVER IS LESS ALONG THE TIDAL INFLUENCED WATER BODIES)
- CRITICAL VULNERABLE COASTAL AREA BOUNDARY (CVCA)
- CRZ - IA
- CRZ - IA (50m MANGROVE BUFFER ZONE)
- CRZ - IB
- CRZ - II
- CRZ - III (NO DEVELOPMENT ZONE)
- CRZ - III (200m TO 500m FROM HTL)
- CRZ - IVA
- CRZ - IVB
- 7Km BUFFER LINE FROM PROJECT SITE

SOURCE : CLIENT

- PROPOSED PROJECT SITE DETAILS
- EXISTING STRUCTURE
- CHAINAGE LINE
- SURVEY BOUNDARY
- VILLAGE BOUNDARY
- PROPOSED STP
- PROPOSED JETTY
- PROPOSED SEWER LINE LAYING
- PROPOSED CANAL BANK BEAUTIFICATION
- PROPOSED BRIDGE / FOOT BRIDGE / EXISTING BRIDGE TO BE RECONSTRUCTION
- PROPOSED WALKWAY
- PROPOSED APPROACH ROAD
- PROPOSED DEEPENING & WIDENING OF EXISTING CANAL

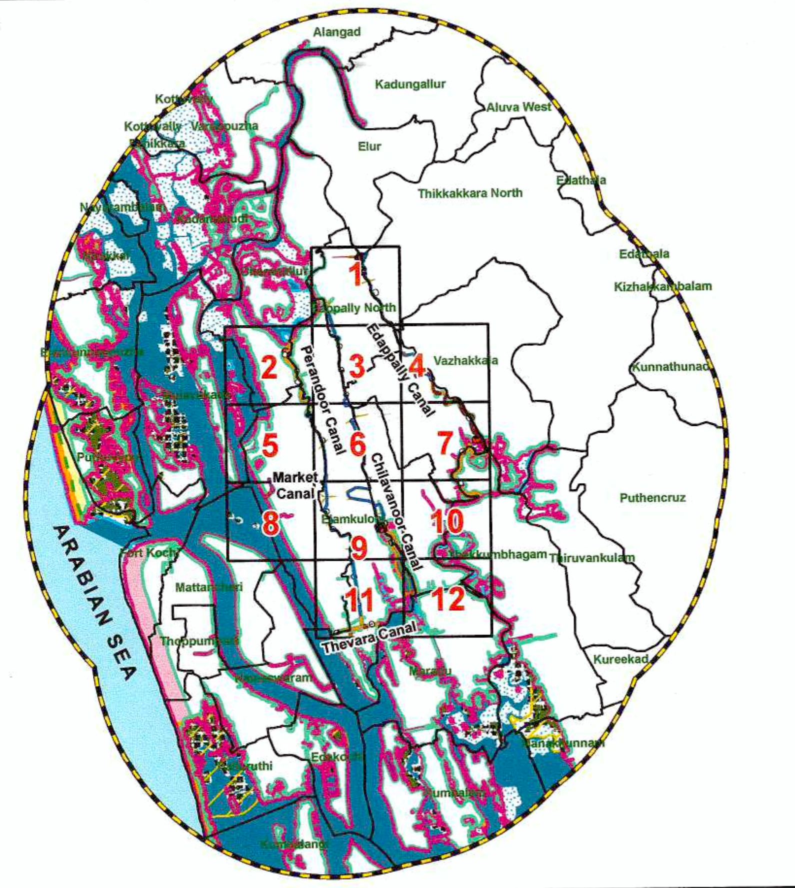
Note:

1. *Coastal Regulation Zone Map of the site is prepared considering Approved CZMP as per CRZ Notification 2011 of MoEF, GoI*
2. *Superimposition of the Project Site on Approved CZMP is subject to scale and generalisation error*
3. *The map comes with a report wherein description of CRZ zonation of project layout details are given. This map is to be referenced and used along with the report bearing the same reference no: AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)*
4. *The DGPS Survey was carried out specific to the referred project site boundary only hence, validation of HTL and CRZ Boundary is limited to the clearance of the same. Institute of Remote Sensing do not carry responsibility for CRZ status of other plots or neighbourhood.*

SCALE 1 : 50,000

0 625 1,250 2,500 3,750 5,000 M

INDEX MAP



PREPARED BY
INSTITUTE OF REMOTE SENSING
ANNA UNIVERSITY
CHENNAI - 600 025

REF NO. AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)

Proponent	FOR	Consultant
KOCHIN METRO RAIL LIMITED (KMRL) JLN METRO STATION, 4th FLOOR KALOOR, ERNAKULAM - 682 017.		WAPCOS LIMITED 76-C, INSTITUTIONAL AREA, SECTOR - 18, GURGAON - 122 015 HARYANA.

PREPARED BY	
VERIFIED BY	
APPROVED BY	Prof. D. Thirumalaivasan, B.E.M.Tech.,Ph.D., Director Institute of Remote Sensing Anna University, Chennai-600 025.

Preparation of Local Level Coastal Regulation Zone Map for the Proposed Project "Integrated Urban Regeneration and Water Transport System (IURWTS)" in Cochin, Kerala State by Superimposing on Approved CZMP as per CRZ Notification 2011

SHEET NO : 01/12

LEGEND

SOURCE : APPROVED CZMP (MAP NO : KL 31, 32, 34 & 35) AS PER CRZ NOTIFICATION 2011

- LOW TIDE LINE (LTL)
- HIGH TIDE LINE (HTL)
- 100m LINE IN CRZ - III AREA
- 200m CRZ LINE - NDZ
- CRZ BOUNDARY (500m FOR SEA, 100m FOR BAY, 50m FOR BACKWATER ISLAND, 100m OR WIDTH OF THE CREEK WHICHEVER IS LESS ALONG THE TIDAL INFLUENCED WATER BODIES)
- CRITICAL VULNERABLE COASTAL AREA BOUNDARY (CVCA)
- CRZ - IA
- CRZ - IA (50m MANGROVE BUFFER ZONE)
- CRZ - IB
- CRZ - II
- CRZ - III (NO DEVELOPMENT ZONE)
- CRZ - III (200m TO 500m FROM HTL)
- CRZ - IVA
- CRZ - IVB
- 7Km BUFFER LINE FROM PROJECT SITE
- HTL REFERENCE POINT

SOURCE : CLIENT

- PROPOSED PROJECT SITE DETAILS
- EXISTING STRUCTURE
- CHAINAGE LINE
- SURVEY BOUNDARY
- VILLAGE BOUNDARY
- PROPOSED STP
- PROPOSED JETTY
- PROPOSED SEWER LINE LAYING
- PROPOSED CANAL BANK BEAUTIFICATION
- PROPOSED BRIDGE / FOOT BRIDGE / EXISTING BRIDGE TO BE RECONSTRUCTION
- PROPOSED WALKWAY
- PROPOSED APPROACH ROAD
- PROPOSED DEEPENING & WIDENING OF EXISTING CANAL

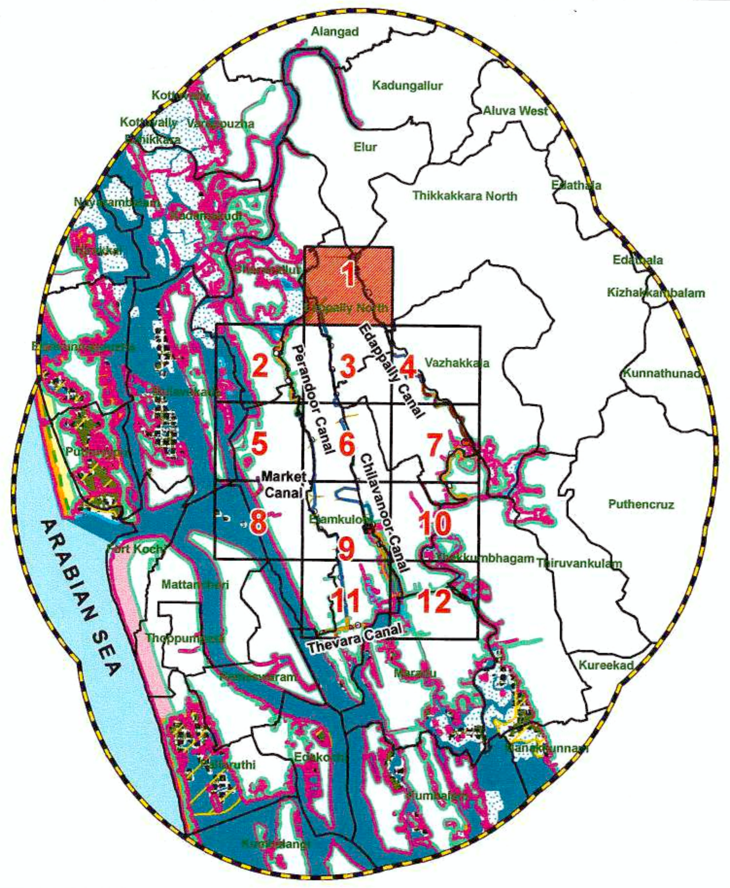
Note:

1. *Coastal Regulation Zone Map of the site is prepared considering Approved CZMP as per CRZ Notification 2011 of MoEF, GoI*
2. *Superimposition of the Project Site on Approved CZMP is subject to scale and generalisation error*
3. *The map comes with a report wherein description of CRZ zonation of project layout details are given. This map is to be referenced and used along with the report bearing the same reference no: AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)*
4. *The DGPS Survey was carried out specific to the referred project site boundary only hence, validation of HTL and CRZ Boundary is limited to the clearance of the same. Institute of Remote Sensing do not carry responsibility for CRZ status of other plots or neighbourhood.*

SCALE 1 : 4,000

0 50 100 200 300 400 M

INDEX MAP



PREPARED BY
INSTITUTE OF REMOTE SENSING
ANNA UNIVERSITY
CHENNAI - 600 025

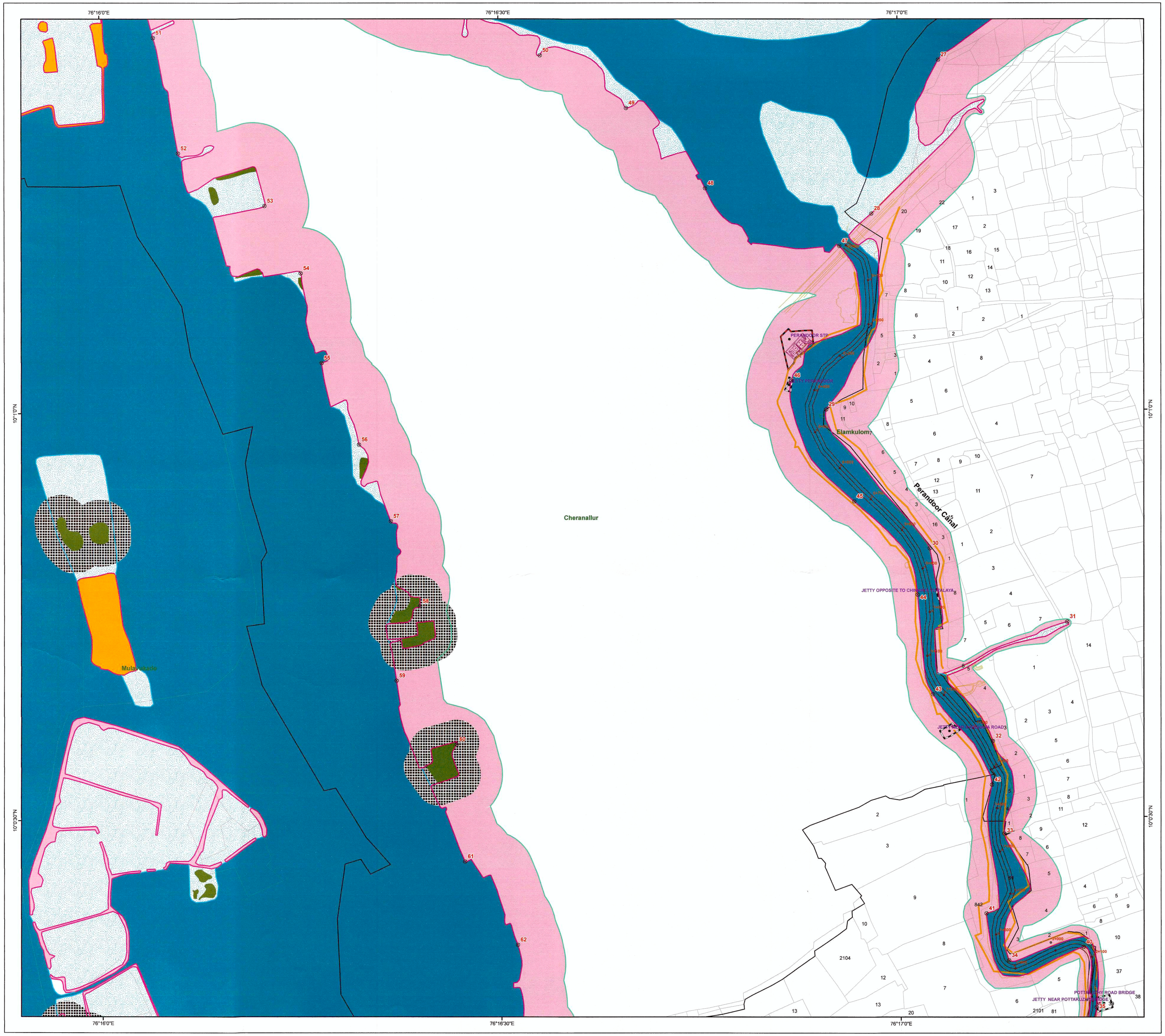
REF NO. AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)

Proponent	*FOR*	*Consultant*
KOCHIN METRO RAIL LIMITED (KMRL) JLN METRO STATION, 4th FLOOR KALOOR, ERNAKULAM - 682 017.		**WAPCOS LIMITED** 76-C, INSTITUTIONAL AREA, SECTOR - 18, GURGAON - 122 015 HARYANA.

PREPARED BY	[signature]
VERIFIED BY	[signature]
APPROVED BY	[signature] Prof. D. Thirumalaivasan, B.E.M.Tech.,Ph.D., Director Institute of Remote Sensing Anna University, Chennai-600 025.

Preparation of Local Level Coastal Regulation Zone Map for the Proposed Project "Integrated Urban Regeneration and Water Transport System (IURWTS)" in Cochin, Kerala State by Superimposing on Approved CZMP as per CRZ Notification 2011

SHEET NO : 02/12



LEGEND

SOURCE : APPROVED CZMP (MAP NO : KL 31, 32, 34 & 35) AS PER CRZ NOTIFICATION 2011

- LOW TIDE LINE (LTL)
- HIGH TIDE LINE (HTL)
- 100m LINE IN CRZ - III AREA
- 200m CRZ LINE - NDZ
- CRZ BOUNDARY (500m FOR SEA, 100m FOR BAY, 50m FOR BACKWATER ISLAND, 100m OR WIDTH OF THE CREEK WHICHEVER IS LESS ALONG THE TIDAL INFLUENCED WATER BODIES)
- CRITICAL VULNERABLE COASTAL AREA BOUNDARY (CVCA)
- CRZ - IA
- CRZ - IA (50m MANGROVE BUFFER ZONE)
- CRZ - IB
- CRZ - II
- CRZ - III (NO DEVELOPMENT ZONE)
- CRZ - III (200m TO 500m FROM HTL)
- CRZ - IVA
- CRZ - IVB
- 7Km BUFFER LINE FROM PROJECT SITE
- HTL REFERENCE POINT

SOURCE : CLIENT

- PROPOSED PROJECT SITE DETAILS
- EXISTING STRUCTURE
- CHAINAGE LINE
- SURVEY BOUNDARY
- VILLAGE BOUNDARY
- PROPOSED STP
- PROPOSED JETTY
- PROPOSED SEWER LINE LAYING
- PROPOSED CANAL BANK BEAUTIFICATION
- PROPOSED BRIDGE / FOOT BRIDGE / EXISTING BRIDGE TO BE RECONSTRUCTION
- PROPOSED WALKWAY
- PROPOSED APPROACH ROAD
- PROPOSED DEEPENING & WIDENING OF EXISTING CANAL

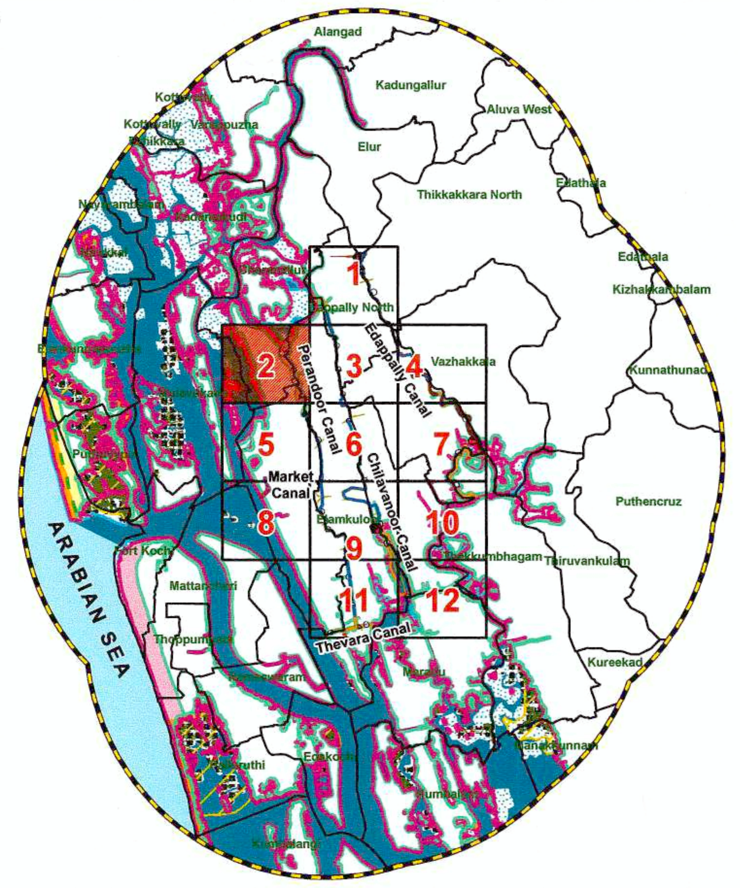
Note:

1. *Coastal Regulation Zone Map of the site is prepared considering Approved CZMP as per CRZ Notification 2011 of MoEF, GoI*
2. *Superimposition of the Project Site on Approved CZMP is subject to scale and generalisation error*
3. *The map comes with a report wherein description of CRZ zonation of project layout details are given. This map is to be referenced and used along with the report bearing the same reference no: AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)*
4. *The DGPS Survey was carried out specific to the referred project site boundary only hence, validation of HTL and CRZ Boundary is limited to the clearance of the same. Institute of Remote Sensing do not carry responsibility for CRZ status of other plots or neighbourhood.*

SCALE 1 : 4,000

0 50 100 200 300 400 M

INDEX MAP



PREPARED BY

INSTITUTE OF REMOTE SENSING
ANNA UNIVERSITY
CHENNAI - 600 025

REF NO. AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)

Proponent	FOR	Consultant
KOCHIN METRO RAIL LIMITED (KMRL) **JLN METRO STATION, 4th FLOOR** **KALOOR, ERNAKULAM - 682 017.**		**WAPCOS LIMITED** **76-C, INSTITUTIONAL AREA,** **SECTOR - 18, GURGAON - 122 015** **HARYANA.**

PREPARED BY	[signature]
VERIFIED BY	[signature]
APPROVED BY	[signature] Prof. D. Thirumalaivasan, B.E.M.Tech.,Ph.D., Director Institute of Remote Sensing Anna University, Chennai-600 025.

Preparation of Local Level Coastal Regulation Zone Map for the Proposed Project "Integrated Urban Regeneration and Water Transport System (IURWTS)" in Cochin, Kerala State by Superimposing on Approved CZMP as per CRZ Notification 2011

SHEET NO : 03/12

LEGEND

SOURCE : APPROVED CZMP (MAP NO : KL 31, 32, 34 & 35) AS PER CRZ NOTIFICATION 2011

- LOW TIDE LINE (LTL)
- HIGH TIDE LINE (HTL)
- 100m LINE IN CRZ - III AREA
- 200m CRZ LINE - NDZ
- CRZ BOUNDARY (500m FOR SEA, 100m FOR BAY, 50m FOR BACKWATER ISLAND, 100m OR WIDTH OF THE CREEK WHICHEVER IS LESS ALONG THE TIDAL INFLUENCED WATER BODIES)
- CRITICAL VULNERABLE COASTAL AREA BOUNDARY (CVCA)
- CRZ - IA
- CRZ - IA (50m MANGROVE BUFFER ZONE)
- CRZ - IB
- CRZ - II
- CRZ - III (NO DEVELOPMENT ZONE)
- CRZ - III (200m TO 500m FROM HTL)
- CRZ - IVA
- CRZ - IVB
- 7Km BUFFER LINE FROM PROJECT SITE
- HTL REFERENCE POINT

SOURCE : CLIENT

- PROPOSED PROJECT SITE DETAILS
- EXISTING STRUCTURE
- CHAINAGE LINE
- SURVEY BOUNDARY
- VILLAGE BOUNDARY
- PROPOSED STP
- PROPOSED JETTY
- PROPOSED SEWER LINE LAYING
- PROPOSED CANAL BANK BEAUTIFICATION
- PROPOSED BRIDGE / FOOT BRIDGE / EXISTING BRIDGE TO BE RECONSTRUCTION
- PROPOSED WALKWAY
- PROPOSED APPROACH ROAD
- PROPOSED DEEPENING & WIDENING OF EXISTING CANAL

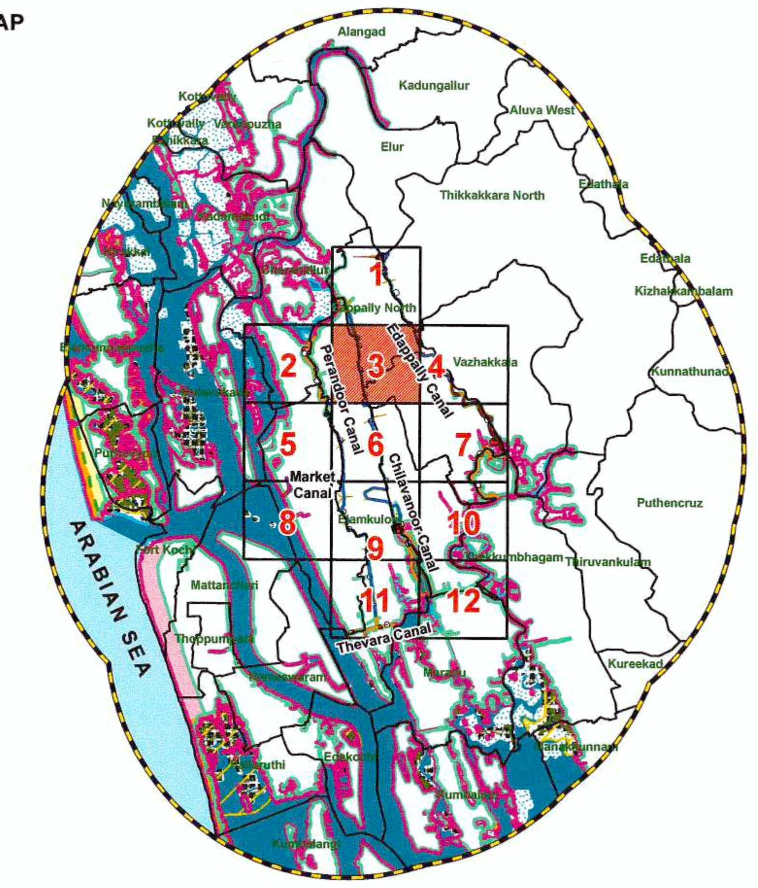
Note:

1. *Coastal Regulation Zone Map of the site is prepared considering Approved CZMP as per CRZ Notification 2011 of MoEF, GoI*
2. *Superimposition of the Project Site on Approved CZMP is subject to scale and generalisation error*
3. *The map comes with a report wherein description of CRZ zonation of project layout details are given. This map is to be referenced and used along with the report bearing the same reference no: AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)*
4. *The DGPS Survey was carried out specific to the referred project site boundary only hence, validation of HTL and CRZ Boundary is limited to the clearance of the same. Institute of Remote Sensing do not carry responsibility for CRZ status of other plots or neighbourhood.*

SCALE 1 : 4,000

0 50 100 200 300 400 M

INDEX MAP



PREPARED BY

INSTITUTE OF REMOTE SENSING
ANNA UNIVERSITY
CHENNAI - 600 025

REF NO. AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)

Proponent	FOR	Consultant
KOCHIN METRO RAIL LIMITED (KMRL) **JLN METRO STATION, 4th FLOOR** **KALOOR, ERNAKULAM - 682 017.**		**WAPCOS LIMITED** **76-C, INSTITUTIONAL AREA,** **SECTOR - 18, GURGAON - 122 015** **HARYANA.**

PREPARED BY	[signature]
VERIFIED BY	[signature]
APPROVED BY	[signature] Prof. D. Thirumalaivasan, B.E.M.Tech.,Ph.D., Director Institute of Remote Sensing Anna University, Chennai-600 025.

Preparation of Local Level Coastal Regulation Zone Map for the Proposed Project "Integrated Urban Regeneration and Water Transport System (IURWTS)" in Cochin, Kerala State by Superimposing on Approved CZMP as per CRZ Notification 2011

SHEET NO : 04/12

LEGEND

SOURCE : APPROVED CZMP (MAP NO : KL 31, 32, 34 & 35) AS PER CRZ NOTIFICATION 2011

- LOW TIDE LINE (LTL)
- HIGH TIDE LINE (HTL)
- 100m LINE IN CRZ - III AREA
- 200m CRZ LINE - NDZ
- CRZ BOUNDARY (500m FOR SEA, 100m FOR BAY, 50m FOR BACKWATER ISLAND, 100m OR WIDTH OF THE CREEK WHICHEVER IS LESS ALONG THE TIDAL INFLUENCED WATER BODIES)
- CRITICAL VULNERABLE COASTAL AREA BOUNDARY (CVCA)
- CRZ - IA
- CRZ - IA (50m MANGROVE BUFFER ZONE)
- CRZ - IB
- CRZ - II
- CRZ - III (NO DEVELOPMENT ZONE)
- CRZ - III (200m TO 500m FROM HTL)
- CRZ - IVA
- CRZ - IVB
- 7Km BUFFER LINE FROM PROJECT SITE
- HTL REFERENCE POINT

SOURCE : CLIENT

- PROPOSED PROJECT SITE DETAILS
- EXISTING STRUCTURE
- CHAINAGE LINE
- SURVEY BOUNDARY
- VILLAGE BOUNDARY
- PROPOSED STP
- PROPOSED JETTY
- PROPOSED SEWER LINE LAYING
- PROPOSED CANAL BANK BEAUTIFICATION
- PROPOSED BRIDGE / FOOT BRIDGE / EXISTING BRIDGE TO BE RECONSTRUCTION
- PROPOSED WALKWAY
- PROPOSED APPROACH ROAD
- PROPOSED DEEPENING & WIDENING OF EXISTING CANAL

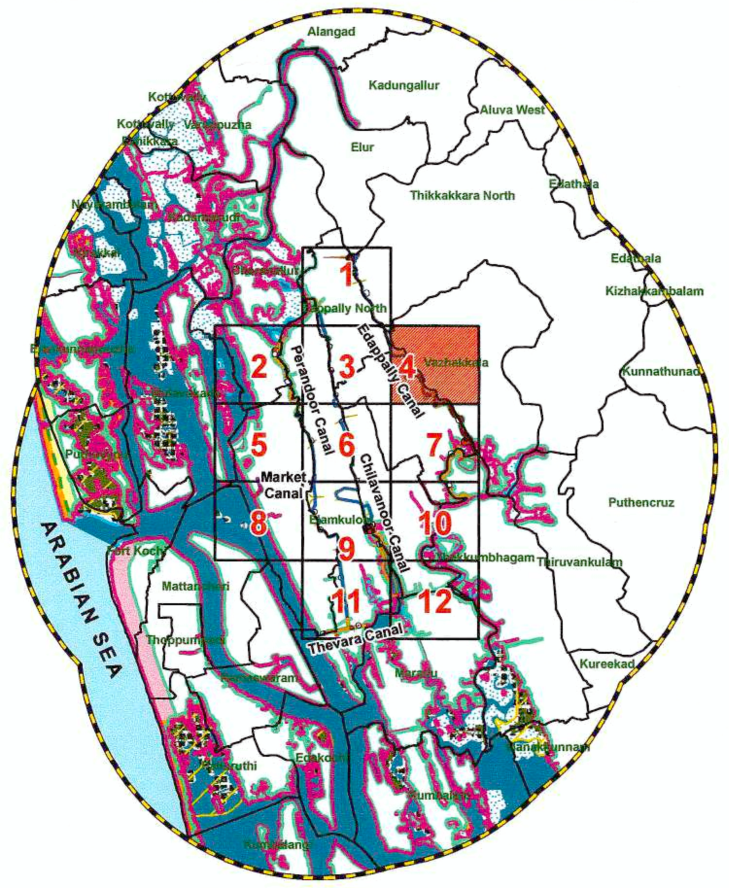
Note:

1. *Coastal Regulation Zone Map of the site is prepared considering Approved CZMP as per CRZ Notification 2011 of MoEF, GoI*
2. *Superimposition of the Project Site on Approved CZMP is subject to scale and generalisation error*
3. *The map comes with a report wherein description of CRZ zonation of project layout details are given. This map is to be referenced and used along with the report bearing the same reference no: AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)*
4. *The DGPS Survey was carried out specific to the referred project site boundary only hence, validation of HTL and CRZ Boundary is limited to the clearance of the same. Institute of Remote Sensing do not carry responsibility for CRZ status of other plots or neighbourhood.*

SCALE 1 : 4,000

0 50 100 200 300 400 M

INDEX MAP



PREPARED BY

INSTITUTE OF REMOTE SENSING
ANNA UNIVERSITY
CHENNAI - 600 025

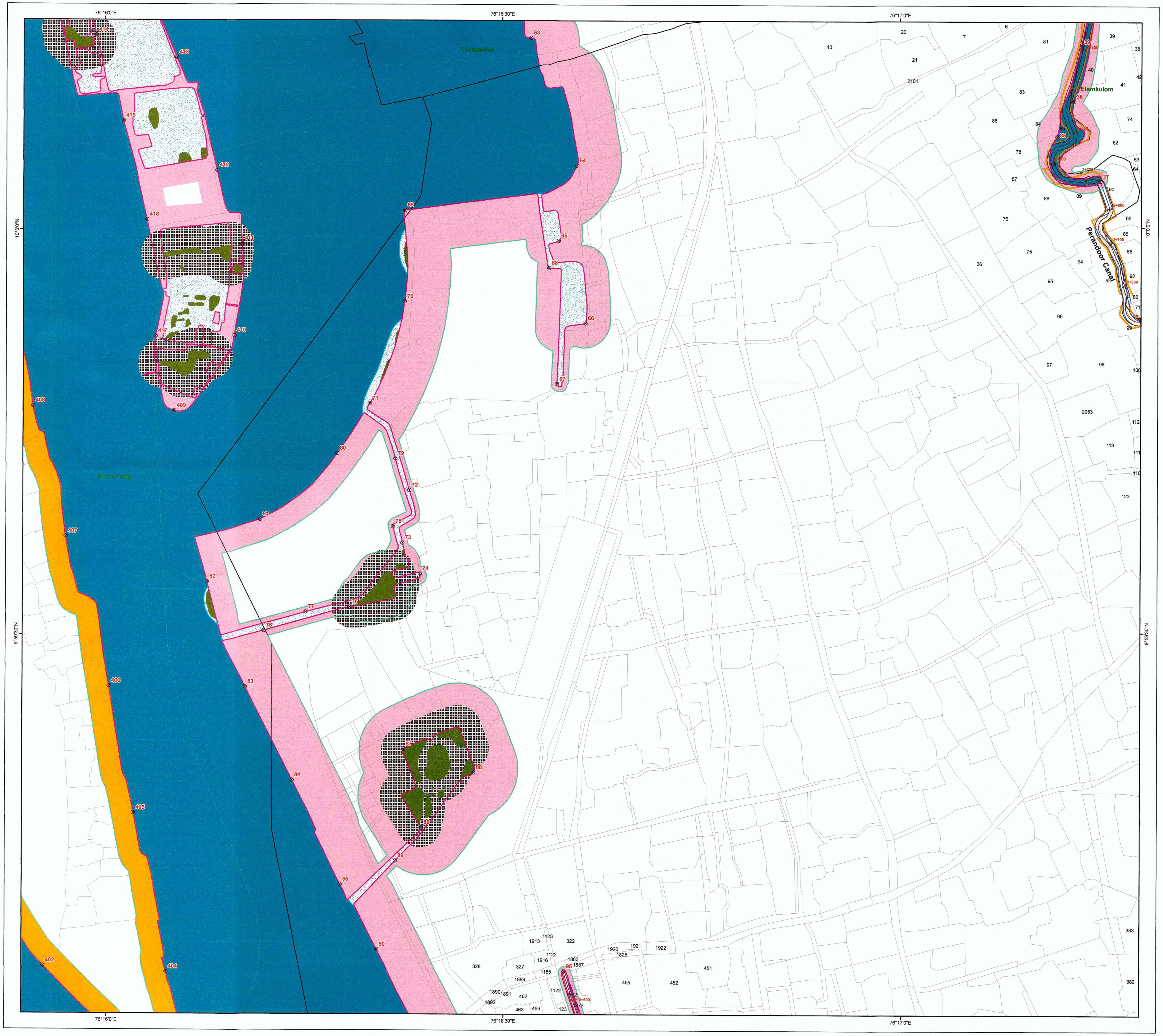
REF NO. AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)

Proponent	*FOR*	*Consultant*
KOCHIN METRO RAIL LIMITED (KMRL) **JLN METRO STATION, 4th FLOOR** **KALOOR, ERNAKULAM - 682 017.**		**WAPCOS LIMITED** **76-C, INSTITUTIONAL AREA,** **SECTOR - 18, GURGAON - 122 015** **HARYANA.**

PREPARED BY	[signature]
VERIFIED BY	[signature]
APPROVED BY	[signature] Prof. D. Thirumalaivasan, B.E.M.Tech.,Ph.D., Director Institute of Remote Sensing Anna University, Chennai-600 025.

Preparation of Local Level Coastal Regulation Zone Map for the Proposed Project "Integrated Urban Regeneration and Water Transport System (IURWTS)" in Cochin, Kerala State by Superimposing on Approved CZMP as per CRZ Notification 2011

SHEET NO : 05/12



LEGEND

N

SOURCE : APPROVED CZMP (MAP NO : KL 31, 32, 34 & 35) AS PER CRZ NOTIFICATION 2011

- LOW TIDE LINE (LTL)
- HIGH TIDE LINE (HTL)
- 100m LINE IN CRZ - III AREA
- 200m CRZ LINE - NDZ
- CRZ BOUNDARY (500m FOR SEA, 100m FOR BAY, 50m FOR BACKWATER ISLAND, 100m OR WIDTH OF THE CREEK WHICHEVER IS LESS ALONG THE TIDAL INFLUENCED WATER BODIES)
- CRITICAL VULNERABLE COASTAL AREA BOUNDARY (CVCA)
- CRZ - IA
- CRZ - IA (50m MANGROVE BUFFER ZONE)
- CRZ - IB
- CRZ - II
- CRZ - III (NO DEVELOPMENT ZONE)
- CRZ - III (200m TO 500m FROM HTL)
- CRZ - IVA
- CRZ - IVB
- 7Km BUFFER LINE FROM PROJECT SITE
- ⊗ HTL REFERENCE POINT

SOURCE : CLIENT

- PROPOSED PROJECT SITE DETAILS
- EXISTING STRUCTURE
- CHAINAGE LINE
- SURVEY BOUNDARY
- VILLAGE BOUNDARY
- PROPOSED STP
- PROPOSED JETTY
- PROPOSED SEWER LINE LAYING
- PROPOSED CANAL BANK BEAUTIFICATION
- PROPOSED BRIDGE / FOOT BRIDGE / EXISTING BRIDGE TO BE RECONSTRUCTION
- PROPOSED WALKWAY
- PROPOSED APPROACH ROAD
- PROPOSED DEEPENING & WIDENING OF EXISTING CANAL

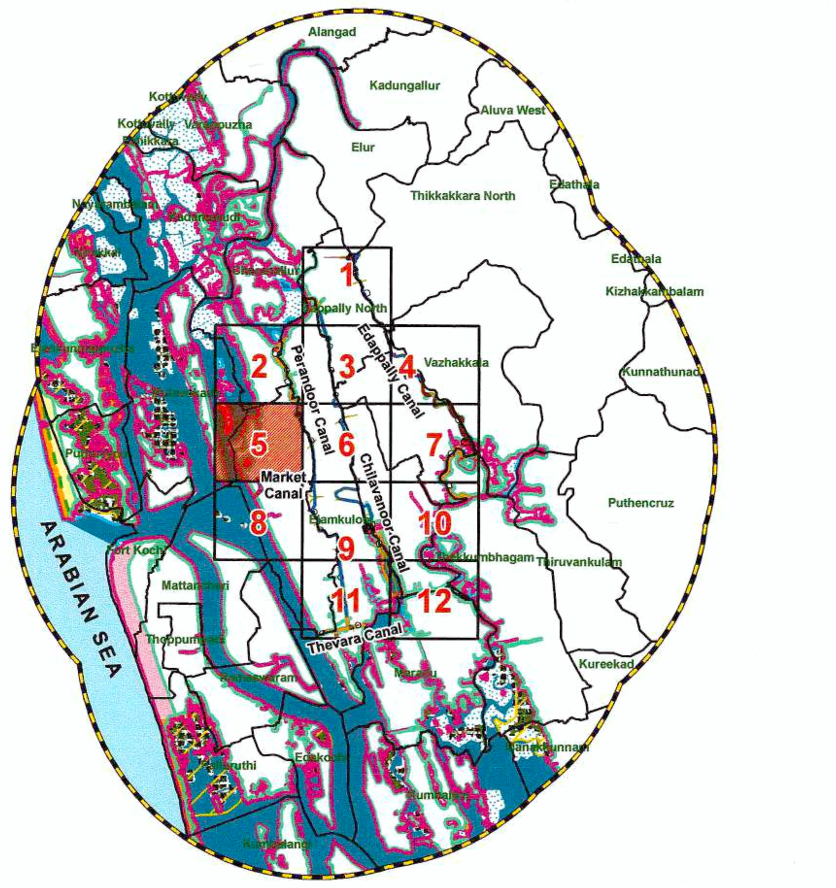
Note:

1. *Coastal Regulation Zone Map of the site is prepared considering Approved CZMP as per CRZ Notification 2011 of MoEF, GoI*
2. *Superimposition of the Project Site on Approved CZMP is subject to scale and generalisation error*
3. *The map comes with a report wherein description of CRZ zonation of project layout details are given. This map is to be referenced and used along with the report bearing the same reference no: AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)*
4. *The DGPS Survey was carried out specific to the referred project site boundary only hence, validation of HTL and CRZ Boundary is limited to the clearance of the same. Institute of Remote Sensing do not carry responsibility for CRZ status of other plots or neighbourhood.*

SCALE 1 : 4,000

0 50 100 200 300 400 M

INDEX MAP



PREPARED BY
INSTITUTE OF REMOTE SENSING
ANNA UNIVERSITY
CHENNAI - 600 025

REF NO. AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)

FOR

Proponent	*Consultant*
KOCHIN METRO RAIL LIMITED (KMRL) **JLN METRO STATION, 4th FLOOR** **KALOOR, ERNAKULAM - 682 017.**	**WAPCOS LIMITED** **76-C, INSTITUTIONAL AREA,** **SECTOR - 18, GURGAON - 122 015** **HARYANA.**

PREPARED BY	[signature]
VERIFIED BY	[signature]
APPROVED BY	[signature] Prof. D. Thirumalaivasan, B.E.M.Tech.,Ph.D., Director Institute of Remote Sensing Anna University, Chennai-600 025.

"Prem...!"

Preparation of Local Level Coastal Regulation Zone Map for the Proposed Project "Integrated Urban Regeneration and Water Transport System (IURWTS)" in Cochin, Kerala State by Superimposing on Approved CZMP as per CRZ Notification 2011

SHEET NO : 06/12

LEGEND

SOURCE : APPROVED CZMP (MAP NO : KL 31, 32, 34 & 35) AS PER CRZ NOTIFICATION 2011

- LOW TIDE LINE (LTL)
- HIGH TIDE LINE (HTL)
- 100m LINE IN CRZ - III AREA
- 200m CRZ LINE - NDZ
- CRZ BOUNDARY (500m FOR SEA, 100m FOR BAY, 50m FOR BACKWATER ISLAND, 100m OR WIDTH OF THE CREEK WHICHEVER IS LESS ALONG THE TIDAL INFLUENCED WATER BODIES)
- CRITICAL VULNERABLE COASTAL AREA BOUNDARY (CVCA)
- CRZ - IA
- CRZ - IA (50m MANGROVE BUFFER ZONE)
- CRZ - IB
- CRZ - II
- CRZ - III (NO DEVELOPMENT ZONE)
- CRZ - III (200m TO 500m FROM HTL)
- CRZ - IVA
- CRZ - IVB
- 7Km BUFFER LINE FROM PROJECT SITE
- HTL REFERENCE POINT

SOURCE : CLIENT

- PROPOSED PROJECT SITE DETAILS
- EXISTING STRUCTURE
- CHAINAGE LINE
- SURVEY BOUNDARY
- VILLAGE BOUNDARY
- PROPOSED STP
- PROPOSED JETTY
- PROPOSED SEWER LINE LAYING
- PROPOSED CANAL BANK BEAUTIFICATION
- PROPOSED BRIDGE / FOOT BRIDGE / EXISTING BRIDGE TO BE RECONSTRUCTION
- PROPOSED WALKWAY
- PROPOSED APPROACH ROAD
- PROPOSED DEEPENING & WIDENING OF EXISTING CANAL

N

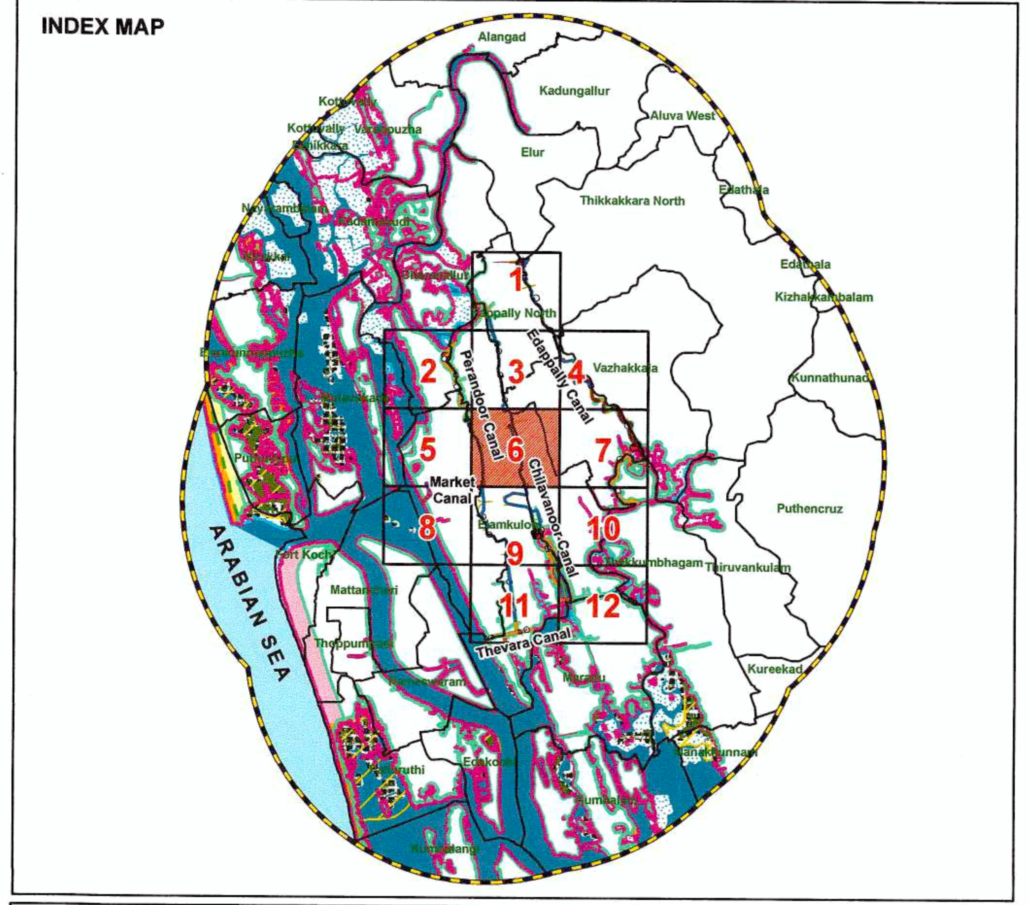
Note:

1. *Coastal Regulation Zone Map of the site is prepared considering Approved CZMP as per CRZ Notification 2011 of MoEF, GoI*
2. *Superimposition of the Project Site on Approved CZMP is subject to scale and generalisation error*
3. *The map comes with a report wherein description of CRZ zonation of project layout details are given. This map is to be referenced and used along with the report bearing the same reference no: AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)*
4. *The DGPS Survey was carried out specific to the referred project site boundary only hence, validation of HTL and CRZ Boundary is limited to the clearance of the same. Institute of Remote Sensing do not carry responsibility for CRZ status of other plots or neighbourhood.*

SCALE 1 : 4,000

0 50 100 200 300 400 M

INDEX MAP



PREPARED BY

INSTITUTE OF REMOTE SENSING
ANNA UNIVERSITY
CHENNAI - 600 025

REF NO. AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)

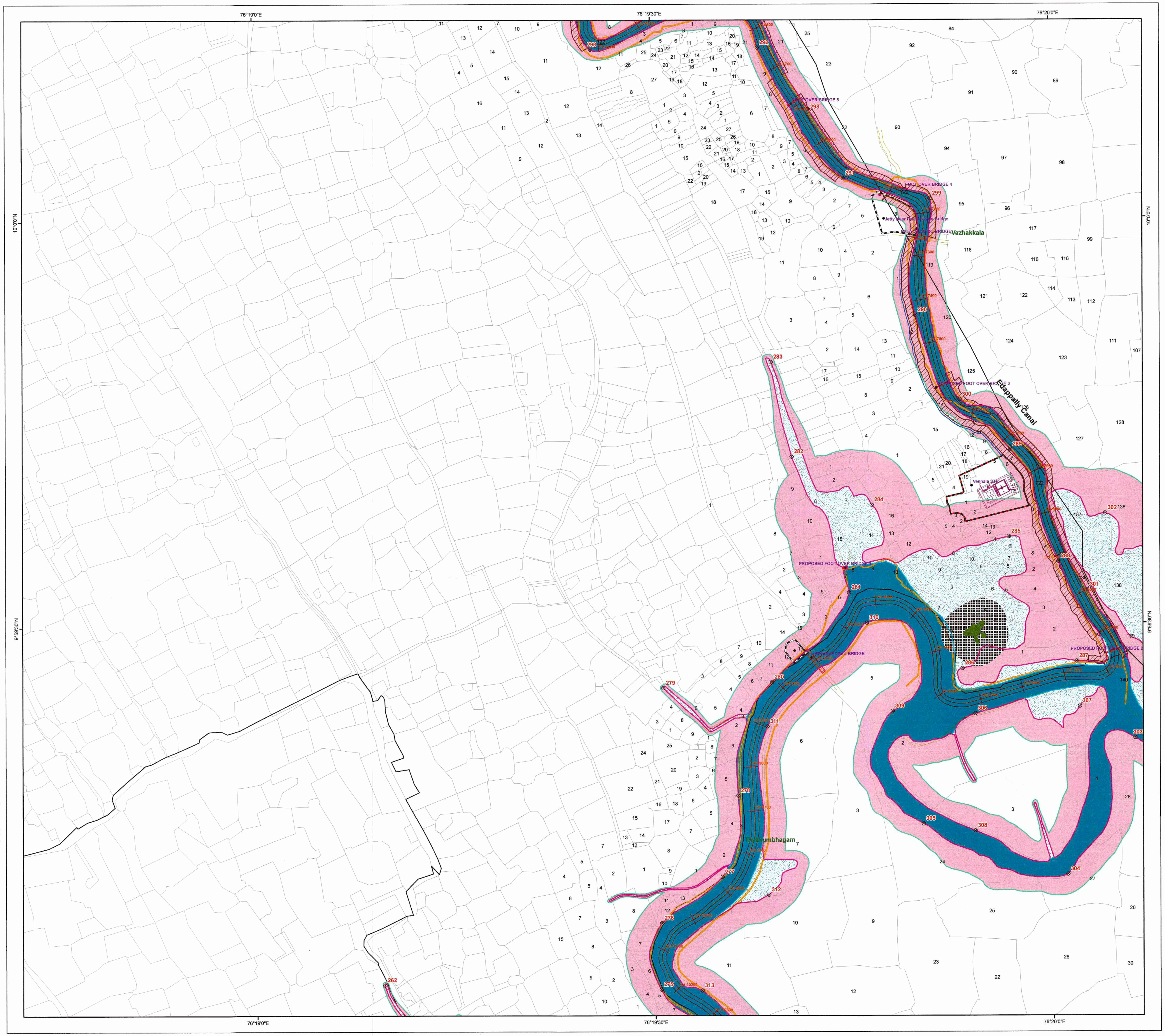
Proponent	*FOR* *Consultant*
KOCHIN METRO RAIL LIMITED (KMRL) JLN METRO STATION, 4th FLOOR KALOOR, ERNAKULAM - 682 017.	**WAPCOS LIMITED 76-C, INSTITUTIONAL AREA, SECTOR - 18, GURGAON - 122 015 HARYANA.**

PREPARED BY	[signature]
VERIFIED BY	[signature]
APPROVED BY	[signature] Prof. D. Thirumalaivasan, B.E.M.Tech.,Ph.D., Director Institute of Remote Sensing Anna University, Chennai-600 025.

"Prem...!"

Preparation of Local Level Coastal Regulation Zone Map for the Proposed Project "Integrated Urban Regeneration and Water Transport System (IURWTS)" in Cochin, Kerala State by Superimposing on Approved CZMP as per CRZ Notification 2011

SHEET NO : 07/12



LEGEND

SOURCE : APPROVED CZMP (MAP NO : KL 31, 32, 34 & 35) AS PER CRZ NOTIFICATION 2011

- LOW TIDE LINE (LTL)
- HIGH TIDE LINE (HTL)
- 100m LINE IN CRZ - III AREA
- 200m CRZ LINE - NDZ
- CRZ BOUNDARY (500m FOR SEA, 100m FOR BAY, 50m FOR BACKWATER ISLAND, 100m OR WIDTH OF THE CREEK WHICHEVER IS LESS ALONG THE TIDAL INFLUENCED WATER BODIES)
- CRITICAL VULNERABLE COASTAL AREA BOUNDARY (CVCA)
- CRZ - IA
- CRZ - IA (50m MANGROVE BUFFER ZONE)
- CRZ - IB
- CRZ - II
- CRZ - III (NO DEVELOPMENT ZONE)
- CRZ - III (200m TO 500m FROM HTL)
- CRZ - IVA
- CRZ - IVB
- 7Km BUFFER LINE FROM PROJECT SITE
- HTL REFERENCE POINT

SOURCE : CLIENT

- PROPOSED PROJECT SITE DETAILS
- EXISTING STRUCTURE
- CHAINAGE LINE
- SURVEY BOUNDARY
- VILLAGE BOUNDARY
- PROPOSED STP
- PROPOSED JETTY
- PROPOSED SEWER LINE LAYING
- PROPOSED CANAL BANK BEAUTIFICATION
- PROPOSED BRIDGE / FOOT BRIDGE / EXISTING BRIDGE TO BE RECONSTRUCTION
- PROPOSED WALKWAY
- PROPOSED APPROACH ROAD
- PROPOSED DEEPENING & WIDENING OF EXISTING CANAL

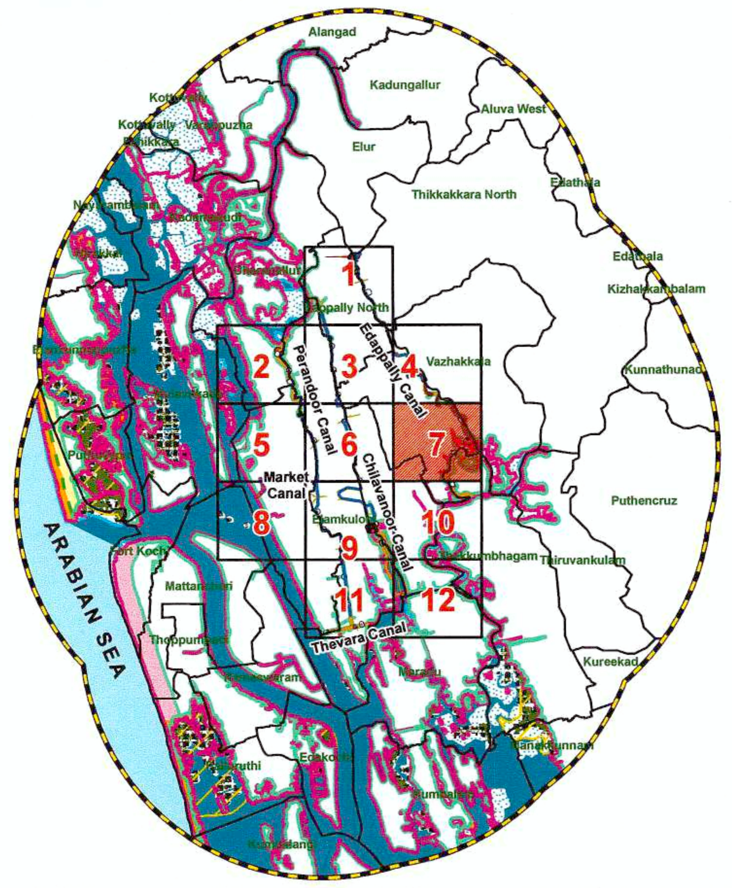
Note:

1. *Coastal Regulation Zone Map of the site is prepared considering Approved CZMP as per CRZ Notification 2011 of MoEF, GoI*
2. *Superimposition of the Project Site on Approved CZMP is subject to scale and generalisation error*
3. *The map comes with a report wherein description of CRZ zonation of project layout details are given. This map is to be referenced and used along with the report bearing the same reference no: AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)*
4. *The DGPS Survey was carried out specific to the referred project site boundary only hence, validation of HTL and CRZ Boundary is limited to the clearance of the same. Institute of Remote Sensing do not carry responsibility for CRZ status of other plots or neighbourhood.*

SCALE 1 : 4,000

0 50 100 200 300 400 M

INDEX MAP



PREPARED BY

INSTITUTE OF REMOTE SENSING
ANNA UNIVERSITY
CHENNAI - 600 025

REF NO. AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)

Proponent	FOR	Consultant
KOCHIN METRO RAIL LIMITED (KMRL) **JLN METRO STATION, 4th FLOOR** **KALOOR, ERNAKULAM - 682 017.**		**WAPCOS LIMITED** **76-C, INSTITUTIONAL AREA,** **SECTOR - 18, GURGAON - 122 015** **HARYANA.**

PREPARED BY	[signature]
VERIFIED BY	[signature]
APPROVED BY	[signature] Prof. D. Thirumalaivasan, B.E.M.Tech.,Ph.D. Director Institute of Remote Sensing Anna University, Chennai-600 025.

Preparation of Local Level Coastal Regulation Zone Map for the Proposed Project "Integrated Urban Regeneration and Water Transport System (IURWTS)" in Cochin, Kerala State by Superimposing on Approved CZMP as per CRZ Notification 2011

SHEET NO : 08/12

LEGEND

SOURCE : APPROVED CZMP (MAP NO : KL 31, 32, 34 & 35) AS PER CRZ NOTIFICATION 2011

- LOW TIDE LINE (LTL)
- HIGH TIDE LINE (HTL)
- 100m LINE IN CRZ - III AREA
- 200m CRZ LINE - NDZ
- CRZ BOUNDARY (500m FOR SEA, 100m FOR BAY, 50m FOR BACKWATER ISLAND, 100m OR WIDTH OF THE CREEK WHICHEVER IS LESS ALONG THE TIDAL INFLUENCED WATER BODIES)
- CRITICAL VULNERABLE COASTAL AREA BOUNDARY (CVCA)
- CRZ - IA
- CRZ - IA (50m MANGROVE BUFFER ZONE)
- CRZ - IB
- CRZ - II
- CRZ - III (NO DEVELOPMENT ZONE)
- CRZ - III (200m TO 500m FROM HTL)
- CRZ - IVA
- CRZ - IVB
- 7Km BUFFER LINE FROM PROJECT SITE
- HTL REFERENCE POINT

SOURCE : CLIENT

- PROPOSED PROJECT SITE DETAILS
- EXISTING STRUCTURE
- CHAINAGE LINE
- SURVEY BOUNDARY
- VILLAGE BOUNDARY
- PROPOSED STP
- PROPOSED JETTY
- PROPOSED SEWER LINE LAYING
- PROPOSED CANAL BANK BEAUTIFICATION
- PROPOSED BRIDGE / FOOT BRIDGE / EXISTING BRIDGE TO BE RECONSTRUCTION
- PROPOSED WALKWAY
- PROPOSED APPROACH ROAD
- PROPOSED DEEPENING & WIDENING OF EXISTING CANAL

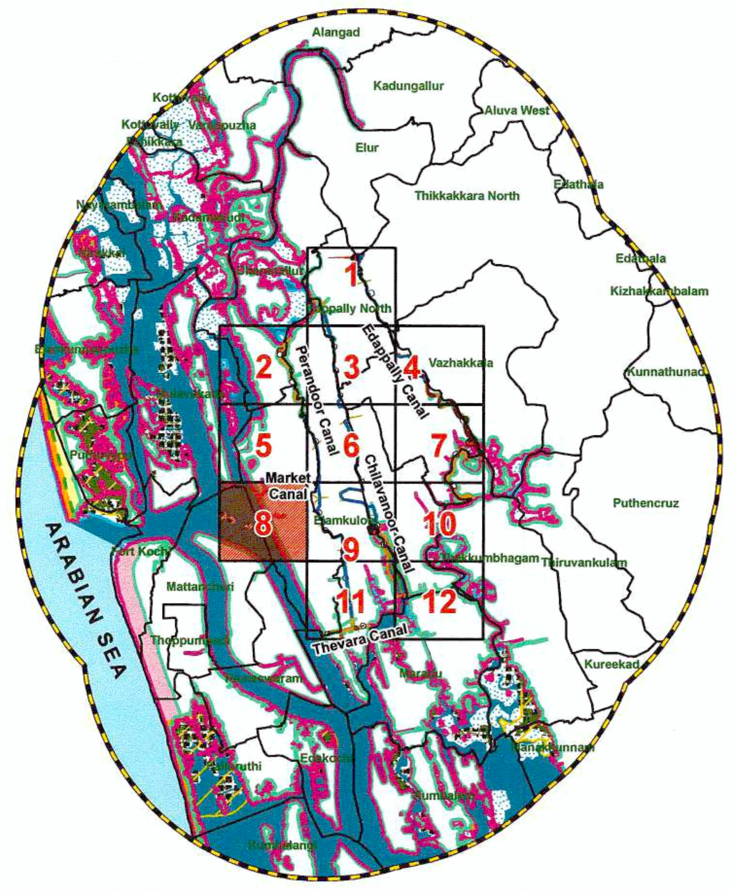
Note:

1. *Coastal Regulation Zone Map of the site is prepared considering Approved CZMP as per CRZ Notification 2011 of MoEF, GoI*
2. *Superimposition of the Project Site on Approved CZMP is subject to scale and generalisation error*
3. *The map comes with a report wherein description of CRZ zonation of project layout details are given. This map is to be referenced and used along with the report bearing the same reference no: AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)*
4. *The DGPS Survey was carried out specific to the referred project site boundary only hence, validation of HTL and CRZ Boundary is limited to the clearance of the same. Institute of Remote Sensing do not carry responsibility for CRZ status of other plots or neighbourhood.*

SCALE 1 : 4,000

0 50 100 200 300 400 M

INDEX MAP



PREPARED BY

INSTITUTE OF REMOTE SENSING
ANNA UNIVERSITY
CHENNAI - 600 025

REF NO. AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)

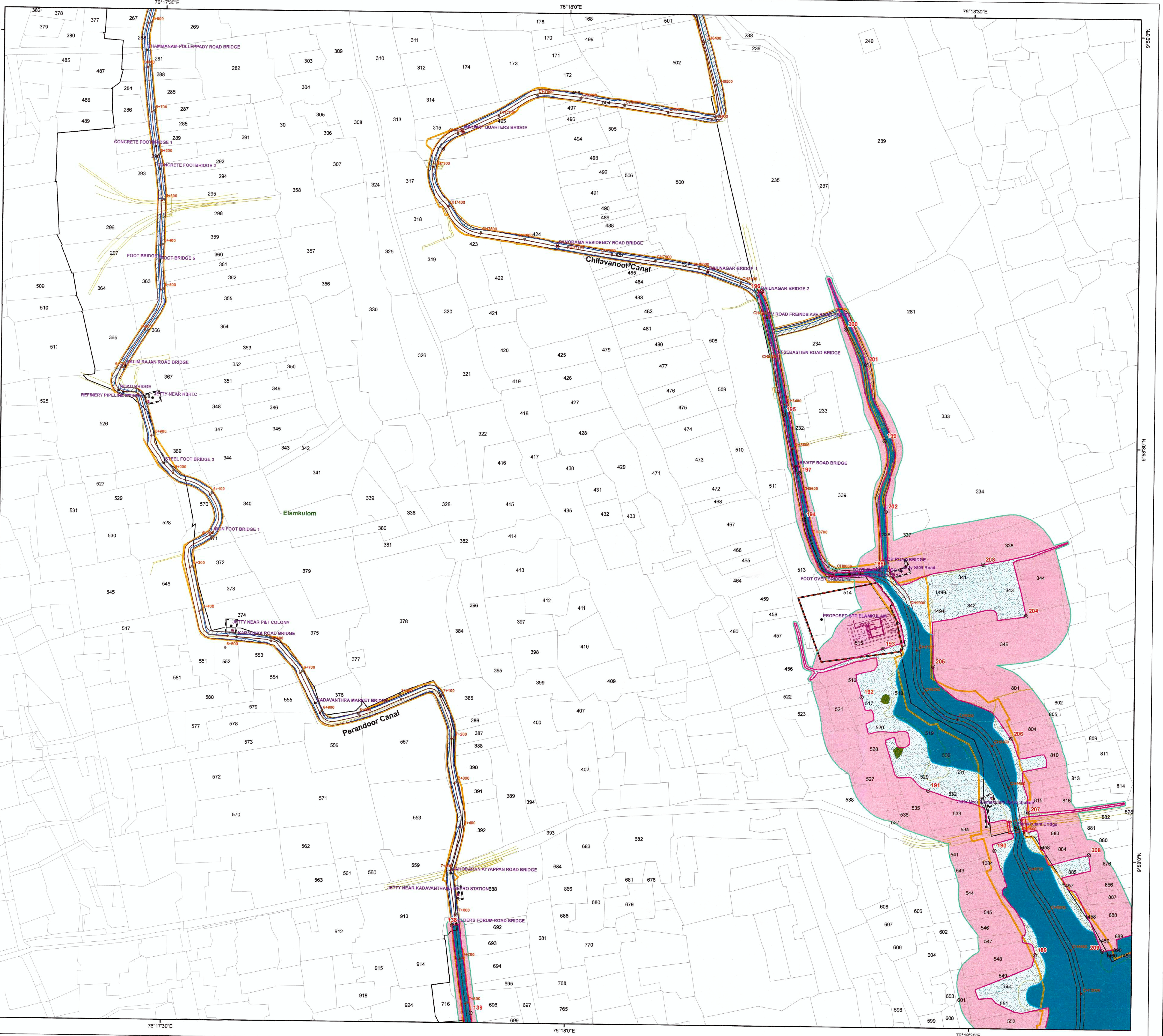
Proponent	*FOR*	*Consultant*
KOCHIN METRO RAIL LIMITED (KMRL) JLN METRO STATION, 4th FLOOR KALOOR, ERNAKULAM - 682 017.		**WAPCOS LIMITED 76-C, INSTITUTIONAL AREA, SECTOR - 18, GURGAON - 122 015 HARYANA.**

PREPARED BY	[signature]
VERIFIED BY	[signature]
APPROVED BY	[signature] 24/12/21 Prof. D. Thirumalaivasan, B.E.M.Tech.,Ph.D., Director Institute of Remote Sensing Anna University, Chennai-600 025.

"Prem...!"

Preparation of Local Level Coastal Regulation Zone Map for the Proposed Project "Integrated Urban Regeneration and Water Transport System (IURWTS)" in Cochin, Kerala State by Superimposing on Approved CZMP as per CRZ Notification 2011

SHEET NO : 09/12



LEGEND

SOURCE : APPROVED CZMP (MAP NO : KL 31, 32, 34 & 35) AS PER CRZ NOTIFICATION 2011

- LOW TIDE LINE (LTL)
- HIGH TIDE LINE (HTL)
- 100m LINE IN CRZ - III AREA
- 200m CRZ LINE - NDZ
- CRZ BOUNDARY (500m FOR SEA, 100m FOR BAY, 50m FOR BACKWATER ISLAND, 100m OR WIDTH OF THE CREEK WHICHEVER IS LESS ALONG THE TIDAL INFLUENCED WATER BODIES)
- CRITICAL VULNERABLE COASTAL AREA BOUNDARY (CVCA)
- CRZ - IA
- CRZ - IA (50m MANGROVE BUFFER ZONE)
- CRZ - IB
- CRZ - II
- CRZ - III (NO DEVELOPMENT ZONE)
- CRZ - III (200m TO 500m FROM HTL)
- CRZ - IVA
- CRZ - IVB
- 7Km BUFFER LINE FROM PROJECT SITE
- HTL REFERENCE POINT

SOURCE : CLIENT

- PROPOSED PROJECT SITE DETAILS
- EXISTING STRUCTURE
- CHAINAGE LINE
- SURVEY BOUNDARY
- VILLAGE BOUNDARY
- PROPOSED STP
- PROPOSED JETTY
- PROPOSED SEWER LINE LAYING
- PROPOSED CANAL BANK BEAUTIFICATION
- PROPOSED BRIDGE / FOOT BRIDGE / EXISTING BRIDGE TO BE RECONSTRUCTION
- PROPOSED WALKWAY
- PROPOSED APPROACH ROAD
- PROPOSED DEEPENING & WIDENING OF EXISTING CANAL

N

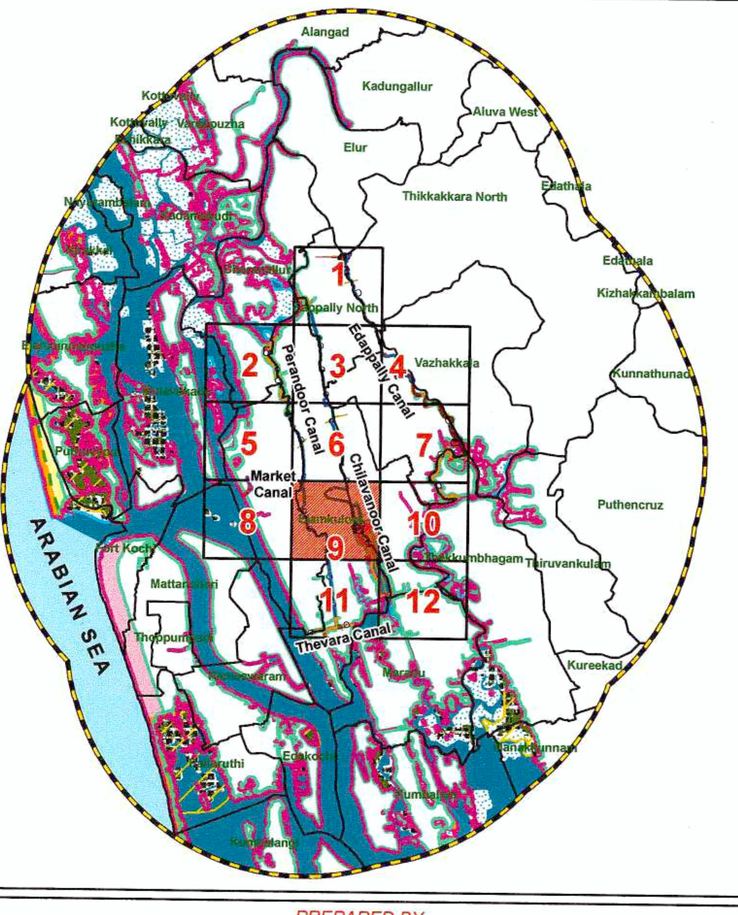
Note:

1. *Coastal Regulation Zone Map of the site is prepared considering Approved CZMP as per CRZ Notification 2011 of MoEF, GoI*
2. *Superimposition of the Project Site on Approved CZMP is subject to scale and generalisation error*
3. *The map comes with a report wherein description of CRZ zonation of project layout details are given. This map is to be referenced and used along with the report bearing the same reference no: AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)*
4. *The DGPS Survey was carried out specific to the referred project site boundary only hence, validation of HTL and CRZ Boundary is limited to the clearance of the same. Institute of Remote Sensing do not carry responsibility for CRZ status of other plots or neighbourhood.*

SCALE 1 : 4,000

0 50 100 200 300 400 M

INDEX MAP



PREPARED BY

INSTITUTE OF REMOTE SENSING
ANNA UNIVERSITY
CHENNAI - 600 025

REF NO. AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)

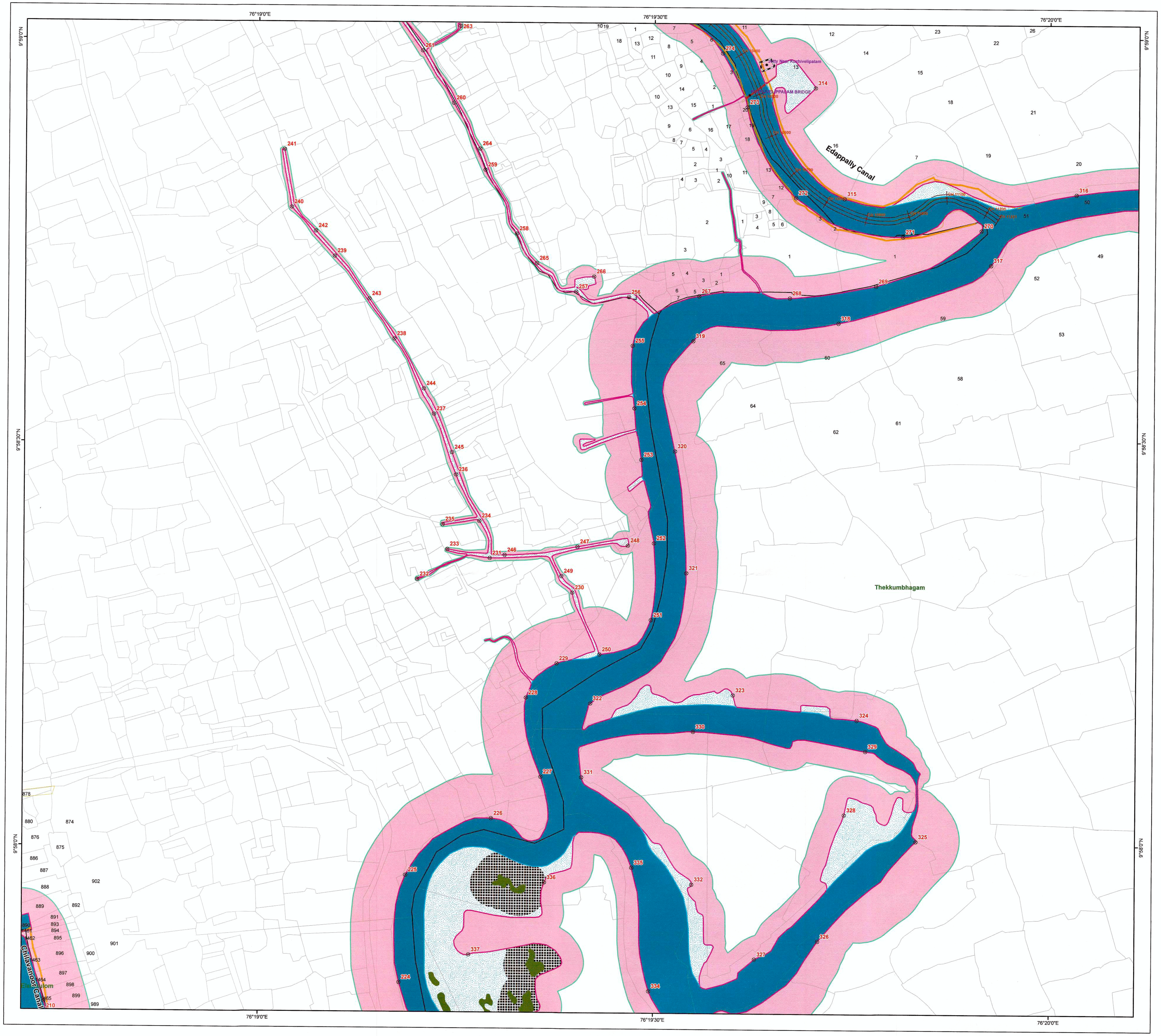
Proponent	*FOR*	*Consultant*
KOCHIN METRO RAIL LIMITED (KMRL) JLN METRO STATION, 4th FLOOR KALOOR, ERNAKULAM - 682 017.		**WAPCOS LIMITED 76-C, INSTITUTIONAL AREA, SECTOR - 18, GURGAON - 122 015 HARYANA.**

PREPARED BY	-Prem
VERIFIED BY	[signature]
APPROVED BY	[signature] 24/12/21 Prof. D. Thirumalaivasan, B.E.M.Tech.,Ph.D., Director Institute of Remote Sensing Anna University, Chennai-600 025.

"Prem...!"

Preparation of Local Level Coastal Regulation Zone Map for the Proposed Project "Integrated Urban Regeneration and Water Transport System (IURWTS)" in Cochin, Kerala State by Superimposing on Approved CZMP as per CRZ Notification 2011

SHEET NO : 010/12



LEGEND

SOURCE : APPROVED CZMP (MAP NO : KL 31, 32, 34 & 35) AS PER CRZ NOTIFICATION 2011

- LOW TIDE LINE (LTL)
- HIGH TIDE LINE (HTL)
- 100m LINE IN CRZ - III AREA
- 200m CRZ LINE - NDZ
- CRZ BOUNDARY (500m FOR SEA, 100m FOR BAY, 50m FOR BACKWATER ISLAND, 100m OR WIDTH OF THE CREEK WHICHEVER IS LESS ALONG THE TIDAL INFLUENCED WATER BODIES)
- CRITICAL VULNERABLE COASTAL AREA BOUNDARY (CVCA)
- CRZ - IA
- CRZ - IA (50m MANGROVE BUFFER ZONE)
- CRZ - IB
- CRZ - II
- CRZ - III (NO DEVELOPMENT ZONE)
- CRZ - III (200m TO 500m FROM HTL)
- CRZ - IVA
- CRZ - IVB
- 7Km BUFFER LINE FROM PROJECT SITE
- HTL REFERENCE POINT

SOURCE : CLIENT

- PROPOSED PROJECT SITE DETAILS
- EXISTING STRUCTURE
- CHAINAGE LINE
- SURVEY BOUNDARY
- VILLAGE BOUNDARY
- PROPOSED STP
- PROPOSED JETTY
- PROPOSED SEWER LINE LAYING
- PROPOSED CANAL BANK BEAUTIFICATION
- PROPOSED BRIDGE / FOOT BRIDGE / EXISTING BRIDGE TO BE RECONSTRUCTION
- PROPOSED WALKWAY
- PROPOSED APPROACH ROAD
- PROPOSED DEEPENING & WIDENING OF EXISTING CANAL

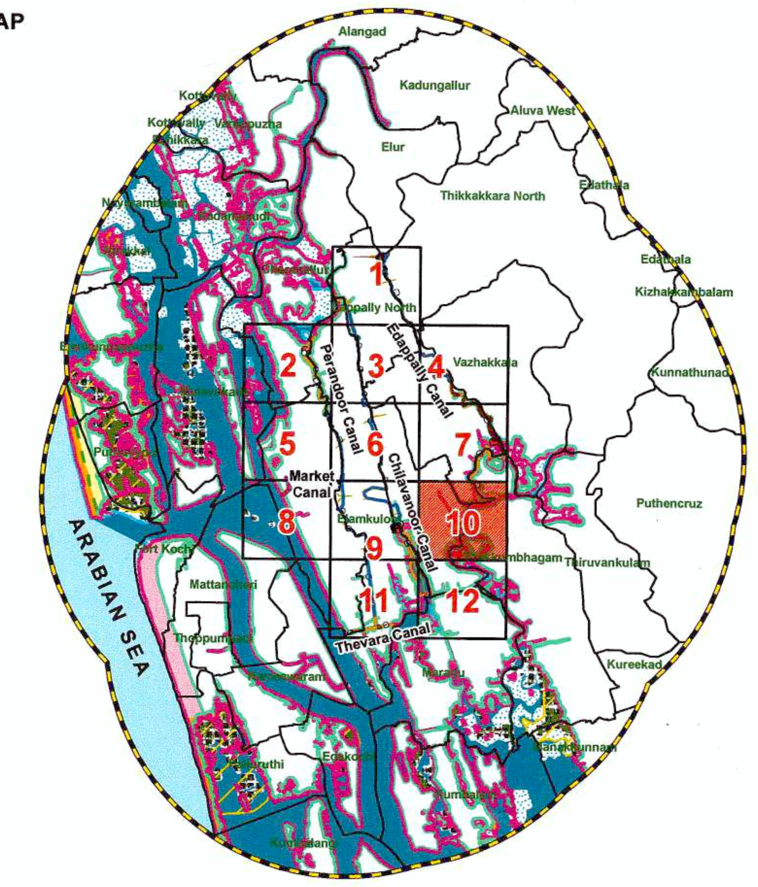
Note:

1. *Coastal Regulation Zone Map of the site is prepared considering Approved CZMP as per CRZ Notification 2011 of MoEF, GoI*
2. *Superimposition of the Project Site on Approved CZMP is subject to scale and generalisation error*
3. *The map comes with a report wherein description of CRZ zonation of project layout details are given. This map is to be referenced and used along with the report bearing the same reference no: AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)*
4. *The DGPS Survey was carried out specific to the referred project site boundary only hence, validation of HTL and CRZ Boundary is limited to the clearance of the same. Institute of Remote Sensing do not carry responsibility for CRZ status of other plots or neighbourhood.*

SCALE 1 : 4,000

0 50 100 200 300 400 M

INDEX MAP



PREPARED BY

INSTITUTE OF REMOTE SENSING
ANNA UNIVERSITY
CHENNAI - 600 025

REF NO. AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)

Proponent	*FOR*	*Consultant*
KOCHIN METRO RAIL LIMITED (KMRL) JLN METRO STATION, 4th FLOOR KALOOR, ERNAKULAM - 682 017.		**WAPCOS LIMITED 76-C, INSTITUTIONAL AREA, SECTOR - 18, GURGAON - 122 015 HARYANA.**

PREPARED BY	
VERIFIED BY	
APPROVED BY	Prof. D. Thirumalaivasan, B.E.M.Tech.,Ph.D., Director Institute of Remote Sensing Anna University, Chennai-600 025.

"Prem...!"

Preparation of Local Level Coastal Regulation Zone Map for the Proposed Project "Integrated Urban Regeneration and Water Transport System (IURWTS)" in Cochin, Kerala State by Superimposing on Approved CZMP as per CRZ Notification 2011

SHEET NO : 011/12

LEGEND

SOURCE : APPROVED CZMP (MAP NO : KL 31, 32, 34 & 35) AS PER CRZ NOTIFICATION 2011

- LOW TIDE LINE (LTL)
- HIGH TIDE LINE (HTL)
- 100m LINE IN CRZ - III AREA
- 200m CRZ LINE - NDZ
- CRZ BOUNDARY (500m FOR SEA, 100m FOR BAY, 50m FOR BACKWATER ISLAND, 100m OR WIDTH OF THE CREEK WHICHEVER IS LESS ALONG THE TIDAL INFLUENCED WATER BODIES)
- CRITICAL VULNERABLE COASTAL AREA BOUNDARY (CVCA)
- CRZ - IA
- CRZ - IA (50m MANGROVE BUFFER ZONE)
- CRZ - IB
- CRZ - II
- CRZ - III (NO DEVELOPMENT ZONE)
- CRZ - III (200m TO 500m FROM HTL)
- CRZ - IVA
- CRZ - IVB
- 7Km BUFFER LINE FROM PROJECT SITE
- HTL REFERENCE POINT

SOURCE : CLIENT

- PROPOSED PROJECT SITE DETAILS
- EXISTING STRUCTURE
- CHAINAGE LINE
- SURVEY BOUNDARY
- VILLAGE BOUNDARY
- PROPOSED STP
- PROPOSED JETTY
- PROPOSED SEWER LINE LAYING
- PROPOSED CANAL BANK BEAUTIFICATION
- PROPOSED BRIDGE / FOOT BRIDGE / EXISTING BRIDGE TO BE RECONSTRUCTION
- PROPOSED WALKWAY
- PROPOSED APPROACH ROAD
- PROPOSED DEEPENING & WIDENING OF EXISTING CANAL

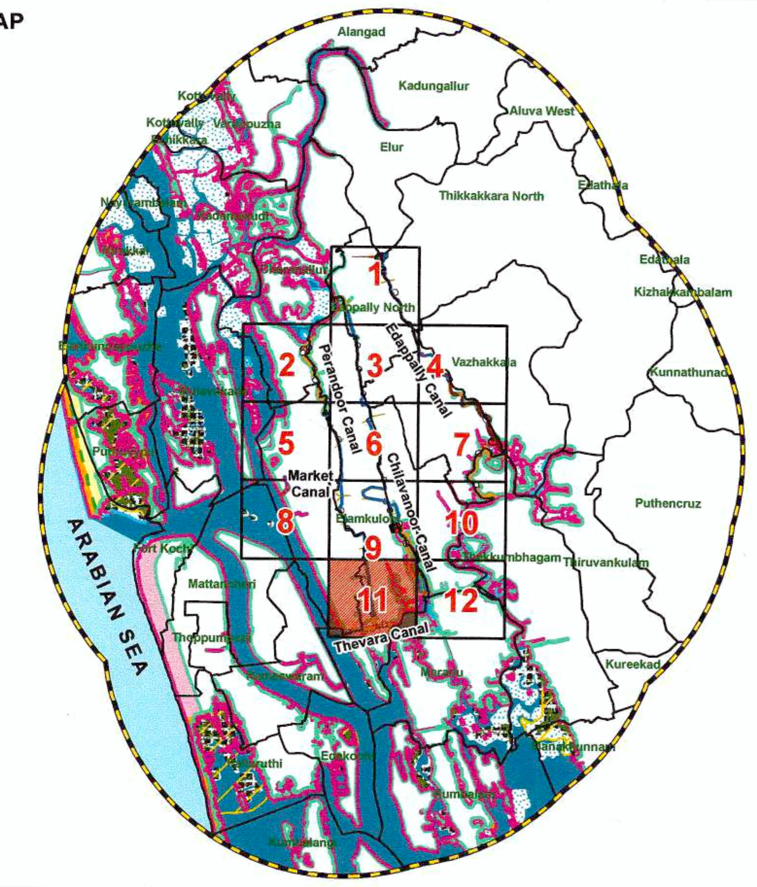
Note:

1. *Coastal Regulation Zone Map of the site is prepared considering Approved CZMP as per CRZ Notification 2011 of MoEF, GoI*
2. *Superimposition of the Project Site on Approved CZMP is subject to scale and generalisation error*
3. *The map comes with a report wherein description of CRZ zonation of project layout details are given. This map is to be referenced and used along with the report bearing the same reference no: AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)*
4. *The DGPS Survey was carried out specific to the referred project site boundary only hence, validation of HTL and CRZ Boundary is limited to the clearance of the same. Institute of Remote Sensing do not carry responsibility for CRZ status of other plots or neighbourhood.*

SCALE 1 : 4,000

0 50 100 200 300 400 M

INDEX MAP



PREPARED BY

INSTITUTE OF REMOTE SENSING
ANNA UNIVERSITY
CHENNAI - 600 025

REF NO. AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)

FOR

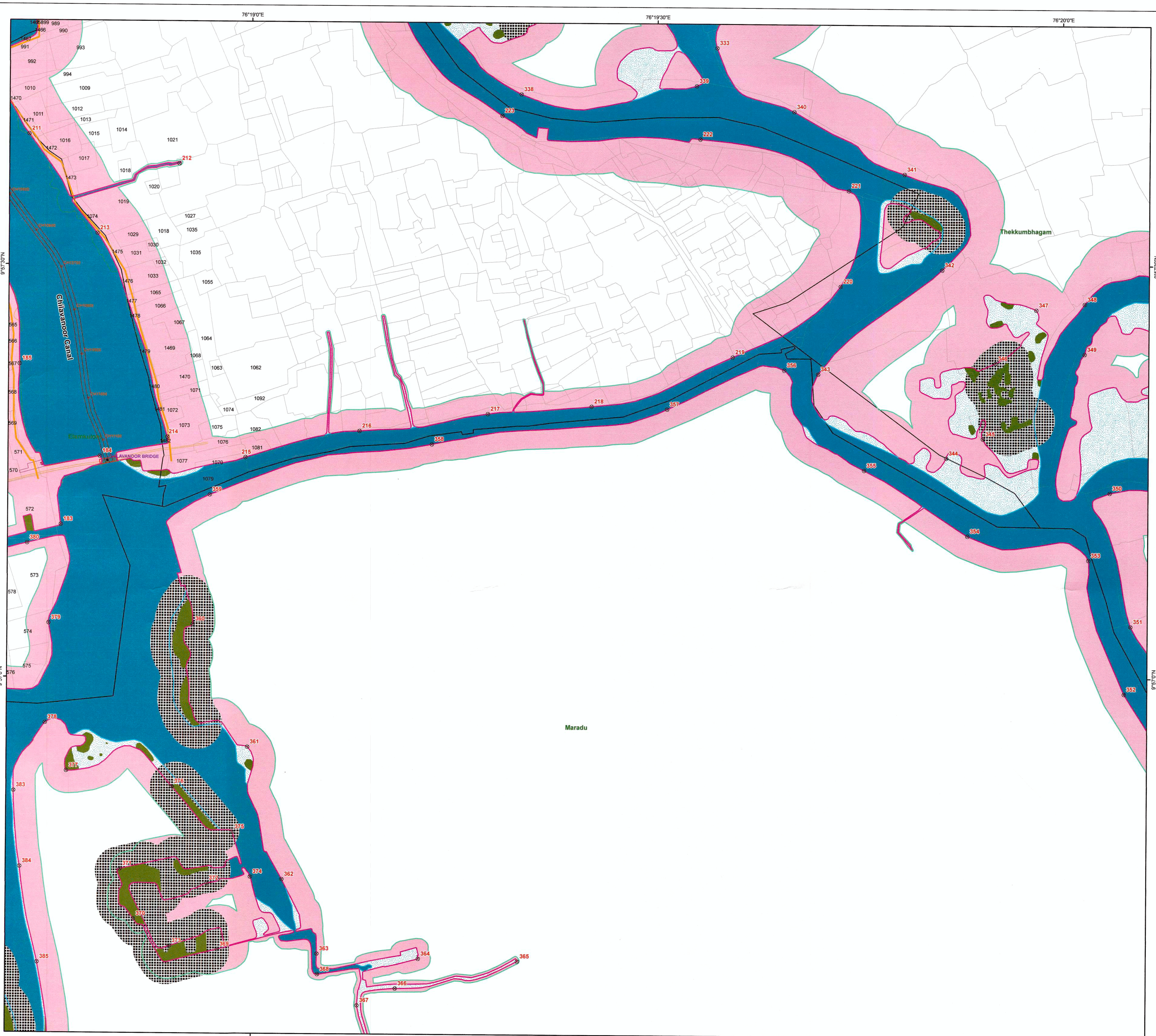
Proponent	*Consultant*
KOCHIN METRO RAIL LIMITED (KMRL) JLN METRO STATION, 4th FLOOR KALOOR, ERNAKULAM - 682 017.	WAPCOS LIMITED 76-C, INSTITUTIONAL AREA, SECTOR - 18, GURGAON - 122 015 HARYANA.

PREPARED BY	[signature]
VERIFIED BY	[signature]
APPROVED BY	[signature] Prof. D. Thirumalaivasan, B.E.M.Tech.,Ph.D., Director Institute of Remote Sensing Anna University, Chennai-600 025.

"Prem....!"

Preparation of Local Level Coastal Regulation Zone Map for the Proposed Project "Integrated Urban Regeneration and Water Transport System (IURWTS)" in Cochin, Kerala State by Superimposing on Approved CZMP as per CRZ Notification 2011

SHEET NO : 012/12



LEGEND

N

SOURCE : APPROVED CZMP (MAP NO : KL 31, 32, 34 & 35) AS PER CRZ NOTIFICATION 2011

- LOW TIDE LINE (LTL)
- HIGH TIDE LINE (HTL)
- 100m LINE IN CRZ - III AREA
- 200m CRZ LINE - NDZ
- CRZ BOUNDARY (500m FOR SEA, 100m FOR BAY, 50m FOR BACKWATER ISLAND, 100m OR WIDTH OF THE CREEK WHICHEVER IS LESS ALONG THE TIDAL INFLUENCED WATER BODIES)
- CRITICAL VULNERABLE COASTAL AREA BOUNDARY (CVCA)
- CRZ - IA
- CRZ - IA (50m MANGROVE BUFFER ZONE)
- CRZ - IB
- CRZ - II
- CRZ - III (NO DEVELOPMENT ZONE)
- CRZ - III (200m TO 500m FROM HTL)
- CRZ - IVA
- CRZ - IVB
- 7Km BUFFER LINE FROM PROJECT SITE
- HTL REFERENCE POINT

SOURCE : CLIENT

- PROPOSED PROJECT SITE DETAILS
- EXISTING STRUCTURE
- CHAINAGE LINE
- SURVEY BOUNDARY
- VILLAGE BOUNDARY
- PROPOSED STP
- PROPOSED JETTY
- PROPOSED SEWER LINE LAYING
- PROPOSED CANAL BANK BEAUTIFICATION
- PROPOSED BRIDGE / FOOT BRIDGE / EXISTING BRIDGE TO BE RECONSTRUCTION
- PROPOSED WALKWAY
- PROPOSED APPROACH ROAD
- PROPOSED DEEPENING & WIDENING OF EXISTING CANAL

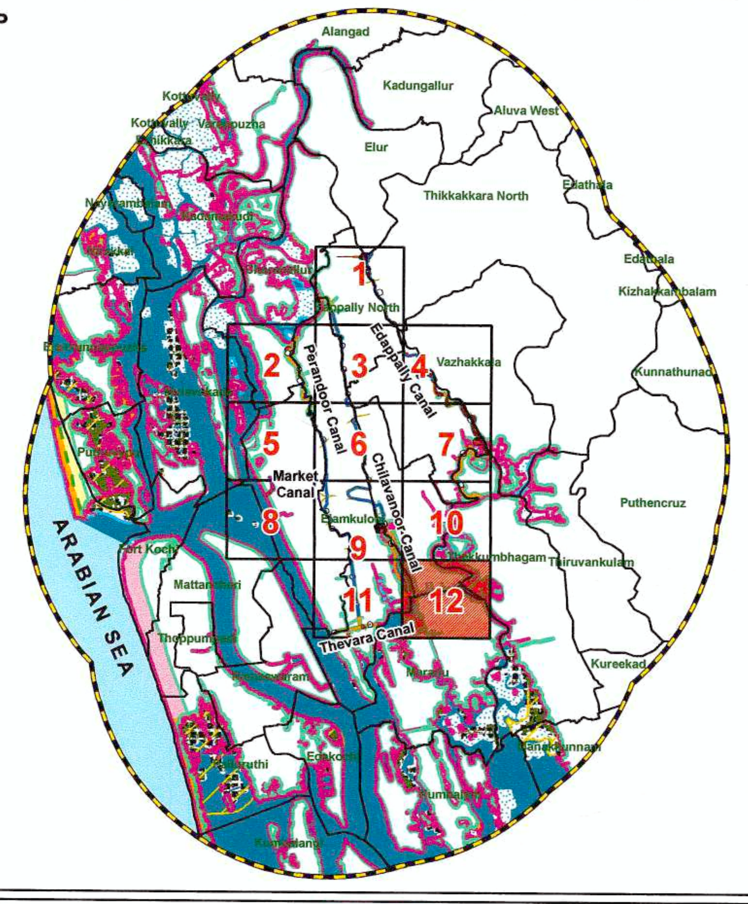
Note:

1. *Coastal Regulation Zone Map of the site is prepared considering Approved CZMP as per CRZ Notification 2011 of MoEF, GoI*
2. *Superimposition of the Project Site on Approved CZMP is subject to scale and generalisation error*
3. *The map comes with a report wherein description of CRZ zonation of project layout details are given. This map is to be referenced and used along with the report bearing the same reference no: AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)*
4. *The DGPS Survey was carried out specific to the referred project site boundary only hence, validation of HTL and CRZ Boundary is limited to the clearance of the same. Institute of Remote Sensing do not carry responsibility for CRZ status of other plots or neighbourhood.*

SCALE 1 : 4,000

0 50 100 200 300 400 M

INDEX MAP



PREPARED BY

INSTITUTE OF REMOTE SENSING
ANNA UNIVERSITY
CHENNAI - 600 025

REF NO. AU/IRS/RM/208-2020-REV DT. 20.12.2021 (19.12.2020)

Proponent	FOR	Consultant
KOCHIN METRO RAIL LIMITED (KMRL) JLN METRO STATION, 4th FLOOR KALOOR, ERNAKULAM - 682 017.		WAPCOS LIMITED 76-C, INSTITUTIONAL AREA, SECTOR - 18, GURGAON - 122 015 HARYANA.

PREPARED BY	
VERIFIED BY	
APPROVED BY	24/12/21 Prof. D. Thirumalaivasan, B.E.M.Tech.,Ph.D., Director Institute of Remote Sensing Anna University, Chennai-600 025.

"Prem...!"

ANNEXURE-V

Government of India
Ministry of Jal Shakti
Department of Water Resources,
River Development and
Ganga Rejuvenation

सत्यमेव जयते

भारत सरकार
जल शक्ति मंत्रालय
जल संसाधन, नदी विकास
और गंगा संरक्षण विभाग

TECHNICAL REPORT NO.5945
AUGUST, 2021

REVIEW OF HYDROLOGIC, HYDRAULIC AND FLOOD PLAIN MODEL OF CANAL SYSTEM FOR KOCHI IURWTS

केन्द्रीय जल और विद्युत अनुसंधान शाला, पुणे
CENTRAL WATER AND POWER RESEARCH STATION, PUNE

A. K. Agrawal
Director

GOVERNMENT OF INDIA

MINISTRY OF JAL SHAKTI

DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT AND GANGA REJUVENATION

CENTRAL WATER AND POWER RESEARCH STATION

PUNE - 411 024

Reservoirs and Appurtenant Structures

TECHNICAL REPORT NO. 5945
AUGUST 2021

REVIEW OF HYDROLOGIC, HYDRAULIC AND FLOOD PLAIN MODEL OF CANAL SYSTEM FOR KOCHI IURWTS

A.K. Agrawal
Director

REPORT DOCUMENTATION SHEET

Technical Report No. 5945 **Month: August 2021**

TITLE: REVIEW OF HYDROLOGIC, HYDRAULIC AND FLOOD PLAIN MODEL OF CANAL SYSTEM FOR KOCHI IURWTS

Officers Responsible for Conducting the Studies
Shri P. Vijayagopal, Shri P. S. Kunjeer, Scientist ‘C’, Mrs. H. P. Chaudhary, Scientist ‘B’, Mrs. S. B. Tayade, Assistant Research Officer, under the supervision of Dr. (Mrs) Neena Isaac, Scientist ‘E’

Name and Address of Organization Conducting the Studies
Reservoirs and Appurtenant Structures

Central Water and Power Research Station, Khadakwasla, Pune-411 024

Name and Address of the Authority Sponsoring the Studies

Shri Krishna Kant Gupta, Head –Water & Urban Infrastructure, Antea Group, Magnum Towers, Tower-1, Unit No 219-221 2nd Floor, Main Golf Course Extension Road, Sector-58, Gurugram-122011

Synopsis
The hydrologic, hydraulic and flood plain model of canal system for Kochi IURWTS have been submitted to CWPRS for review and validation. The IURWTS canal system consist of five canals viz. Edappally Canal (11.23 Km), Chilavanoor Canal (9.88Km), Thevara-Perandoor canal (11.15Km), Thevara canal (1.41km) and Market canal (0.66 Km). Hydrological and hydraulic models have been developed for three main canals Edappally, Chilavanoor and Thevara-Perandoor canal. Initially the models along with all the input data (topographic, rainfall and water levels at canal boundaries) were submitted for checking and validation. CWPRS thoroughly checked the methodology, input data, boundary conditions and model parameters adopted for the model simulations. CWPRS had some observations on the model parameters and based on that and site inspection modifications were suggested to be incorporated in the model.

The modified model and study report after complying the changes were again submitted to CWPRS by M/S Aneta group. It was observed that all changes suggested were incorporated in the model and study report.

The methodology adopted for the study in respect of rainfall analysis, flood hydrograph generation, use of mathematical models for flood routing are acceptable. Rainfall analysis results and generation of flood hydrograph using HEC-HMS model and flood routing using HEC-RAS under unsteady condition for all the three canals along with the required width for mitigating the design flood are acceptable. Flood inundation maps were prepared based on the results obtained from simulations for all the conditions and the maps generated are acceptable.

Key words: IURWTS, Kochi, Hydrological model, HEC-HMS, Hydraulic model, HEC-RAS, flood inundation map

TABLE OF CONTENTS

REVIEW OF HYDROLOGIC, HYDRAULIC AND FLOOD PLAIN MODEL OF CANAL SYSTEM FOR KOCHI IURWTS

Technical Report No. 5945 **August 2021**

1.0 INTRODUCTION

The Integrated Urban Regeneration and Water Transport Studies (IURWTS), project, Kochi which has been in progress since July 2018 is a comprehensive and visionary project of the Govt. of Kerala to address many of the social woes faced by city residents and businesses within the catchment limits of the project. The IURWTS intends the use of waterways to build urban resilience in the city and seeks to restore a number of primary canals to provide possibilities for mass water transport. The Govt. of Kerala (GOK), India has engaged Kerala Metro Rail Ltd (KMRL) as the Special Purpose Vehicle (SPV) for implementing the IURWTS project. M/s Antea Group was selected as the General Consultant by the KMRL to assist in the planning, design, cost estimation, tendering and implementation stage of the project. The IURWTS study is focused on five main drainage canals namely Edappally Canal (11.23 km), Chilavanoor Canal (9.88 km), Thevara-Perandoor canal (11.15 km), Thevara canal (1.41km) and Market canal (0.66 km). The hydrological, hydraulic and flood plain model of canal system for Kochi IURWTS was submitted to Central Water and Power Research Station (CWPRS), Pune, by M/s Antea Group for review and validation. CWPRS thoroughly checked the methodology, input data, boun`dary conditions and model parameters adopted for the model simulations and the details are presented in this report.

2.0 STUDY AREA

Nearly one third of IURWTS catchment lies inside the Kochi Corporation limits, which includes 74 wards having a total area of 94.88 sq.km. The Kochi Corporation area is geographically located between $76^0 15'9.4"$- $76^0 30'8.35"$ east longitude and $9^0 42'3"$-$9^0 58'9.39"$ north latitudes. The majority of the Kochi region lies within the lowland region and the average land elevation of the Kochi Corporation area towards the eastern fringes is about 7.5 m above MSL, and towards the west, the elevation is less than 1.0 m on an average. Approximately, 40% of the surface area consists of water formed by the rivers, canals, and lagoons of the Kochi Estuary.

The IURWTS project covers a total area of 41.49 sq.km. Out of this, 33.08 sq.km forms part of Kochi Corporation with an area of 8.41 sq.km on the eastern side falling in three municipalities (Kalamassery, Thrikkakkara and Thripunithura Municipalities). Out of the 74 wards of Kochi Corporation, 54 wards fall within the IURWTS project area including 19 wards each in Kalamassery and Thrikkakkara municipality and 2 wards in Thripunithura municipality. The IURWTS catchment comprises of five canals (Figure 1):

- Edappally Canal - 11.23 km
- Chilavanoor Canal - 11.15 km
- Thevara-Perandoor Canal - 9.88 km
- Thevara Canal - 1.41 km
- Market Canal - 0.66 km

Out of the above five canals, Thevara canal and 0.66 km long Market canal being a man-made extension into the land area from Kochi lagoon do not have catchments of its own and hence not considered in the present hydrological and hydraulic studies. The major canals (Edappally, Chilavanoor and combined catchment of Thevara + Thevara-Perandoor canal) which are the focus of the study, run roughly north-south through Kochi city. The IURWTS canal water levels are influenced by the tide and sea conditions, by the flows in the adjoining rivers which drain into the lagoon to the north and south of the catchment and by local stormwater flows into the canals.

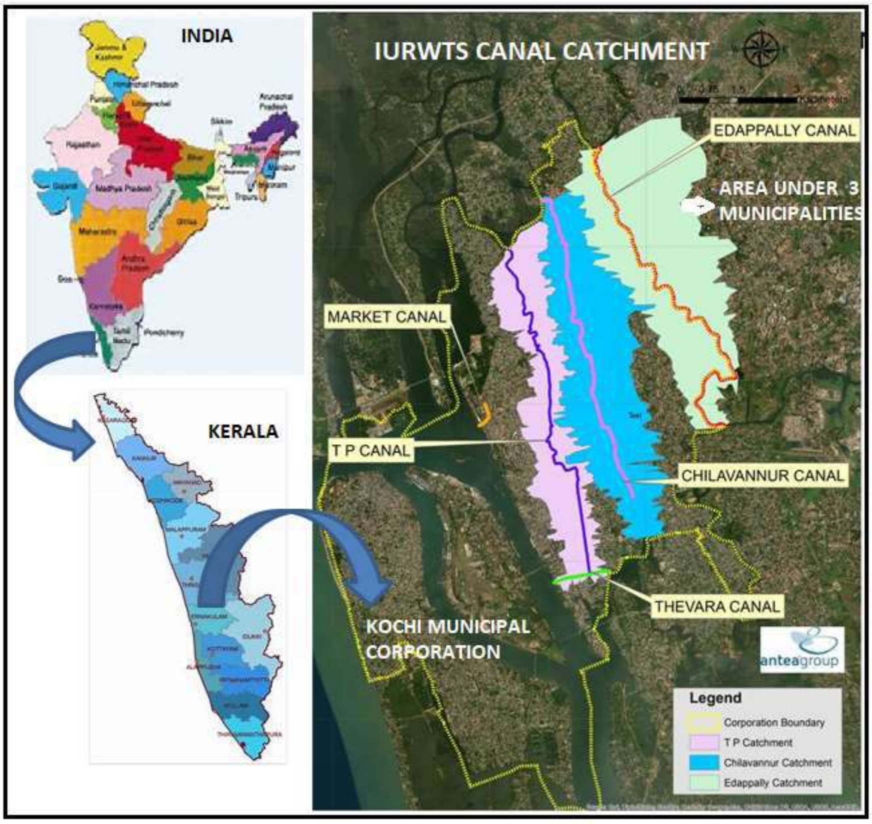


Figure 1: Index Map of Kochi IURWTS Project

3.0 TERMS OF REFERENCE

- Approval of the TOR/methodology for undertaking the hydrological, hydraulic and flood plain studies
- Review and validate the output of the hydrological, hydraulic and flood plain model studies carried out by M/s Antea Group for Kochi IURWTS project
- Validation of the final outputs submitted by M/s Antea Group
- Any other consultation required during the study

4.0 METHODOLOGY

- Review of the TOR/methodology for undertaking the hydrological, hydraulic and flood plain studies and suggesting modifications, if any
- The model developed will be reviewed for the input data and other parameters. Changes required, if any to the model set up will be suggested
- The model simulation will be carried out by M/s Antea Group for various flood scenarios and boundary conditions. The results of the model studies will be reviewed by CWPRS and comments will be communicated to account for changes in the model studies
- Support will be provided during the presentation of the results in the review meetings

5.0 SITE VISIT

Site visit was planned to get the knowledge of physiographic parameters of the catchments and other hydrological and hydraulic parameters. Accordingly, a combined site inspection was carried out by CWPRS and M/s Antea Group officials from 09/03/2021 to 10/03/2021. CWPRS team comprised of Dr (Mrs.) Neena Isaac, Scientist E, Shri P Vijayagopal, Shri P.S. Kunjeer, Scientist C and Mrs. H.P.Chaudhary, Scientist B. Dr (Mrs) Jany George, Expert and other officials from M/s Antea group accompanied CWPRS team. The team visited all the five canal systems viz. Edappally Canal, Chilavanoor Canal, Thevara-Perandoor canal, Thevara canal and Market canal. The team collected ground information regarding the flow conditions, encroachments in the canals, ground levels, bridges and other cross structures. The team also visited the area nearby the canals to inspect the flood marks of 2018 flood. The data collected was used in the calibration and validation of the model.

Photo 1: Downstream of Thevara-Perandoor canal near electric Substation, Shastri Nagar

Photo 2: CWPRS team along with M/s Antea group expert
(Chilavanoor Canal, Subhashchandra Bose Road)

Photo 3: National highway crossing Edappally canal
near Lulu mall

6.0 REVIEW AND VALIDATION OF STUDIES

The M/s Antea Group collected the required input data for the above studies and developed the hydrological and hydraulic models. The report containing the input data, methodology and results along with the model setups were submitted to CWPRS for review and validation. The expert from M/s Antea Group visited CWPRS along with the model setup and explained various aspects in detail. CWPRS reviewed the model setups and report with respect to various aspects of model development and suggested few modifications in the model setup and editorial and technical corrections in the report. Subsequently, CWPRS officials inspected the project site (canal systems) for ground truthing and ascertaining various parameters used in the model setup. The final report (Appendix – I) along with the input data, model setup and results incorporating the modifications suggested by CWPRS was submitted for final verification and approval. The details of the review are given in the following paragraphs.

6.1 Data Used

Rainfall data

Rainfall data collected from two main sources were used in the analysis. The data consists of hourly rainfall data from the Kochi Naval Base covering the period from 1993-2015 and gridded data (0.25^0x0.25^0) of daily rainfall for Kochi station (9.96^0 N, 76.27^0 E) from the India Meteorological Department (IMD) for the period 1975-2013, 2018 and 2019 data collected from Southern Railway Department, Ernakulam. The details of data are explained in Appendix – I, Section-3.

Survey data

ALOS PALSAR DEM of 10.2 m resolution was used for delineation of sub basins for Edappally, Chilavanoor and Thevara + Thevara-Perandoor catchments in hydrological analysis module of HEC-HMS software.

Topographic data in the form of canal bathymetries and floodplain elevations were collected. River bathymetry was collected using GPS survey equipment while floodplain elevations on each bank of the canals were obtained from airborne LiDAR surveys. Supplementary topographic surveys were used to establish the vertical and horizontal controls and survey the main features in the floodplain to tie the LiDAR and bathymetric surveys together.

The LiDAR derived floodplain elevations together with the topographic survey spot levels and channel bathymetries were merged into a single high resolution (0.5 m grid) Digital

Elevation Model (DEM) for the purposes of building the hydraulic models (Figure 2). The details of data are explained in Appendix – I, Section 2.0.

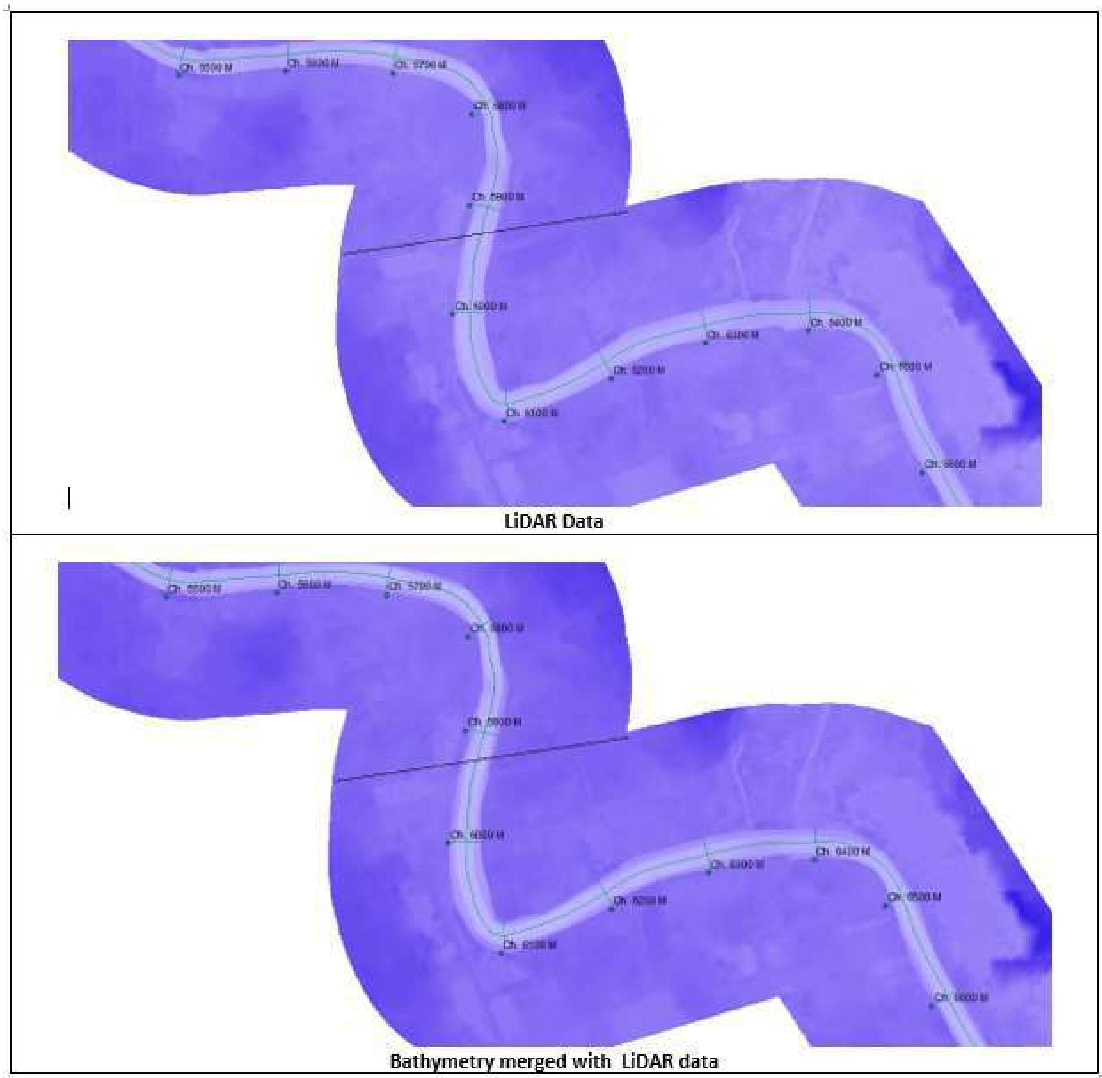


Figure 2: Sample of Merged DEM

Tidal and Water level data

Tide and sea level data from Kochi Port gauge station at 30-minute resolution for the period 2007-2019 and measured tidal data (at 15 min intervals) at 6 locations were used in the analysis for deriving the boundary conditions for the hydraulic model.

Kochi has experienced a major flood event in August 2018. The recorded high water marks from the 2018 flood event were also used in the analysis for deriving the boundary conditions. The details of data are explained in Appendix – I, Section 4.0.

6.2 Rainfall Data Analysis

Rainfall data collected from two main sources were used in the analysis. The data consists of hourly rainfall data from the Kochi Naval Base covering the period from 1993-2015 and gridded data (0.25 x 0.25) of daily rainfall for Kochi station (9.960 N, 76.270 E) from the India Meteorological Department (IMD) for the period 1975-2013, 2018 and 2019 data collected from Southern Railway Department, Ernakulam. The raw data was analysed for checking the consistency and missing values.

Intensity-Duration-Frequency (IDF) curves were developed from the above data based on 16 years of hourly data and based on 16 years of hourly gauge data infilled and extended with empirically derived hourly data extracted from the daily data. The IDF curves were developed for various duration (1, 2, 4, 6, 12, 24 hr) and return periods (2, 5, 10, 25, 50,100 yr). The input data and methodology adopted were reviewed and found to be correct. The Gumbel Extreme Value Type-I Distribution was used to compute rainfall intensities for IDF curves. The IDF curves were also developed with empirical method and compared with the IDF from observed data.

The rainfall hyetographs were derived from the IDF curves using the block method for various return periods (2, 5, 10, 25, 50,100 yr). The hyetographs were used as input for computation of design flood discharge in hydrological models. The details are explained in Appendix – I, Section 3.0.

6.3 Hydrological Analysis

Runoff generation and estimation of flood discharge for various return periods for all the three canal catchments were carried out using HEC-HMS software. The catchment delineation of the basins was carried out based on ALOS PALSAR DEM. Using the derived catchment characteristics of the sub basins and rainfall hyetographs, design flood hydrographs were computed using SCS curve number method and SCS unit hydrograph in HEC-HMS software.

6.3.1 The HEC-HMS Model

HEC-HMS model was used to generate flood hydrographs for various return periods for all the three canals. The details are explained in Appendix – I, Section 6.0.

Edappally Canal

The delineation of the basin was carried out based on ALOS PALSAR DEM. Based on the characteristics of the terrain, 13 sub basins were delineated (Figure 3). SCS curve method was used to convert excess rainfall into runoff. The SCS curve number 73 was used in the analysis based on Land Use Land Cover (LULC) and soil data. SCS (Delmarva) dimensionless Unit Hydrograph method was used for computations since the catchment is characterized by flat terrain (coastal catchment). The rainfall hyetographs developed based on storm event of 24 hours duration was used in the model to generate the flood hydrographs (Figure 4). The peak discharges were also computed using the rational method and compared with the peak discharges computed using HEC-HMS model.

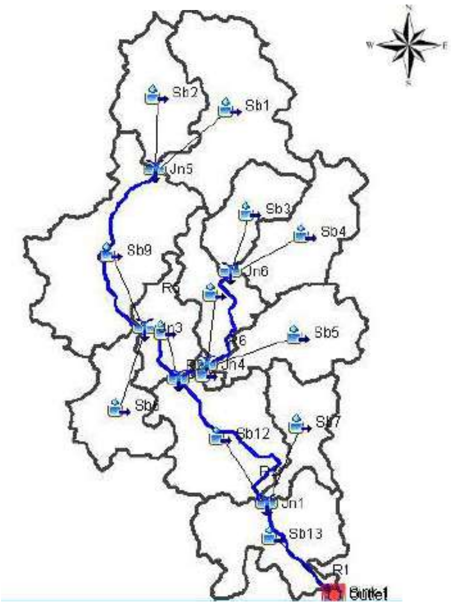


Figure 3: Sub basins of Edappally Canal Catchment

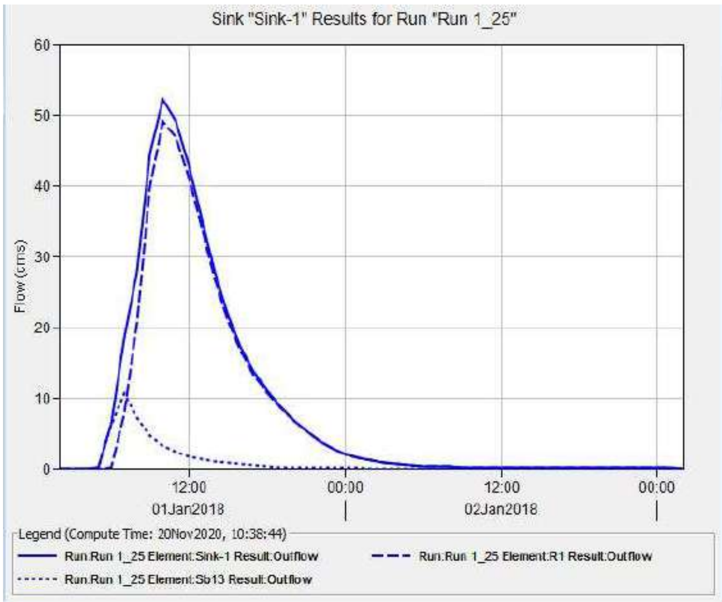


Figure 4: Flood hydrograph for Edappally Catchment for 25 years ARI

CWPRS reviewed the model setup and results. The results obtained were cross verified by CWPRS using CWC method for deriving the floods for ungauged catchments. The results obtained from HEC-HMS model are within the acceptable limits.

Chilavanoor Canal and Thevara + Thevara-Perandoor canal

Similar exercise using HEC-HMS software was carried out for the Chilavanoor Canal and Thevara + Thevara-Perandoor canal.

CWPRS is in agreement of the parameters used for the hydrological model and results obtained.

6.4 Hydraulic Modelling

Hydraulic modelling of the canals was carried out using one-dimensional hydrodynamic model HEC-RAS. Separate models were developed for each canal for two geometries viz., the existing (un-restored) and the restored condition. The merged DEM of LIDAR and bathymetry survey data were used to derive the river cross sections and flood plain geometries for the model utilizing the RAS Mapper GIS utility in HEC-RAS. The RAS geometry file included the river, bank lines, edge lines and cross sections. Bridges and other cross structures were also created at the corresponding locations. The geometry data was finally checked and edited in the HEC-RAS geometric data editor.

Unsteady flow analysis was carried out for all the canals. Catchment flood hydrographs generated from HEC-HMS were introduced as lateral inflows from the respective sub basins. The boundary conditions at the upstream and downstream ends of the canals were defined as static water levels. Simulations were carried out for all combinations of boundary conditions, storm return periods and canal conditions (un-restored and restored). The details are explained in Appendix – I, Section 7.0.

Existing (Un-restored) Condition

The existing channel geometry along with bridges and other cross structures were incorporated in the simulations for existing condition. The Manning's roughness coefficients for channel and overbanks were revised based on CWPRS suggestion and discussions. The cross section extraction method and modelling of bridges and other cross structures were also revised based on CWPRS suggestions. The channel section of Edappally canal was assigned a Manning's n of 0.075 reflecting the large degree of encroachment and vegetation growth in the canal and along the banks. The Chilavanoor and Thevara canals are slightly less overgrown and were assigned a Manning's n of 0.06. The overbank sections generally comprise high density housing and other urban infrastructure and were assigned a Manning's n of 0.20 in all cases.

Restored Condition

In the improved or restored condition, the cross structures are removed, the canal is widened to a width of 16.5m and a minimum bed level of -0.9m CD was maintained. Where the existing bed level was less than -0.9m CD no changes to the bed level were made but a minimum width of 16.5m was maintained. The same lateral inflows and external boundary water levels applied to the existing (un-restored) condition are used in the restored condition simulations. To reflect the cleaned and restored condition the channel sections were assigned a Manning's n value of 0.03. The Manning number for the overbank urbanized floodplain areas remained unchanged at 0.20.

6.4.1 Flood Routing under Existing Condition

The following series of simulations were carried out for each of the three canals for the un-restored and restored conditions.

1) **Ex 1**: Simulation with 50 years storm event with boundary condition at normal mean sea level at 0.8m CD at both upstream and downstream boundaries for existing and restored conditions of all the canals.
2) **Ex 2**: Simulation with 25 years storm event with high tide condition of 1.1m CD at both upstream and downstream boundaries for existing and restored conditions of all the canals.
3) **Ex 3**: Simulation with 25 years storm event with highest astronomic tide (HAT) level of 1.4m CD at both upstream and downstream boundaries for existing and restored conditions of all the canals.
4) **Ex 4**: Simulation with 25 years storm event with river flood level of 1.6m CD at north end and 1.45m CD at south end for existing and restored conditions of Edappally canal; river flood level of 1.4m CD at north end and 1.1m CD at south end for existing and restored conditions of Chilavanoor canal; river flood level of 1.25m CD at north end and 1.1m CD at south end for existing and restored conditions of Thevara + Thevara-Perandoor canal.

6.4.2 Edappally Canal

The unsteady flow simulations were carried out for un-restored conditions for 100 year return period flood hydrograph. The manning's n of 0.075 for canal section and 0.2 for overbanks were used in the simulations. The water levels measured at few locations along the canals during the 2018 flood were available. The simulated water levels were compared with the observed 2018 flood levels. The observed and simulated water levels were in agreement and hence the model parameters used in the simulations are validated.

Further, unsteady flow simulations were carried out in HEC-RAS for all the above mentioned boundary conditions for un-restored and restored conditions.

The input data and boundary conditions adopted in the model were verified by CWPRS. The simulations were also independently carried out for all the three canals. The Figure 5 shows the comparison of the water level simulated by CWPRS and M/s Antea Group for simulation of series 4 (Ex.4) for Edappally canal. It was observed that the water levels obtained by CWPRS for both the restored and un-restored conditions are in agreement with M/s Antea Group results.

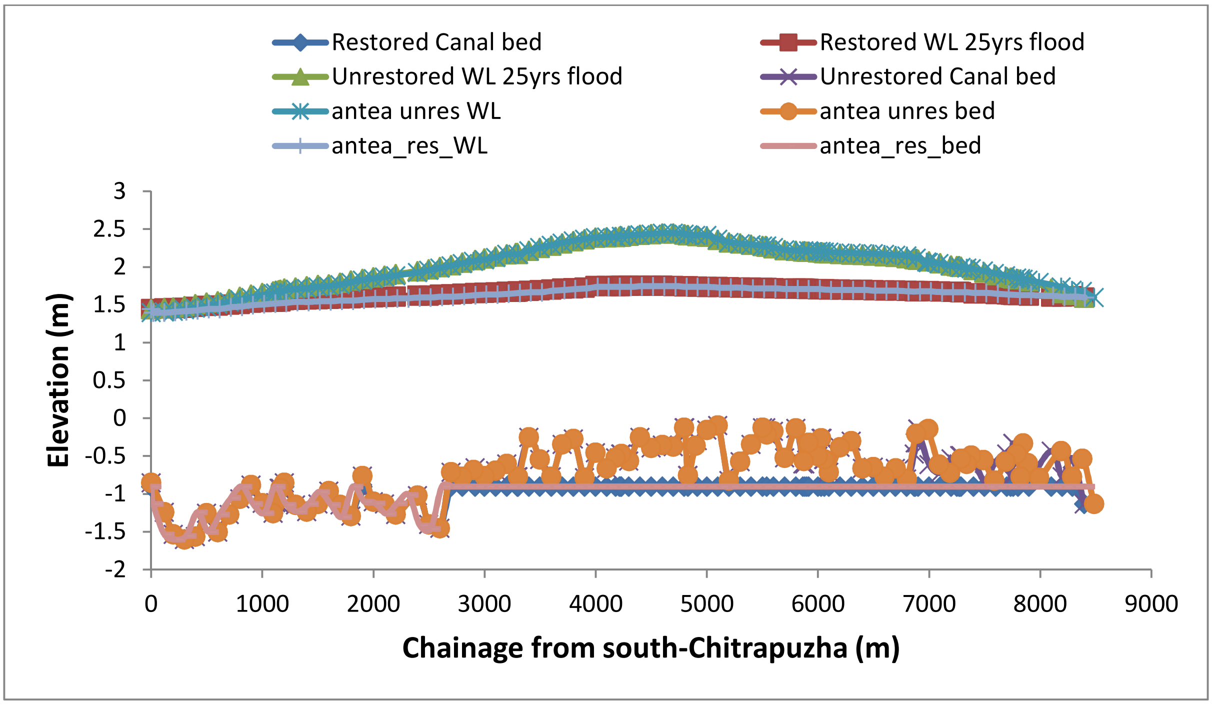


Figure 5: Comparison of Simulation results for Edappally Canal (Ex.4)

Similar exercise was carried out for Chilavanoor and Thevara + Thevara-Perandoor canal systems. It was observed that the simulation results obtained by CWPRS are in agreement with M/s Antea Group results.

6.5 Flood Inundation Maps

Flood inundation maps were prepared (Figure 6) based on the results obtained from simulations for all the conditions and the maps are presented in the M/s Antea Group report. The details are explained in Appendix – I, Section 7.0.

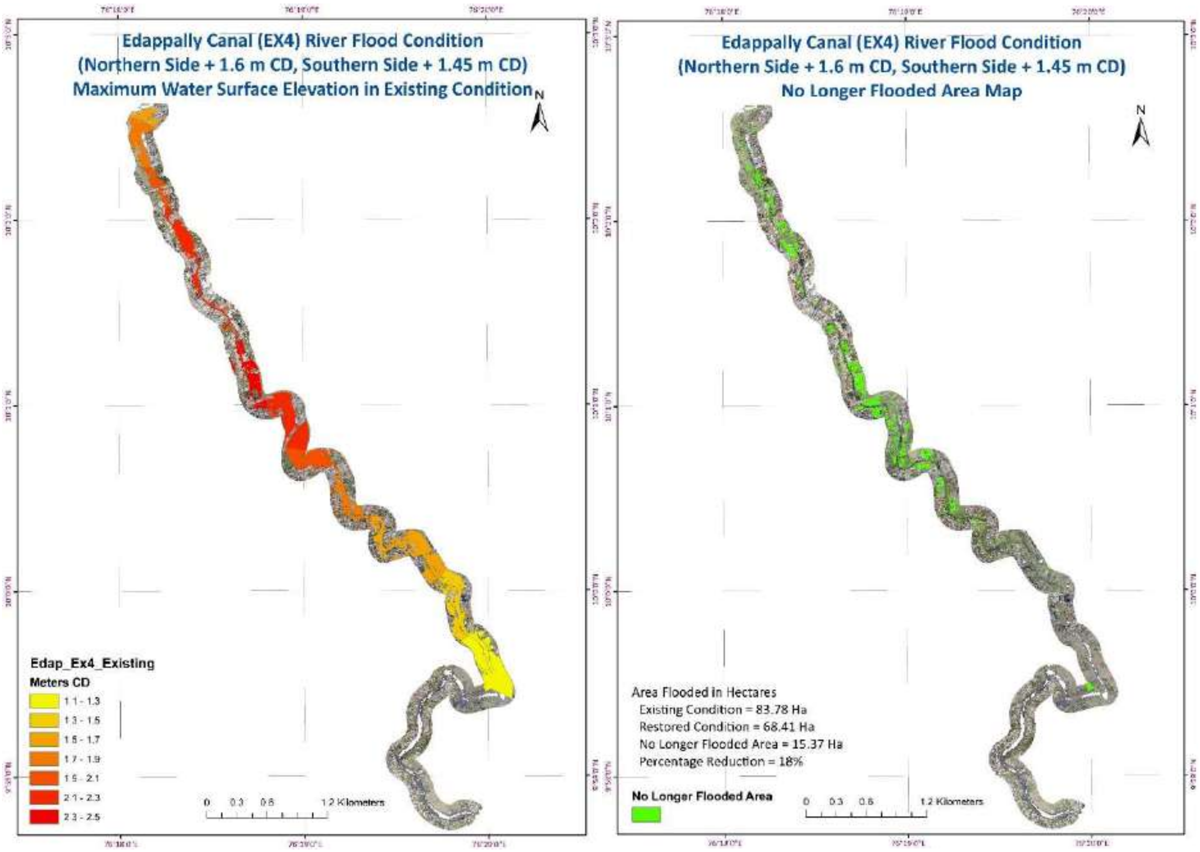


Figure 6: Flood Inundation map for Edappally Canal (Ex.4)

7.0 CONCLUSIONS

The hydrological, hydraulic and flood plain model and study report of canal systems for Kochi IURWTS was submitted to Central Water and Power Research Station (CWPRS), Pune, by M/s Antea Group for review and validation. The study was carried out for three major canal systems viz. Edappally Canal, Chilavanoor Canal and Thevara + Thevara-Perandoor canal. Market canal having a length of 660m was not included as delineation in

HEC-HMS was not possible. The model studies consist of hydrological, hydraulic modelling and flood plain mapping. CWPRS thoroughly checked the methodology, input data, boundary conditions, and model parameters adopted in the simulations.

- The model developed was reviewed for the input data and other parameters. Changes required were suggested and were incorporated in the final model simulations and study report.
- The methodology adopted for the study in respect of rainfall analysis, flood hydrograph generation, use of mathematical models for flood routing are acceptable.
- Rainfall analysis results and generation of flood hydrograph using HEC-HMS model and flood routing using HEC-RAS under unsteady condition for all the three canals along with the required width for mitigating the design flood are acceptable.
- Flood inundation maps were prepared based on the results obtained from simulations for all the conditions and the maps generated are acceptable.

ACKNOWLEDGMENT

Central Water and Power Research Station, Pune is thankful to M/s Antea Group, Kochi for referring the studies. We wish to express our sincere gratitude to Shri A.K. Agrawal, Director, CWPRS, Pune for his constant encouragement and continuous guidance during the execution of the studies. We also wish to express gratitude to Dr J.D. Agrawal, Scientist E for his help during the studies. The help and efforts of Shri P.D. Patil, Scientist C, Shri S.A. Kamble, Scientist B, Smt Snehal Shinde, Shri Sarvesh Pingale, Shri Vinit Medhe, Research Assistants, Smt Indu Menon, Steno and other staff members of the division are acknowledged with thanks. The contribution and support of Shri Anilkumar Gopinath, Team Leader, Dr (Mrs) Jany George, Expert and project Director Mr Krishna Kant Gupta of M/s Antea Group, Kochi and discussion with KMRL team is gratefully acknowledged.

Aleena Isaac
17/08/2021

APPENDIX – I

(Integrated Urban Regeneration and Water Transport System, Kochi, India Hydraulic Modelling and Flood Plain Studies - Report)

Integrated Urban Regeneration and Water Transport System (IURWTS) in Kochi

Project # : WT/2024
Revision # : R0
Date : 21-01-2021

Hydraulic Modelling and Flood Plain Studies

Integrated Urban Regeneration & Water Transport System

Antea Group

Antea Nederland. Antea India

Understanding today.
Improving tomorrow.

General Consultancy Services for Integrated Urban Regeneration and Water Transport System, Kochi, India

Hydraulic Modelling and Flood Plain Studies

Project number : WT/2024

Document Number : AI-IURWTS-HS-003

Revision number : R0

Date : 21-01-2021

Revision History

Rev	Date	Prepared by	Reviewed by	Approved for Issue by
0	21-01-2021	Dr. Jany George (Urban Infrastructure - Public Health Engineering Expert)	Terrence Van Kalken (Hydraulic/ WRM Modelling Expert)	Anilkumar Gopinath (Team Leader)
		Jany	T. van Kalken	G. Anil

Issue Register

Distribution List	Date Issued	Copies
Submitted to CWPRS, Pune for validation	21-01-2021	1S

Submitted by,

General Consultant – IURWTS Project

Antea Nederland B.V. and Antea India Pvt. Ltd. (JV)

Client:

Kochi Metro Rail Limited, (A Joint Venture of Govt. of Kerala and Govt. of India)

Table of Contents

List of Annexures

List of Figures

List of Tables

Project :	General Consultancy Services for Integrated Urban Regeneration and Water Transport System (IURWTS) Project in Kochi, Kerala.
Subject :	Hydraulic Modelling and Flood Plain Studies
Date :	21-01-2021

1. Project Description and Study Objectives

1.1 Project Description

Urban sprawl, unplanned development, encroachment into the canal commands, flooding, inadequate solid waste management, lack of sewer facilities resulting in water and air pollution issues, are the list of woes faced in the Kochi urban fabric. In addition, as Kochi city is a coastal/riverine city, climate change impacts are a major consideration in the future development of the metropolis.

The "Integrated Urban Regeneration and Water Transport Studies" (IURWTS) project which has been in progress since July 2018 is a comprehensive and visionary project of the Govt. of Kerala to address many of the social woes faced by city residents and businesses within the catchment limits of the project. The IURWTS builds on earlier assessments of the use of waterways to build urban resilience in the city (Aziz et al., 2018) and seeks to restore a number of primary canals to provide possibilities for mass water transport. For implementing the IURWTS project, the Govt. of Kerala (GOK), India has engaged, Kerala Metro Rail Ltd (KMRL) as the Special Purpose Vehicle (SPV). Antea Nederland was selected as the General Consultant by the SPV to assist in the planning, design, cost estimation, tendering and implementation stage of the project.

The IURWTS study is focused on five main drainage canals namely Edappally Canal (11.23 Km), Chilavanoor Canal (9.88Km), Thevara-Perandoor canal (11.15Km), Thevara canal (1.41km) and Market canal (0.66Km), see **Figure 1**.

Nearly one third of IURWTS catchment lies inside the Kochi Corporation limits which includes 74 wards having a total area of 94.88 Sq.Km. The Kochi Corporation area is geographically located between 76^{0}15' 9.4"- 76^{0}30' 8.35" east longitude and 9^{0}42' 3"-9^{0}58' 9.39" north latitudes. Being a coastal district the majority of the Kochi region lies within the lowland region of the state. The average land elevation of the Kochi Corporation area towards the eastern fringes is about 7.5 m above MSL, and towards the west the elevation is less than one metre on an average.

Approximately, 40% of the surface area consists of water formed by the rivers, canals, and lagoons of the Kochi Estuary.

The IURWTS project covers a total area of 41.49 sq.km. Out of this, 33.08 Sq.km forms part of Kochi Corporation with an area of 8.41 sq.km on the eastern side falling in 3 municipalities (Kalamassery, Thrikkakkara and Thripunithura Municipalities). Out of the 74 wards of Kochi Corporation, 54 wards fall within the IURTWS project area including 19 wards each in Kalamassery and Thrikkakkara municipality and 2 wards in Thripunithura municipality. The physiographic setting of IURWTS Catchment is given in **Figure 1**.

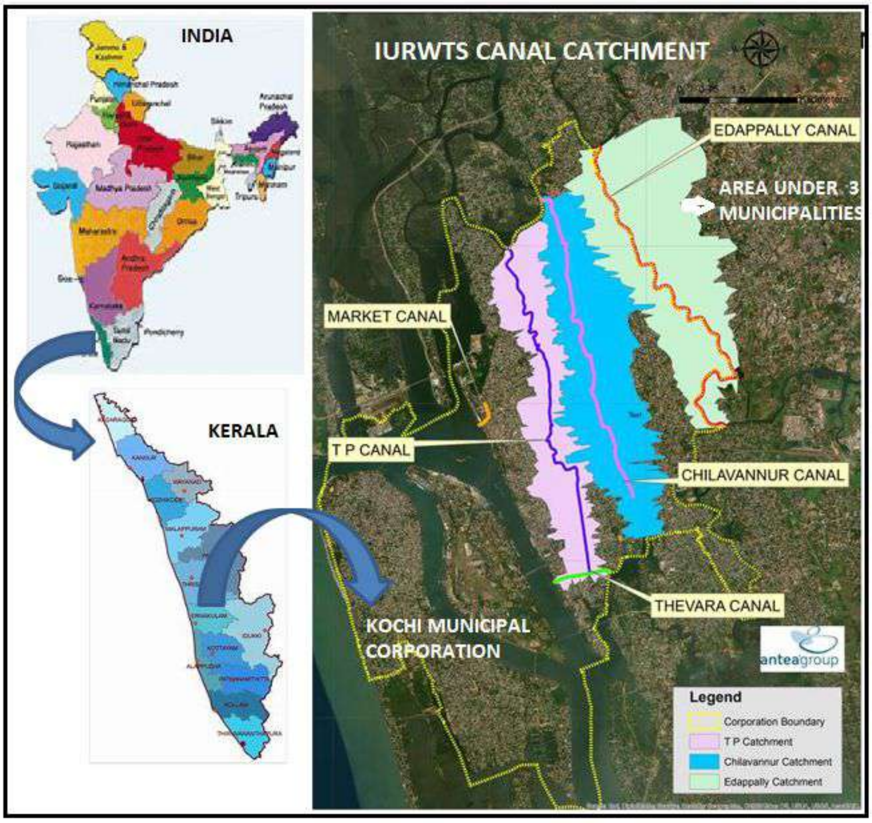


Figure 1: Physiographic setting of IURWTS Catchment

1.2 Location Description

The major canals (Edappally, Chilavanoor and combined catchment of Thevara-Perandoor which are the focus of the study run roughly north-south through Kochi city, which is located in a large coastal lagoon. The IURWTS canal water levels are influenced by the tide and sea conditions, by the flows in the adjoining rivers which drain into the lagoon to the north and south of the catchment and by local storm water flows into the canals. The latitude and longitude at the canal ends are given in **Table 1** and **Figure 2**.

Table 1: Latitude and longitude at extreme ends of the canal

		Edappally	Thevara	Thevara-Perandoor	Chilavanoor	Market
a) Start points	Latitude	10°2'36.88"N	9°56'46.81"N	10°1'12.12"N	10°1'53.21"N	9° 59' 4.71"N
	Longitude	76°18'11.73"E	76°18'17.27"E	76°16'55.85"E	76°17'23.35"E	76°16'34.40"E
b) End points	Latitude	9°58'46.35"N	9°56'36.94"N	9°56'46.81"N	9°57'14.89"N	9°58' 47.35"N
	Longitude	76°19'55.55"E	76° 19’20.02"E	76°18'20.52"E	76°18'49.20"E	76°16'29.82"N

Major Rivers draining into Kochi Lagoon

Kochi city lies within a large and complex estuarine system(Strikwerda, 2004)(Revichandran et al., 2012). On the southern side of the IURWTS canal catchments, four major rivers (Achencoil, Pamba, Meenachal, and Manimala) drain into Vembanad lake which forms the southern upstream boundary of Kochi lagoon. The excess flow from Vembanad lake system is drained out through the Thanneermukkom barrage. The Muvattupuzha river joins the outflow from Thanneermukkom barrage and the combined flow passes through the Kochi lagoon and harbor to the sea. A small catchment of the Chitrapuzha River flows through the Ambalamedu region from the east and meets the southern Edappally canal outfall before joining the Kochi lagoon.

To the north of the canals the Periyar river represents a major river source that drains an area of 5398 km^2. In the downstream stretch at Aluva, the river bifurcates into the Marthanda Varma and the Mangalapuzha branches. The Mangalapuzha is the main branch that flows to the sea at Munambam, Kuzhuppilly 15km north of Kochi. The Marthanda Varma branch flows south towards the Kochi lagoon, dividing into many distributaries on its way and finally drains into the lagoon on the eastern side of IURWTS catchment.

One of the distributaries forms a small loop in the river at Muttar and meets the northern boundary of the Edappally canal. Another loop of the distributary meets the northern boundaries of the Chilavanoor and Thevara-TP canals.

The drainage area of the upstream rivers is given in **Table 2**. The drainage map of major rivers flowing into Kochi lagoon from upstream catchments is given in **Figure 3**.

Table 2: Drainage area of upstream catchment rivers

Sl.No	Rivers draining into Kochi lagoon on southern side of IURWTS catchment	Basin area of the rivers Sq.km [1]
1	Achencoil	1484
2	Pamba	2235
3	Manimala	804
4	Meenachal	1272
5	Muvattupuzha	1554
6	Periyar	5398

Source[1]: Wikipedia

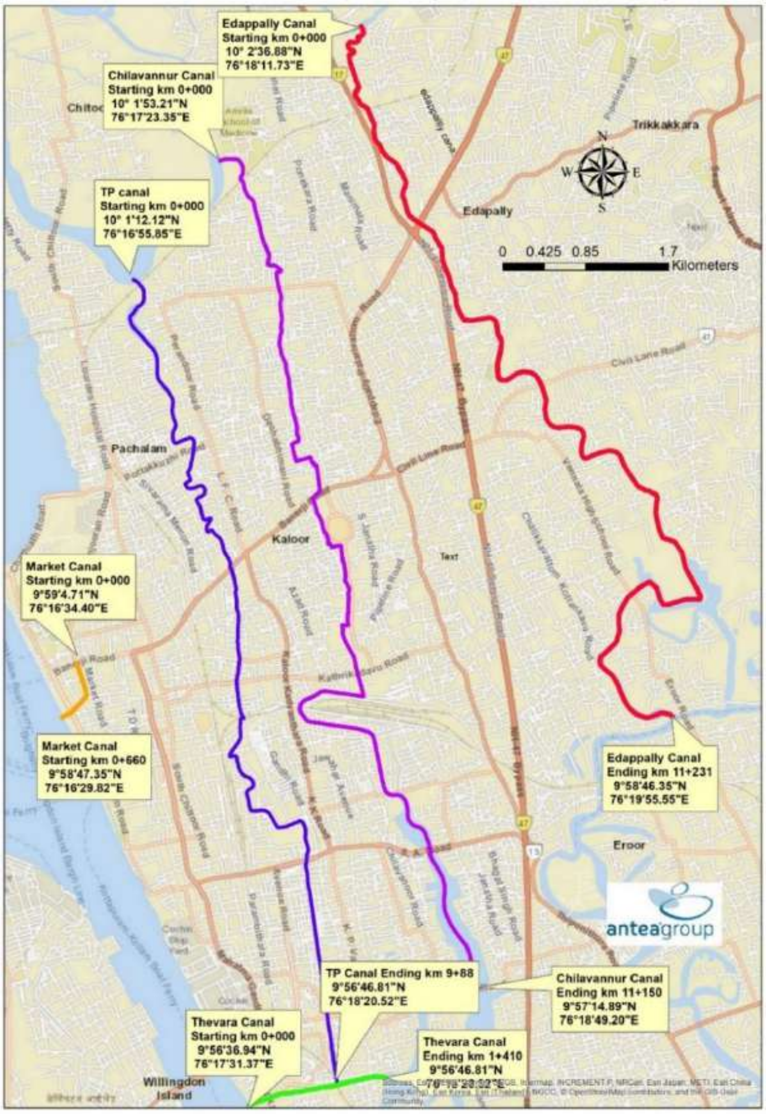


Figure 2: Layout of 5 canals of IURWTS catchment

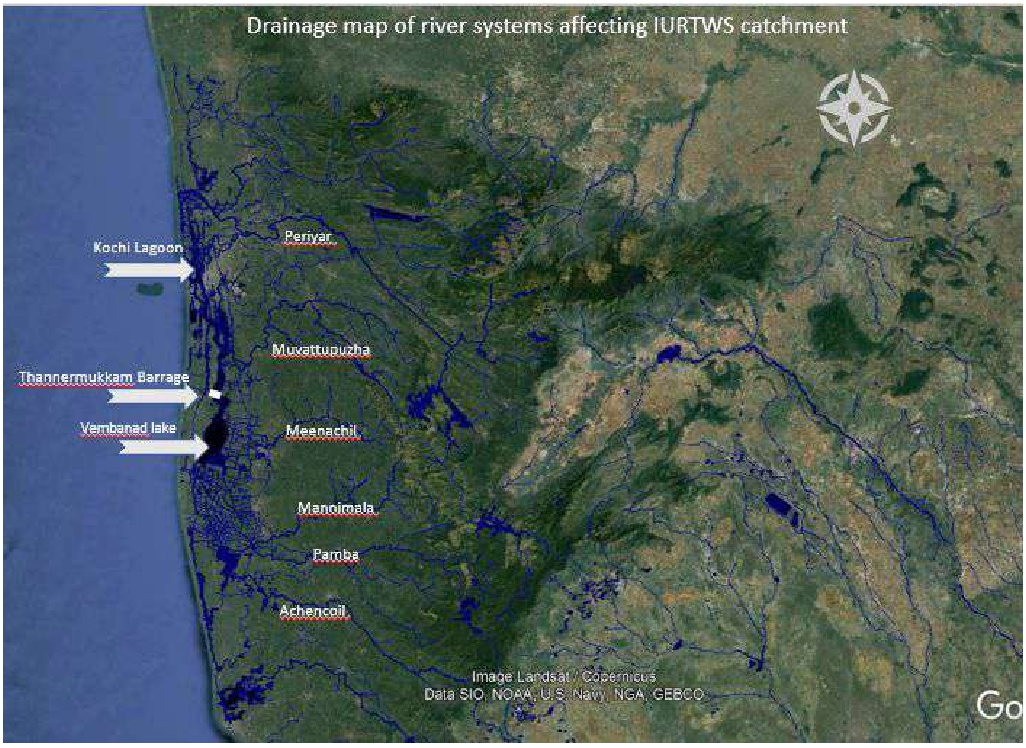


Figure 3: Drainage map of river systems draining into Kochi lagoon

1.3 Past flooding history

The IURWTS catchment lies in the lowland coastal region of Kerala state. The average elevation at the eastern side of the catchment is 7.5m above MSL while in the west the average elevation is less than 1m above MSL. The entire IURWTS catchment slopes gradually from east to west.

The maximum and minimum ground elevations in the catchment areas of the three main canals namely Edappally, Chilavanoor and Thevara-Perandoor are given in **Table 3**.

Table 3: Ground level variation in the project catchment

Sl.No	Catchment	Max. Ground level elevation MSL (m)	Min. Ground level elevation MSL (m)
1	Edappally	31.40	0.95
2	Chilavanoor	5.89	0.76
3	Thevara Perandoor	4.45	0.68

Source: Topographic contour levels (KSUDP) (2015) supplied by Client

The rainfall analysis of the catchment shows that there are **124.7 rainfall days**, and an average annual rainfall of **2886mm, Table 4**. Most of the rainfall occurs during the S-W monsoon (June to September) and the N-E monsoon (Oct-Nov) months of the year. Due to the low-lying nature of the catchment, many pockets are subjected to frequent flooding.

Table 4: Average decadal annual rainfall for Kochi

Decadal year	1974-1983	1984-1993	1994-2003	2004-2013
Annual rainfall (mm)	2926	2769	3015	2835
			Average rainfall	2886 mm

Source: IMD data collected (2020)(GC)

Flooding tends to occur when the maximum daily rainfall exceeds 150mm. Recent floods where this has occurred (1974-2019) in the catchment are listed in **Table 5**. It is notable that the two most recent floods in 2018 and 2019 represent the third and second highest daily totals respectively since 1974.

Table 5: Daily maximum rainfall > 150mm (1974-2019)

Sl.No	Year	Daily maximum rainfall (mm) > 150mm
1	1978	154.8
2	1991	179.7
3	1992	208.1
4	1996	152.2
5	2003	154.6
6	2007	167.5
7	2011	162.6
8	2014	172.9
9	2018	182.0
10	2019	197.6

Source: IMD data collected 2020)(GC)

In studies undertaken by (Sowmya et al., 2014) it has been identified that approximately 24% of the Kochi Corporation area (a major portion of which is within the IURWTS catchment) is vulnerable to floods. Generally the city is vulnerable to a range of natural events (Oak Ridge National Laboratory and Cochin University of Science of Technology, 2003) including sea level rise (Kumar, 2006), (Mani Murali and Dinesh Kumar, 2015). Recommendations to take immediate steps to improve the drainage systems by way of restoring the dilapidated drainage canal systems and the linkages of the sub-drains reaching the main canals was also proposed as part of the study.

Figure 4 shows a photograph of IURWTS catchment area in Kochi city being inundated due to heavy rains on 15th Aug 2020.

Figure 4: Flooding in project catchment on 15th August 2020

(Source: (2020) Indian Express daily)

1.4 Study objectives

The IURWTS project addresses two main components,

1. Restoration of **five major dilapidated canals** and associated catchments to mitigate storm water flooding, and to allow public transport navigation to enhance connectivity and provide pollution free water bodies.
2. **Urban regeneration** of the canal catchments by a canal-oriented development (COD) approach, incorporating sewer connectivity up to the households in the catchments with purpose built sewerage infrastructure.

The Hydraulic and Floodplain Studies described in this report form part of the first component. The three major canals (Edappally, Chilavanoor and the combined catchment of Thevara Perandoor) are currently in a dilapidated state with many bottlenecks such as encroachment into the canal boundaries by squatters , unplanned road and footbridge crossings and major utility crossings of the canals without adequate vertical clearances for draining the flood waters.

This has resulted in drainage congestion leading to overbank flooding in many pockets along the canals during heavy rainstorm events. In the existing condition, navigation through the canals is not possible due to encroachments and siltation. Under the proposed restored state, the canal width and depth are increased as per PIANC guidelines [15] for ensuring two-way movement of vessels.

The objective of the Hydraulic and Floodplain Studies is to assess the drainage capacities and affected flooded areas of the canals during extreme events. Hydrologic and hydraulic models have been used to assess both the existing state and the restored state of the canals under different return periods of extreme precipitation events, tidal conditions and river floods. The restored state of the canals is designed to address both flood mitigation and navigation requirements.

1.5 Methodology

The methodology adopted has followed these steps:

1. **Generation of rainfall Intensity-Duration-Frequency (IDF) curves and design rainstorm hyetographs:** An IDF Curve gives the expected rainfall intensity (mm/hr.) of a given duration of a storm and its frequency of occurrence. IDF curves have been generated for a range of probabilities and durations from historical data. From the IDF relations, design storm hyetographs defining the temporal distribution of the rainfall have been derived using the alternating block method – see section 3.3.8.
2. **Hydrologic Analysis:** This analysis is undertaken to obtain estimates of catchment inflows to the canals for the selected rainfall design return periods. The catchment runoff hydrographs are generated using **HEC HMS** software. As the canal catchments are ungauged, no flow data was available for calibration of the model; however, peak flows from HEC-HMS have been compared with a simple Rational Method as a means to crosscheck the hydrograph estimates.
3. **Hydraulic and floodplain modelling:** Routing the runoff hydrographs through the canal systems has been undertaken using **HEC RAS** software. The hydraulic modelling has assumed one dimensional unsteady flow regimes and has generated the water surface profiles and flows along the canals as well as inflow/outflow hydrographs at the canal boundaries. Energy losses due to channel contractions and expansions as well as the effects of obstructions such as bridges and cross structures have also been taken into account in the computations. Flood maps generated for extreme events along the canal are also brought out.

2. Survey Data

Topographic data in the form of canal bathymetries and floodplain elevations are required in order to develop the hydraulic model. River bathymetry was collected using GPS survey equipment while floodplain elevations on each bank of the canals were obtained from airborne LiDAR surveys.

Supplementary topographic surveys were used to establish the vertical and horizontal controls and survey the main features in the floodplain to tie the LiDAR and bathymetric surveys together. Details of the data collection program are described in the following sections.

Establishment of Reference Benchmark

Leica GS14 GPS receivers were used to establish 20 nos. of reference benchmarks along the road networks in the project catchment as shown in **Figure 5**. This was connected with the nearest permanent benchmark of hydrographic survey wing office at Cochin Port Trust having RL 3.300m. These reference benchmarks were established to provide additional control points along the canal and survey paths to aid the LiDAR, topography and bathymetry surveys.

LOCATION GOOGLE MAP	PHOTOGRAPH
	 BM 01

Figure 5: Sample reference benchmark

2.1 Topographic Surveys

Following establishment of the control points, topographic surveys were conducted to identify and map the main features (cross structures) along the canals and on the floodplains. The surveys were conducted using both total station and GS 14 GPS RTK system. Detailed topographic maps were also prepared at 1: 500 scale.

2.2 Bathymetry surveys

Bathymetry surveys of the canal bed levels were carried out for all canals between 15 June and 10 August 2020. The survey was carried out using Real Time Kinematic (RTK) equipment with horizontal control established based on Differential Global Positioning System (DGPS) in real time mode. The survey was carried out with respect to the reference benchmarks established as explained above. The bathymetry survey comprised a total of 2305 regular cross sections for all the 5 canals taken at 15m intervals from water edge to water edge. A sample section of bathymetry survey is shown in **Figure 6**.

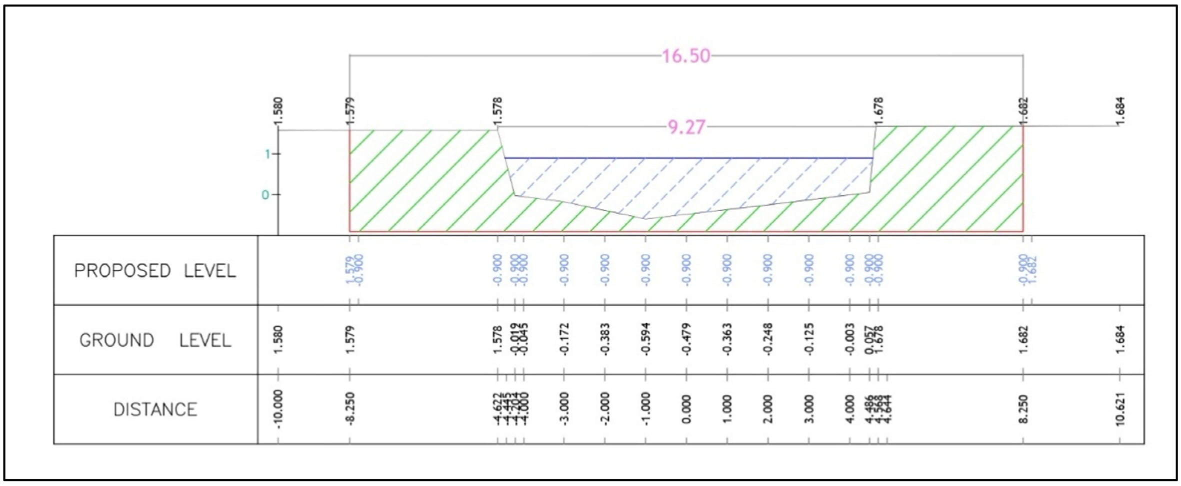


Figure 6: Sample section of the bathy survey- points with levels

2.3 Aerial LiDAR and Ortho Photo Surveys

A Light Detection and Ranging (LiDAR) survey was carried out by drone along the canals extending to 125m on either side of the canal banks. From the reference benchmarks established along the canal sides, the LiDAR survey tracks were prepared, and an additional 20 Control points were established along the survey track for monitoring during the LIDAR survey as shown in **Figure 7**.

The LiDAR surveys were undertaken in February 2020 and utilized a Velodyne VLP-16 instrument flown in an Unmanned Aerial Vehicle (UAV) at elevations of 40-100m. A total of 80 flights were executed to cover the required survey extent.

In addition to the LiDAR data additional flights were undertaken to collect RGB oblique imagery. A total of 32 flights were made at elevations of 60-150m.

LOCATION GOOGLE MAP	PHOTOGRAPH
	

Figure 7: Typical Control point fixed along the canal

Primary ground control points (GCP) were connected by static GPS methods.

a) Marking and coordination of GCP points: Two different DGPS crew established around 382 GCP control points along the LiDAR survey corridor width by paint marking on hard surface.
b) This DGPS network points were further extended using RTK methods.

The LiDAR data was processed and projected to UTM Zone 43N grid coordinates and reduced to Chart Datum vertical reference. A sample is given in **Figure 8**. Details given in **Annexure 1**.

2.1 Merged DEM preparation

The LiDAR derived floodplain elevations together with the topographic survey spot levels and channel bathymetries were merged into a single high resolution (0.5m grid) Digital Elevation Model (DEM) for the purposes of building the hydraulic models.

As a first step each raw LiDAR data tiles were processed to remove vegetation and buildings to create a “bare earth” surface. All tiles were then interpolated to a 0.5m x 0.5m grid using Terra Solid software, mosaicked, cropped, and converted into ArcGIS rasters and geo tiff files.

The bathymetric surveys were similarly processed into the same 0.5m x 0.5m grid domain. Finally, the bathymetry grid was “burnt in” to the LiDAR grids in the canal areas to form a final fused product, comprising interpolated bathymetry in the canal areas and LiDAR derived land level data in the remaining overbank areas.

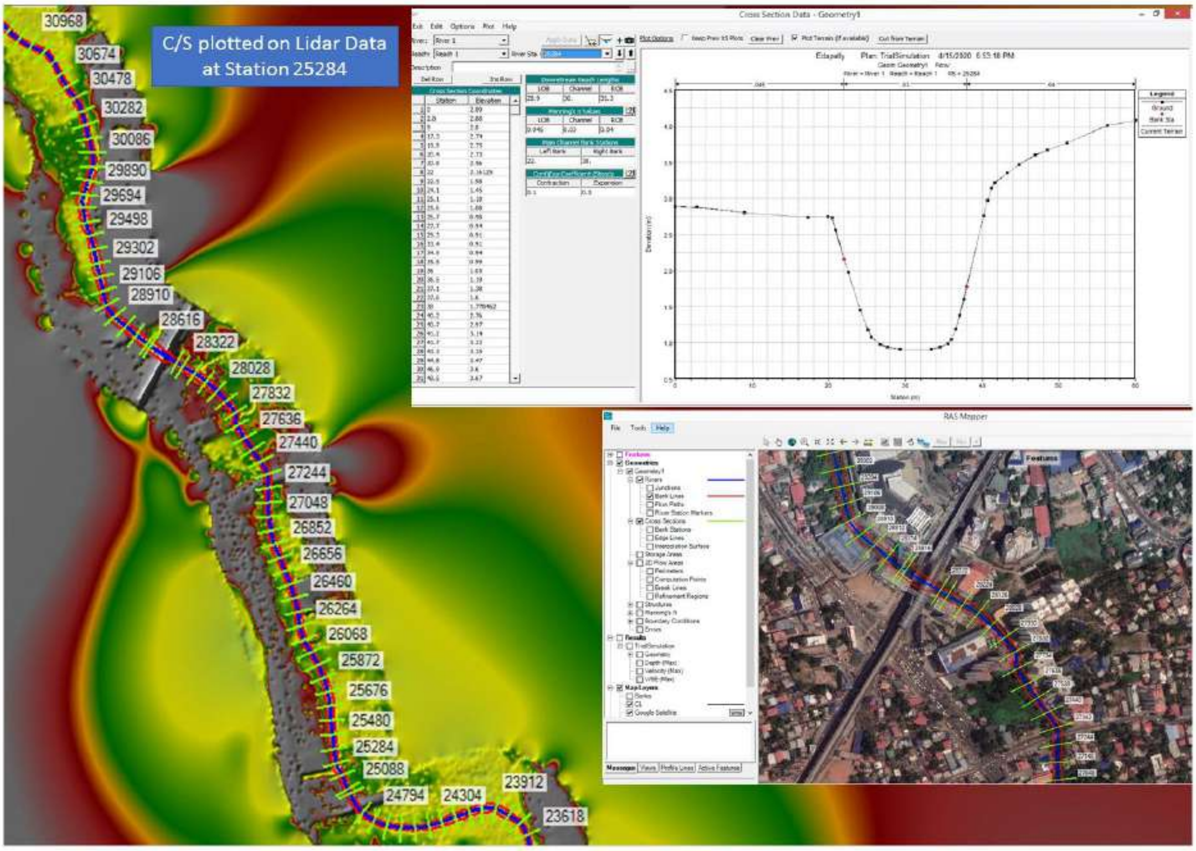


Figure 8: Sample of the LiDAR survey and orthophoto

DTM fusion with Bathymetry (unrestored & restored condition)

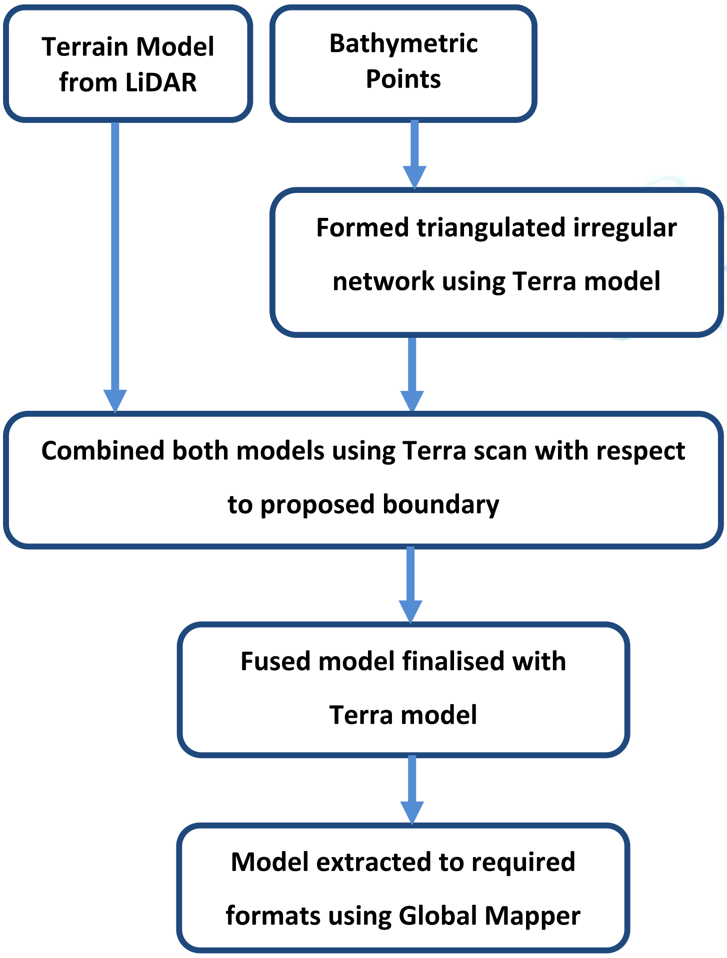
Software used:

1. MicroStation connect Edition.
2. Terra Solid-Terra Scan & Terra Model.
3. Global Mapper.

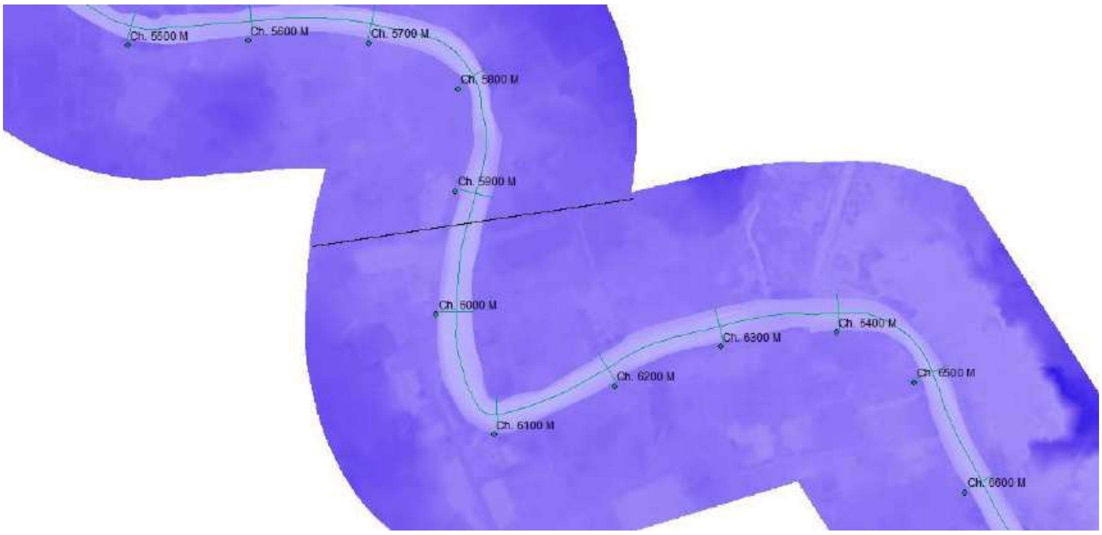
Procedure

- Bathymetry levels are imported into Terra Scan and a Triangular Irregular Network (TIN) model generated using Terra Model.
- The generated TIN model of bathymetry data is exported as a separate terrain model.
- Terrain Model from LiDAR is imported excluding the areas of standing water inside the canal channels.
- The bathymetry model is imported into the LiDAR terrain model to replace the standing water areas using Terra Scan.
- A new model is generated using the Bathymetry data inside the canal boundary and LiDAR data outside canal boundary
- The generated fused model is then exported into 0.5m grid formats using global mapper.

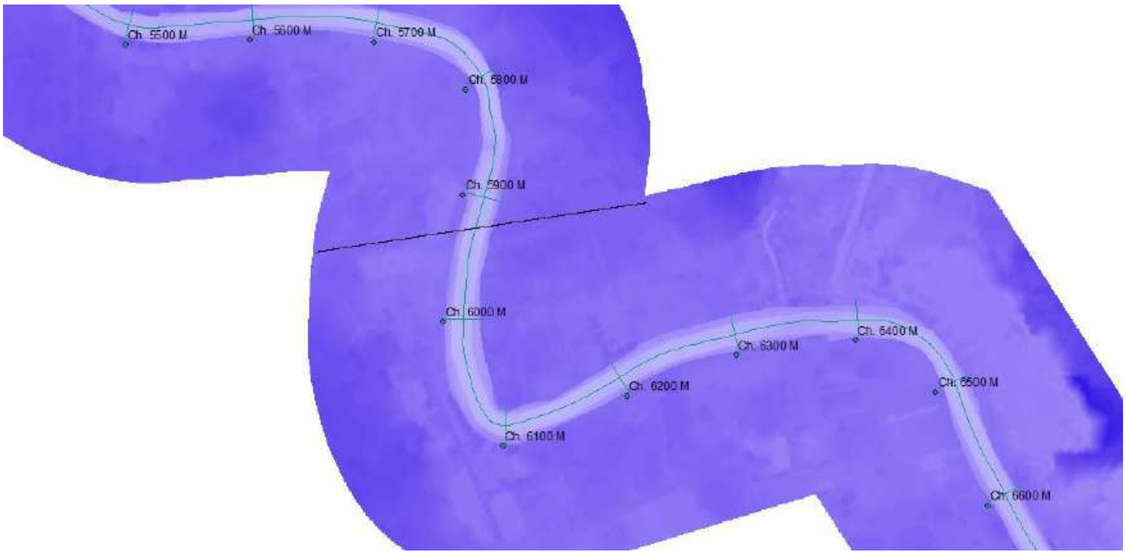
Methodology flow diagram



The merged DEM was created for both the unrestored condition (using surveyed bathymetry) and for the restored condition. For the latter case, the canal was widened to 16.5m and vertical depth maintained to a minimum of -0.9m CD with the help of point cloud transformation tool in terra scan software. Cross structures were also removed. These dimensions were based on the necessity for maintaining navigation standards in the canal. As sample section is shown in **Figure 9**.



LiDAR Data



Bathymetry merged with LiDAR data

Figure 9: Sample of Merged DEM

3. Rainfall data and processing

3.1 Rainfall data

Rainfall data has been obtained from two main sources. Hourly rainfall data has been collected from the Kochi Naval base covering the period from 1993—2015 (**Annexure 1(a)**). A gridded product of daily rainfall (0.25^0x0.25^0) was obtained for Kochi station (9.96^0 N, 76.27^0E) from the India Meteorological Department (IMD) for the period 1975-2013[1], 2018 and 2019 data collected from Southern Railway Department, Ernakulam (**Annexure 2**).

3.2 Rainfall Analysis

In hydrological analysis, extreme rainfall events are required for estimation of design floods or storm water drainage analysis in an urban catchment. The tail portion towards the right or left of the probability distribution represents the extreme values. The probability associated with such extreme values are all small, but the distribution of these extreme values has unique characteristics, and hence this region of the parent population is the area of interest in rainfall analysis.

Specifically, for hydraulic design, the maximum intensity of rainfall for a given duration and return period is required to arrive at the design discharge for a given return period. The intensities and associated durations thus calculated are converted into design rainfall hyetographs as input to a hydrological model, which generates storm runoff for hydraulic modelling analysis. The hydraulic model is used in estimating the carrying capacity of the canal required to accommodate the storm water discharge through the canals under study.

3.3 Derivation of Intensity-Duration-Frequency curves

Rainstorms or rain events are characterized by three variables, the depth of rainfall, the time over which it occurs (which defines the intensity in mm/hr.) and the probability or frequency of occurrence, expressed generally as an average Annual Recurrence Interval (ARI) or return period, in years. The three variables are linked via an Intensity-Duration-Frequency (IDF) relation, are generally derived from historical observations, and differ from place to place. The developed IDF curve at a site can be used to

[1] Some years of data are missing

inform the subsequent hydrological analysis and is basically a risk analysis tool for deciding the parameters in design of hydraulic structures.

Rainfall intensities decrease with longer storm durations. The rainfall event that gives rise to the maximum runoff from a given catchment is generally associated with the catchment **time of concentration (T_c),** which is a measure of the time taken for runoff from the farthest part of the catchment to reach the outlet. In urban catchments that are characterized by large impermeable areas such as rooftops, roads and paving, times of concentration are generally short, in the order of a few minutes to a few hours. Consequently, short duration and therefore high intensity rainfalls are of great importance in urban storm water design due to the fast hydrological response times of the built environment.

3.3.1 Methodology and Analysis of the available data for construction of IDF Curves

For an urban catchment, the generally recommended return period for hydrological design per the CPHEOO manual(Central Public Health and Environmental Engineering Organization (CPHEEO), 2019) is 2yrs, 5yrs or 10yrs. In contrast the Central Water commission (CWC 2011), Govt. of India guidelines suggest the return periods for hydrological analysis in an urban catchment to be considered are 25yrs, 50yrs or 100yrs. For IURWTS a nominal design return period of 25 years has been defined.

The Intensity of rainfall is the rate of rainfall or the depth of rainfall in unit time. The average intensity is calculated as,

$$I = \frac{P}{t}$$

Where, I= Average Intensity (mm/hr.)

P= Total Precipitation (mm) in the duration t (hr.)

In this analysis, the shortest measurement duration was one hour, and therefore IDF relations have been derived for durations of between 1 to 24 hours. The assumption in calculating the rainfall intensity is that the rainfall has occurred uniformly throughout the duration specified. The calculation of the return period (or frequency) assumes a certain statistical distribution of the recorded rainfall intensities. A goodness of fit from the data available determines the statistical distributions that best match the observed data for the purpose of deriving the IDF relationship.

3.3.2 Analysis of available data

The data used has been obtained from two sources: different format hourly-observed gauge data for the period 1993-2015 and daily data for 1975-2013.

Note: there are periods with missing data in both records.

- Out of the observed hourly data for 22 years (1993-2015), 6 years (1996, 2005, 2006 2009, 2012, 2013) data is missing, hence 16 years of data are available for the analysis.
- In the daily data set, data for years 2016 and 2017 were missing. **Note:** The daily data for the year 2006 showed an outlier which was subsequently validated and corrected from a rain gauge station maintained by southern railway, Ernakulam. Daily data for 2018 and 2019 were added as extreme events occurred during these periods.

The IDF analysis has been undertaken in two ways:

- **Option 1**: Based on the 16 years of hourly data. See **Annexure 1 (b)**.
- **Option 2**: The 16 years of hourly gauge data have been infilled and extended with empirically derived hourly data extracted from the daily data (raw data is provided in **Annexure 3**) as described in Section 3.2.6.

The procedure adopted for IDF development is described as follows.

3.3.3 Option 1: Derivation of IDF from observed hourly data

- The analysis was undertaken preliminarily with good quality 16 years of data.
- From the daily record of hourly data (1993-2015), rainfall values for different durations: 1hr, 2hr, 4hr, 6hr, 12hr and 24hr values were calculated and compiled by adding consecutive hourly data for different durations.
- The annual maximum rainfall for each year is extracted for different durations.

The annual maximum data series (Extreme value series) obtained for the different durations is shown in **Table 6.**

Table 6: Maximum hourly rainfall depth in mm from observed gauge data

Year	1hr	2hr	4hrs	6hrs	12hrs	24hrs
1993	73.0	73.5	105.2	105.2	106.4	134.7
1994	62.5	89.0	89.0	89.0	108.6	144.2
1995	50.0	50.0	50.0	76.5	91.6	152.2
1997	65.5	70.0	80.0	93.8	104.7	115.3
1998	34.5	36.5	44.3	70.3	86.0	95.6
1999	51.0	64.0	68.8	69.3	105.1	118.3
2000	30.0	46.6	49.0	54.7	57.4	68.8
2001	47.0	57.0	78.8	89.5	134.5	136
2002	73.5	84.8	86.0	104.2	104.4	154.6
2003	63.0	69.7	97.7	97.7	97.7	126.4
2004	71.5	73.7	91.0	102.5	135.6	160.8
2007	56.5	78.1	82.1	83.4	84.0	167.5
2008	69.5	72.0	73.8	81.6	89.9	89.9
2011	68.3	90.3	94.3	120.3	162.6	162.6
2014	53.5	60.0	81.0	109.8	168.2	172.9
2015	66.5	78.9	78.9	78.9	81.1	81.1

Goodness of fit (Probability distribution):

Chi-Square Test is the most commonly used method to compare between actual number of observation and the theoretical number of observations. Chi-square test is used to identify the type of distribution (normal, log normal, exponential distribution etc.) for the data used in **Table 6**.

Steps involved identifying the type of distribution is as follows.

1. The rainfall data available has been distributed into a number of class intervals.
2. Count the number of data N_i in each class interval (i) from the data given.
3. Determine the probability by which each random variable lies in each of the class interval using the selected normal distribution.
4. Calculate E_i the expected number of observations in the class interval (i) by multiplying the probability with the number of sample values (n).

Chi-Square test statistics is calculated by,

$$X_{data}^2 = \sum_{i=1}^{k} (N_1 - E_1)^2 / E_1$$

This test follows the Chi-square distribution with the number of degrees for freedom equal to (y = k-p-1), where k is the number of class interval, where p is the number of parameters the distribution has. We do this for certain significance level α say 5%, 10 % etc.

The hypothesis that the data follows,

$$X_{data}^2 < X_{1-\propto,k-p-1}^2(critical)$$

The critical value is obtained from Chi-square table (available in textbooks).

The test has been applied to data series obtained against **option: 1 for** observed hourly series (1973-2015) obtained from Kochi naval base.

A sample calculation for chi-square test for a 1hr is given in **Table 7** for significance level 10%.

Note: The number of class interval chosen has been assured that it is not less than five.

Table 7: Chi Square test for 1 hr. annual observed data (Split into series)

	Chi square test for 1 hr.					
Class interval	**Observed data (N_i)**	**(Z1) of upper limit**	**$F(Z_1)$**	**P1= $F(Z_1)$-$F(Z_1$ -1)**	**E_1 -nP1**	**$(N_1- E_1)^2/E_1$**
<35	2	-1.767	0.039	0.039	0.624	3.034
35-50	2	-0.639	0.204	0.165	2.640	0.155
50-60	3	0.114	0.456	0.252	4.032	0.264
60-70	6	0.867	0.805	0.349	5.584	0.031
>70	3				16.000	3.485
n	16					
		χ^2	3.48			
		K	5			
		p	2			
		y	2			
	Significance level	10%	0.1	4.61		**Good fit**

Since $X^2_{data} < X^2_{1-\propto,k-p-1}(critical)$, **3.48 < 4.61**, We can accept the hypothesis that the data taken follows a normal distribution at 10% significance level.

Similarly, the checks are done for 2hrs, 6hrs, 12hrs and 24hrs data were found to fit well for a significance level of 10% for a normal distribution and details given **in Table 8**.

Table 8: Chi-square test values between data and Critical value

Duration	X^2_{data}	$X^2_{1-\alpha,k-p-1}$ (critical),	Acceptance condition $X^2_{data} < X^2_{1-\alpha,k-p-1}$ (critical)
1hr	3.5	4.6	Accepted
2hr	2.1	9.2	Accepted
6hr	0.9	9.2	Accepted
12hr	6.5	7.8	Accepted
24hr	6.2	9.2	Accepted

Detailed calculation for Chi square test for Option 1 given in **Annexure 4**(as sheet 1). The frequency analysis was then undertaken using Gumbel's Extreme Value Type-1 distribution using frequency factors.

3.3.4 Rainfall intensity by Extreme Value Distribution Type 1 : Option 1

For undertaking the frequency analysis the Gumbel's EVI distribution was used. The data set was following a normal distribution and the related frequency factor K_T was used.

The Gumbel Type I distribution is given by the formula.

$$G(x;\mu,\beta) = \frac{1}{\beta} e^{\frac{x-\mu}{\beta}} e^{-e^{\frac{x-\mu}{\beta}}}$$

Where, μ is the location parameter and β is the scale parameter. When μ,β is set to zero, it represents a standard Gumbel distribution depending on whether it is a smallest extreme or largest extreme.

Some probability distribution functions such as the Normal. Lognormal and Pearson type-III distributions are not readily invertible. Hence, in such cases an alternative method of calculating the magnitudes of extreme events is by using frequency factors as discussed below as the data set used follows normal distribution.

The value of the random variable X_T associated with a given return period T, may be obtained from the following expression,

$$X_T = X_{mean} + K_T S$$

Where, X_{mean} is the mean of values, K_T is the frequency factor and S is the standard deviation.

The frequency factor K_T, associated with return period T is given by,

$$K_T = -\frac{\sqrt{6}}{\pi\left[0.5772 + \ln\left(\ln\left(\frac{T}{(T-1)}\right)\right)\right]}$$

From the maximum data series in **Table 6**, the intensity of rainfall is computed by dividing the rainfall (mm) with the duration (hr.). The mean and standard deviation estimated are given in **Table *9***.

Table 9: Maximum annual rainfall intensity (mm/hr.) for observed hourly data

Duration	Rainfall intensity (mm/hr.)					
	1hr	**2hr**	**4hr**	**6hr**	**12hr**	**24hr**
1993	73.0	36.7	26.3	17.5	8.9	5.6
1994	62.5	44.5	22.3	14.8	9.1	6.0
1995	50.0	25.0	12.5	12.7	7.6	6.3
1997	65.5	35.0	20.0	15.6	8.7	4.8
1998	34.5	18.3	11.1	11.7	7.2	3.9
1999	51.0	32.0	17.2	11.5	8.8	4.9
2000	30.0	23.3	12.3	9.1	4.8	2.9
2001	47.0	28.5	19.7	14.9	11.2	5.7
2002	73.5	42.4	21.5	17.4	8.7	6.4
2003	63.0	34.9	24.4	16.3	8.1	5.3
2004	71.5	36.9	22.8	17.1	11.3	6.7
2007	56.5	39.1	20.5	13.9	7.0	6.9
2008	69.5	36.0	18.4	13.6	7.5	3.8
2011	68.3	45.2	23.6	20.1	13.5	6.8
2014	53.5	30.0	20.3	18.3	14.0	7.2
2015	66.5	39.5	19.7	13.2	6.8	3.3
Mean	56.8	33.3	19.0	14.6	8.6	5.2
Std. Dev.	13.3	7.6	4.4	2.9	2.5	1.4

The frequency factors are calculated for all the selected return period based on the selected distribution as given in **Table 10**.

Table 10: Frequency factor table

T in years	2	5	10	25	50	100
KT	-0.1643	0.719	1.305	2.045	2.592	3.137

Rainfall intensities X_T calculated for different return periods as given in **Table 11**.

Table 11: Rainfall Intensities (mm/hr.) for IDF relation based on observed rainfall (option 1)

	Return Period (years)					
Duration in hrs.	**2**	**5**	**10**	**25**	**50**	**100**
1	54.6	66.4	74.1	83.9	91.2	98.5
2	32.0	38.8	43.2	48.9	53.1	57.2
4	18.2	22.1	24.7	27.9	30.4	32.8
6	14.1	16.6	18.3	20.5	22.0	23.6
12	8.2	10.4	11.9	13.7	15.0	16.4
24	5.0	6.2	7.0	8.0	8.7	9.5

The IDF curve for different return periods is shown in **Figure 10**.

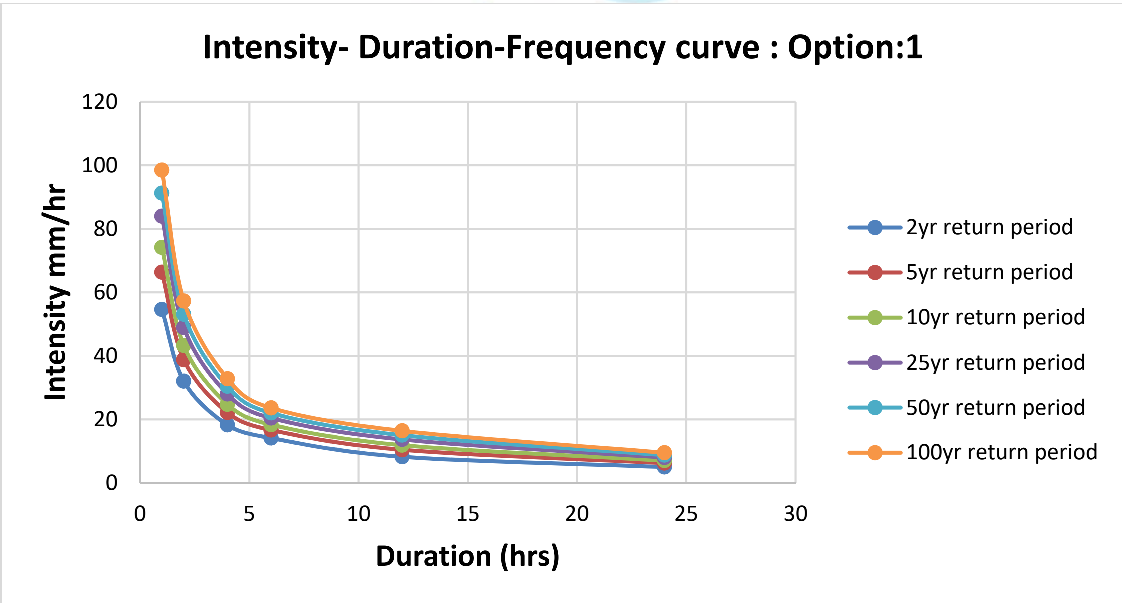


Figure 10: IDF developed for IURWTS catchment from observed hourly data (Option 1)

The detailed calculation in excel format is as given in **Annexure 1(b)**.

3.3.5 Option 2: Infilling missing hourly data from daily data

The observed hourly data only extended to 2015 and also included 6 years of missing data. In order to infill and extend this dataset, the daily data from IMD was used with an empirical relation between maximum daily rainfall and the sub-daily maximum values.

IMD provides an empirical formula (Shivakumar 2013) for deriving the sub-daily rainfall depths in t hour durations from daily values as follows:

$$P_t = P_{24}\left(\frac{t}{24}\right)^{\frac{1}{3}}$$

Where P_t is the required rainfall depth in t hr. duration.

This has been used to infill the years where hourly data are missing, and also to extend the record to 2019 (and therefore including the severe floods of 2018 and 2019).

Methodology adopted:

- The rainfall depths for 1hr, 2hr, 4hr, 6hr and 12hr are calculated for each day from daily rainfall data using this empirical relation
- The annual maximum value of rainfall is extracted from the series for each duration.
- The annual maximum Intensity of rainfall, mean and standard deviation are computed for each duration.
- The Extreme Value Type 1 (Gumbel) distribution is fitted to the series to generate an extended IDF relation.

The maximum annual totals for 1993 – 2019 including the infilled years (1996, 2005, 2009, 2010, 2012 and extension to 2018 and 2019 – highlighted) are shown in **Table 12**.

Table 12: Maximum annual rainfall depths (mm) for observed hourly data infilled and extended based on daily data (highlighted)

Year	1hr	2hr	4hrs	6hrs	12hrs	24hrs
1993	73.0	73.5	105.2	105.2	106.4	134.7
1994	62.5	89.0	89.0	89.0	108.6	144.2
1995	50.0	50.0	50.0	76.5	91.6	152.2
1996	33.9	42.6	53.6	61.3	77.0	96.8
1997	65.5	70.0	80.0	93.8	104.7	115.3
1998	34.5	36.5	44.3	70.3	86.0	95.6
1999	51.0	64.0	68.8	69.3	105.1	118.3
2000	30.0	46.6	49.0	54.7	57.4	68.8
2001	47.0	57.0	78.8	89.5	134.5	136.0
2002	73.5	84.8	86.0	104.2	104.4	154.6

Year	1hr	2hr	4hrs	6hrs	12hrs	24hrs
2003	63.0	69.7	97.7	97.7	97.7	126.4
2004	71.5	73.7	91.0	102.5	135.6	160.8
2005	34.2	43.1	54.5	62.1	78.2	98.5
2006	33.6	42.3	53.2	60.8	76.4	96.0
2007	56.5	78.1	82.1	83.4	84.0	167.5
2008	69.5	72.0	73.8	81.6	89.9	89.9
2009	47.6	59.8	75.2	85.9	108.0	135.8
2010	46.3	58.1	73.1	83.5	105.0	132.0
2011	68.3	90.3	94.3	120.3	162.6	162.6
2012	17.2	21.7	27.2	31.1	39.1	49.2
2013	42.1	52.9	66.6	76.1	95.7	118.6
2014	53.5	60.0	81.0	109.8	168.2	172.9
2015	66.5	78.9	78.9	78.9	81.1	81.1
2018	63.2	79.6	100.2	114.7	144.5	182.0
2019	68.6	86.4	108.8	124.5	156.8	197.6

The frequency factors are calculated for all the selected return period based on the selected distribution as given in**Table 13.**

Table 13: Frequency factor table

Frequency factors						
T	2	5	10	25	50	100
Kt	-0.643	0.71946	1.3045	2.0448	2.592	3.137

Maximum annual rainfall intensities (1975-2019) are given in **Table 14**.

Table 14: Maximum annual rainfall intensities (mm/hr.) for observed hourly data infilled and extended based on daily data (highlighted)

Year	1hr	2hr	4hrs	6hrs	12hrs	24hrs
1993	73.0	36.8	26.3	17.5	8.9	5.6
1994	62.5	44.5	22.3	14.8	9.1	6.0
1995	50.0	25.0	12.5	12.8	7.6	6.3
1996	33.9	21.3	13.4	10.2	6.4	4.0
1997	65.5	35.0	20.0	15.6	8.7	4.8
1998	34.5	18.2	11.1	11.7	7.2	3.9
1999	51.0	32.0	17.2	11.6	8.8	4.9
2000	30.0	23.3	12.2	9.1	4.8	2.9
2001	47.0	28.5	19.7	14.9	11.2	5.7
2002	73.5	42.4	21.5	17.4	8.7	6.4
2003	63.0	34.9	24.4	16.3	8.1	5.3

Year	1hr	2hr	4hrs	6hrs	12hrs	24hrs
2004	71.5	36.9	22.8	17.1	11.3	6.7
2005	34.2	21.5	13.6	10.4	6.5	4.1
2006	33.6	21.1	13.3	10.1	6.4	4.0
2007	56.5	39.0	20.5	13.9	7.0	6.9
2008	69.5	36.0	18.5	13.6	7.5	3.8
2009	47.6	29.9	18.8	14.3	9.0	5.7
2010	46.3	29.1	18.3	13.9	8.8	5.5
2011	68.3	45.2	23.6	20.1	13.6	6.8
2012	17.2	10.8	6.8	5.2	3.3	2.1
2013	42.1	26.5	16.7	12.7	7.9	4.9
2014	53.5	30.0	20.3	18.3	14.0	7.2
2015	66.5	39.5	19.7	13.2	6.8	3.4
2018	63.1	39.8	25.1	19.1	12.0	7.6
2019	68.3	43.2	27.2	20.8	13.1	8.2
Mean	52.9	31.6	18.6	14.2	8.7	5.3
Std dev.	15.9	9.1	5.2	3.7	2.7	1.5

Goodness of fit check: Chi Square test

Summary is shown in **Table 15**. Detailed calculation is given in **Annexure 4**(as sheet 2).

Table 15: Chi-square test values between data and Critical

Sl.no	X^2_{data}	$X^2_{1-\alpha,k-p-1}$ (critical),	Acceptance condition $X^2_{data} < X^2_{1-\alpha,k-p-1}$ (critical)
1hr	2.35	6.25	Accepted
2hr	3.19	6.25	Accepted
6hr	2.95	6.25	Accepted
12hr	3.89	6.25	Accepted
24hr	1.13	6.25	Accepted

The resulting IDF relation is shown in **Table 16** and the resulting IDF curve is given in **Figure 11**.

Table 16: Rainfall Intensities (mm/hr.) for IDF relation based on infilled& extended rainfall (option 2)

	Return period T yrs.					
Duration	**2yr**	**5yr**	**10yr**	**25yr**	**50yr**	**100yr**
1	50.3	64.3	73.6	85.3	94.0	102.7
2	30.1	38.1	43.4	50.1	55.1	60.0
4	17.8	22.4	25.4	29.2	32.0	34.8
6	13.6	15.7	19.0	21.7	23.8	25.8
12	8.2	10.6	12.1	14.1	15.5	16.9
24	5.1	6.4	7.3	8.5	9.3	10.2

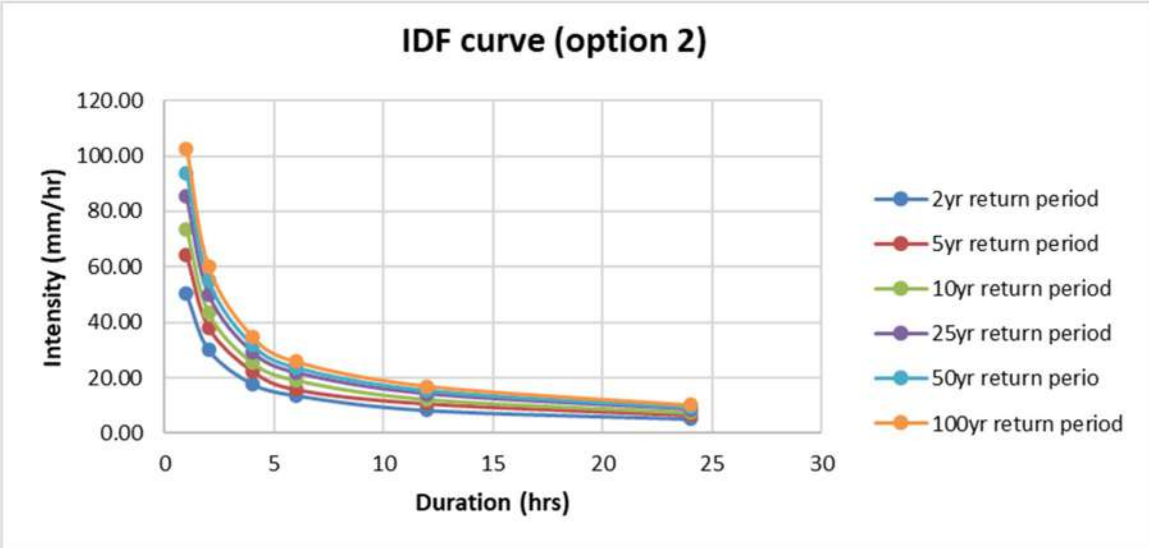


Figure 11: IDF curve (1993-2019) (Infilled and extended data) (Option 2)

The detailed calculation in excel format is as given in **Annexure 3** for option 2 analysis**.**

3.3.6 Comparison of IDF values

A comparison of the rainfall intensities based on the Option 1 and 2 approaches computed for different return periods and durations is shown **Figure 12** for 10, 25 and 50-year return periods.

The comparison of hourly intensity values (1993-2015) with missing years (Option-1) and hourly intensity values filled with missing data (1993-2019) (option 2) generally show slight increases in the option 2 analysis, most likely due to the inclusion of the 2018 and 2019 data which represent two of the highest rainfall events in the recent record.

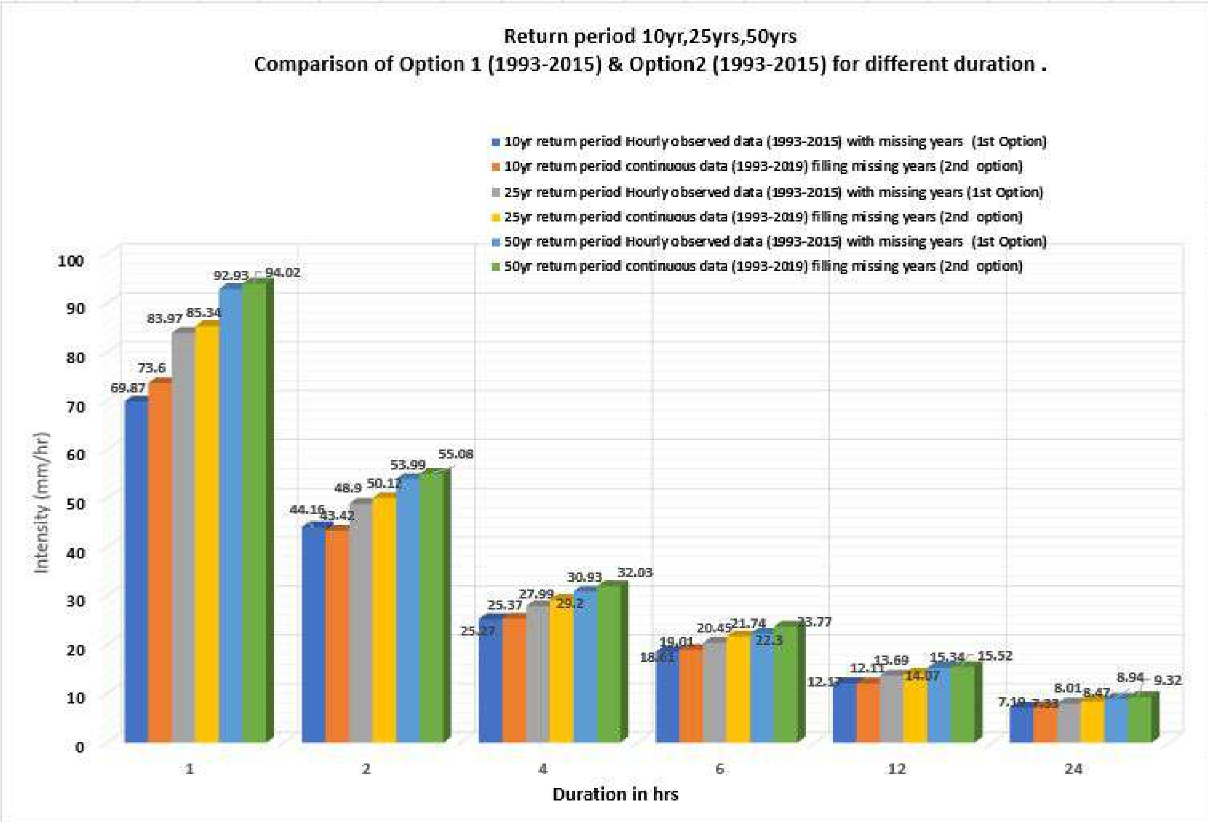


Figure 12: Comparison of IDF values

3.3.7 Comparison with regional IDF data

In order to cross check the derived IDF relation against other available data, a comparison has been made against regional estimates.

A generalized form of the Intensity relation is as follows:

$$I = (k * T^a)/(t + b)^n \text{cm/hr.}$$

Where:

k, a, b, and n are constants depending on the geographical location.

I is the rainfall intensity in cm/hr., and

T is the return period in years.

For Indian conditions, the values of the constants for Kerala have been derived (Ram Babu et al., 1979) based on the meteorological data obtained from Trivandrum observatory of IMD as shown in **Table 17**.

Table 17: IMD Regional constants derived by Ram babu et al.

Ram Babu et al. (1972)	k	T[a]	b	n
	6.762	0.1536	0.5	0.8158

Table 18 shows the Comparison of rainfall intensity calculated with regional formula and Option 2 data.

Table 18: Comparison with intensity calculated with regional formula and Option 2 data

Duration Hrs.	Return period yrs.											
	2yrs		5yrs		10yrs		25yrs		50yrs		100yrs	
	Emp	Obs	Emp	Obs	Emp	Obs	Emp	Obs	Emp	Obs	Emp	Obs
1	54.0	50.3	62.2	64.3	69.2	73.6	79.6	85.3	88.6	94.0	98.5	102.7
2	35.6	30.1	41.0	38.1	41.0	43.4	52.5	50.1	58.4	55.1	65.0	60.0
4	22.1	17.8	28.2	22.4	28.2	25.4	32.5	29.2	36.2	32.0	40.2	34.8
6	16.3	13.6	18.8	15.7	20.9	19.0	24.1	21.7	26.8	23.8	29.8	25.8
12	9.6	8.2	9.6	10.6	12.3	12.1	14.1	14.1	15.7	15.5	17.5	16.9
24	5.5	5.1	6.4	6.4	7.1	7.3	8.2	8.5	9.1	9.3	10.1	10.2

Detailed calculation given as **Annexure 5**.

A scatter plot of the data between observed and regional estimates for various return periods is shown in **Figure 13**.

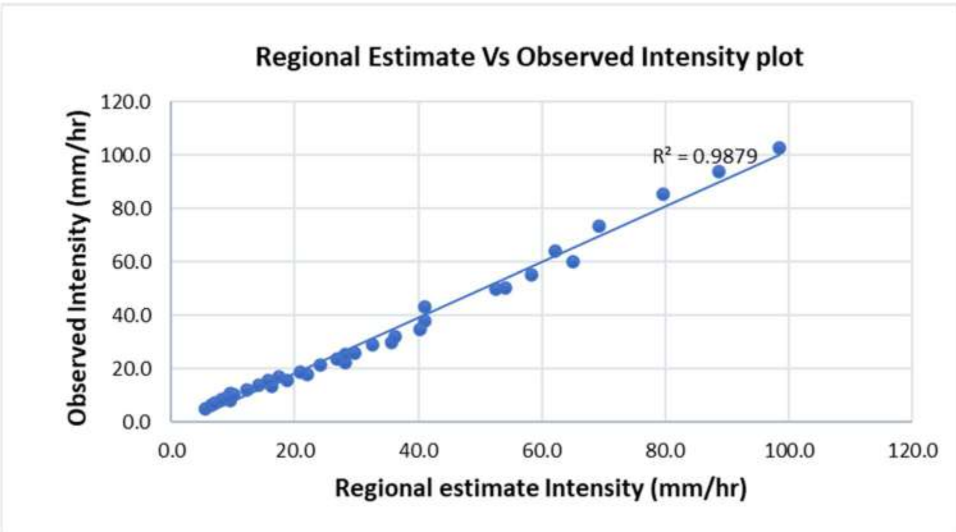


Figure 13: Scatter plot of maximum rainfall intensities Option 2 vs regional estimates

The comparison is satisfactory and does not highlight any significant issues with the derived Option 2 IDF relation which has subsequently been used for derivation of the design rainfall hyetographs.

3.3.8 Design Hyetograph Generation

The IDF relation derived above has been used to develop a design rainfall profile (hyetograph) using the alternating block method which is a standard method applied for hydrological design (Chow et al., 1988). The IDF data are used to compute the incremental rainfall depths in hourly intervals from 1 to 24 hours. These are then arranged in a 24-hour time sequence with the highest one hour depth at 12 hours, the next highest at 11 hours, 13 hours and so on. A sample calculation using the block method for a return period of 2yrs is given below in **Table 19**.

Table 19: Sample calculation using block method

Return Period 2 yrs.					
Duration (hrs)	Intensity mm/hr	Successive depth mm	Incremental depth	Time in hrs	Precipitation in mm
1.00	52.57	52.57	52.57	0-1	1.06
2.00	29.92	59.84	7.27	1-2	1.25
3.00	22.79	68.37	8.53	2-3	1.75
4.00	17.98	71.91	3.54	3-4	1.86
5.00	14.99	74.96	3.05	4-5	2.29
6.00	13.38	80.25	5.30	5-6	2.55
7.00	11.79	82.54	2.29	6-7	2.71
8.00	10.82	86.56	4.02	7-8	3.22
9.00	10.01	90.09	3.53	8-9	3.53
10.00	9.19	91.86	1.77	9-10	4.02
11.00	8.72	95.89	4.03	10-11	7.27
12.00	8.22	98.59	2.71	11-12	52.57
13.00	7.72	100.35	1.75	12-13	8.53
14.00	7.31	102.30	1.95	13-14	5.30
15.00	6.99	104.84	2.55	14-15	4.03
16.00	6.58	105.32	0.48	15-16	3.34
17.00	6.26	106.38	1.06	16-17	3.54
18.00	6.01	108.27	1.89	17-18	3.05
19.00	5.76	109.44	1.17	18-19	2.23
20.00	5.63	112.66	3.22	19-20	1.95
21.00	5.52	116.00	3.34	20-21	1.89
22.00	5.36	117.86	1.86	21-22	1.77
23.00	5.22	120.09	2.23	22-23	1.17
24.00	5.06	121.34	1.25	23-24	0.48
			121.34		121.34

The hyetographs generated for 10yrs, 25yrs and 50yrs is given below as **Figure 14**.

The detailed calculation is given as **Annexure 6**(sheet 1, 2&3). The hyetographs generated with tables is given as **Annexure 6 (sheet 4).**

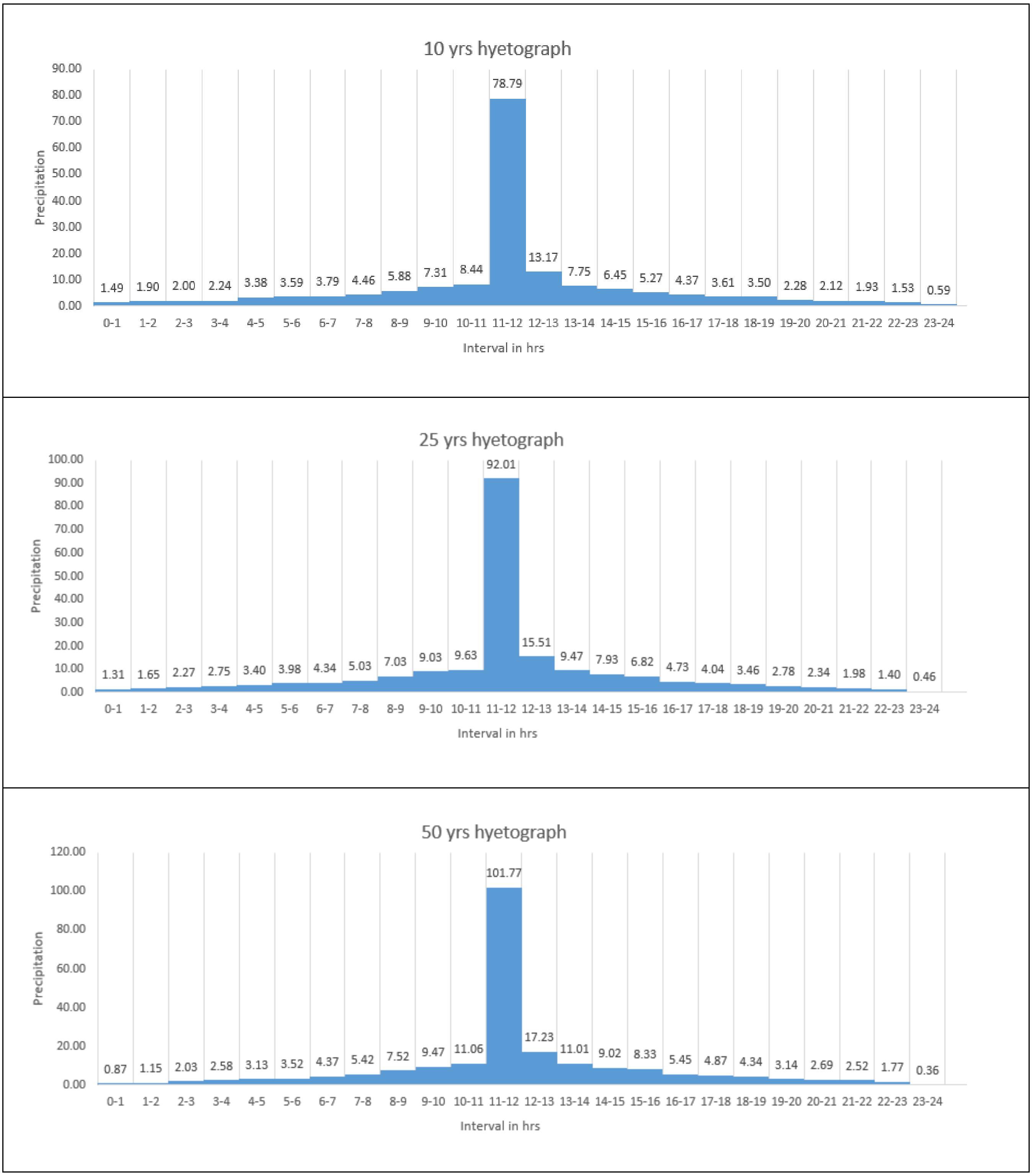


Figure 14: Hyetograph generated for 10yrs, 25yrs and 50 yrs ARI

4. Tide and River Level Data

The water levels in the rivers and lagoons where they meet the ends of the canals are influenced by sea and tide conditions, as well as river flows from the upstream catchments. These water levels represent the hydraulic model boundary conditions for the canals and will affect the outflows from the canals as well as the flood levels during rainstorm events.

In order to quantify the boundary conditions for the hydraulic modelling data from the Port of Kochi gauge was assessed together with measurements undertaken for the project, as described below.

4.1 Tide and Sea levels

4.1.1 Kochi Port Gauge

Kochi Port gauge data was available in 30 minute resolution for 2007-2019 (**Figure 15**). The original data had quality issues with missing data points often registered as zero. The data have been corrected (zero replaced with "nil" value) and converted from CD to MSL (MSL datum = CD datum + 0.6m).

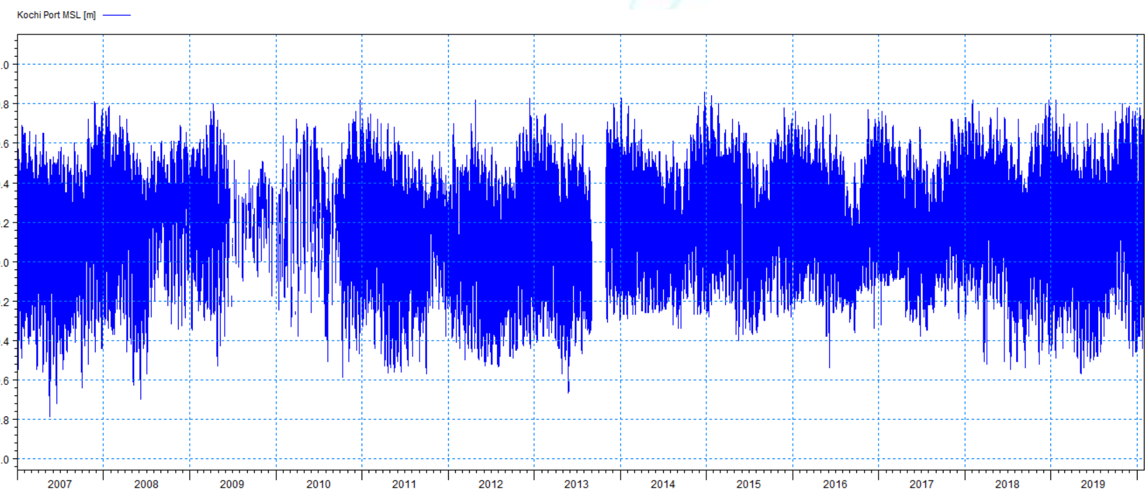


Figure 15: Kochi Port gauge tide record 2007-2019 (MSL)

Based on this data the following statistics shown in **Table 20** have been generated for the whole record, and for a sub-set of more complete data for 2014-2019. This indicates that the mean level of the sea is actually 0.20m above the current MSL datum (or 0.8m above Chart Datum). This may be partly due to the relative sea level rise trends[2] (NOAA) which indicate a rising trend of 1.54mm/yr., see **Figure 16**. Land subsidence may also contribute to an apparent increase in MSL.

Table 20: Kochi Port data statistics (MSL)

Port Gauge period of analysis	Mean(m)	Max(m)	Min(m)	Range(m)
Whole record	0.18	0.86	-0.79*	1.65
Jan 2014-Dec 2019	0.20	0.86	-0.57	1.43
Nov-Dec 2019	0.22	0.76	-0.48	1.24

** very low records may not be reliable*

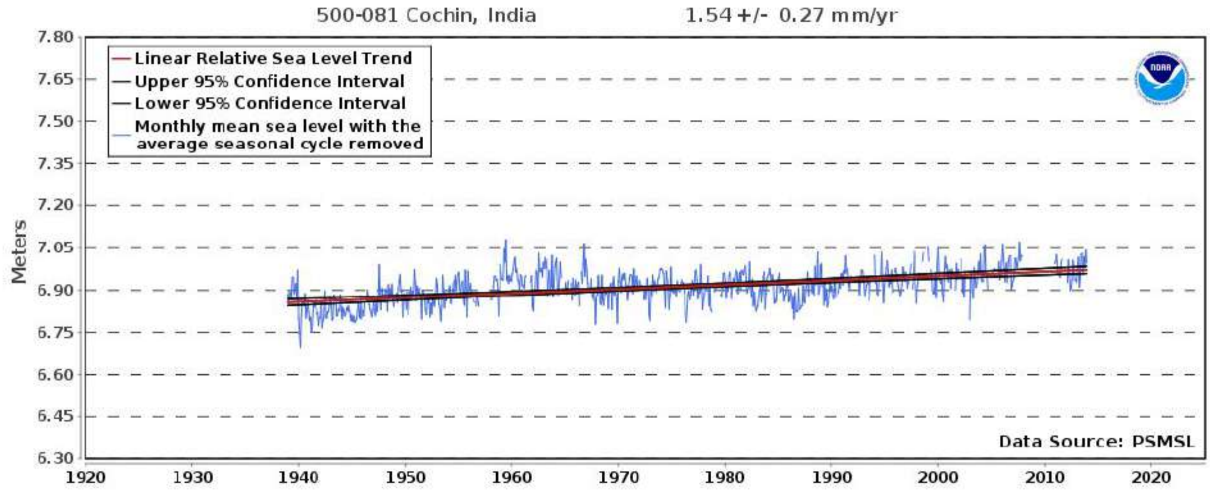


Figure 16: Sea level trend at Cochin (NOAA)

The tide characteristics published in Admiralty tide tables for Kochi are shown in **Table 21** in Column 1 relative to Chart Datum (CD). Values are rounded to the nearest 0.1m. These have been converted to MSL (MSL=CD – 0.6m) in Column (2). The above assessment of the tidal record at the Port suggests the current mean level of the sea to be 0.20m above the MSL datum. The tidal attributes such as HAT and MHHW will remain unchanged however relative to the true mean level of the sea. Therefore relative to the existing MSL or chart datums, these levels increase by 0.2m, as shown in Column 3 (referenced to CD) and Column 4 (referenced to the MSL datum).

Table 21: Kochi Admiralty Tide Tables

Cochin	(1)	(2)	(3)	(4)

[2]https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=500-081

	CD (m)	MSL (m)	Corrected CD (m)	Corrected MSL(m)
Lowest Astronomical Tide (LAT)	-0.2	-0.8	0.0	-0.6
Mean Low Low Water (MLLW)	+0.3	-0.3	+0.1	-0.1
Mean High Low Water (MHLW)	+0.6	0.0	+0.8	+0.2
Mean Sea Level (MSL)	+0.6	0.0	+0.8	+0.2
Mean High Low Water (MHLW)	+0.8	+0.2	+1.0	+0.4
Mean High High Water (MHHW)	+0.9	+0.3	+1.1	+0.5
Highest Astronomical Tide (HAT)	+1.2	+0.6	+1.4	+0.8
Tidal range (HAT – LAT)			1.4	

The corrected HAT value of 0.8m MSL (1.4m CD) is less than that observed in the record from the Port (0.86m MSL) however the Port record has not been thoroughly checked for errors and may contain some isolated incorrect readings. For design purposes, the tide levels in the above table (column 3 and 4) are adopted.

4.1.2 Tide Measurements at Jetties

Continuous tide measurements were undertaken (at 15 min intervals) at 6 locations as shown in **Figure 17**. Measurements were carried out during the dry season between 26/11/2019 and 31/12/2019. Although the tide measurements were corrected to MSL it is evident that benchmark errors have occurred at some locations. In order to correct to a common benchmark, the average of the Kochi port gauge during this period (0.22m, see **Table 20**) was compared to the averages of the jetty measurements and any differences were applied to the jetty data. This correction assumes that river flows were very low (a reasonable assumption considering the time of year) and that mean water levels at the jetties were not affected by these flows or local bathymetric influences.

Figure 17: Tide measurement locations

Table 22 shows the tide corrections applied.

Table 22: Level corrections applied at jetty gauges and measurement statistics

Location	Correction (m)	Corrected Max (m MSL)	Corrected Min (m MSL)	Range(m)
Eloor	-0.21	0.71	-0.38	1.09
Amritha	1.30	0.68	-0.47	1.15
Kadamakudy	0.36	0.53	-0.20	0.73
Kakkanadu	0.15	0.45	-0.12	0.57
Mulavukadu	None	0.67	-0.40	1.07
Varappuzha	-0.11	0.70	-0.38	1.08
Kochi Port	None	0.82	-0.50	1.32

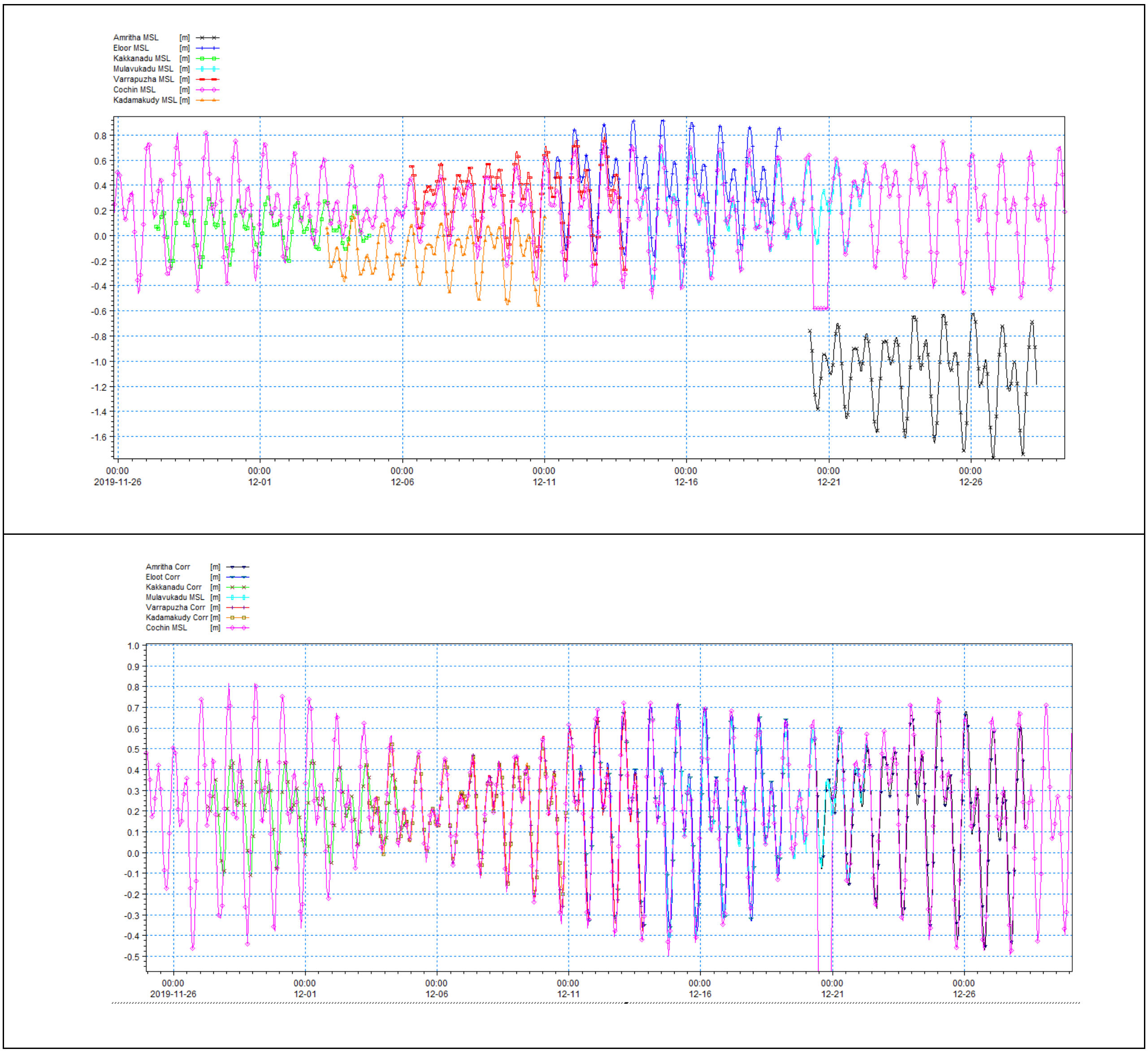


Figure 18: Tidal water level measurements provided (top) and corrected (bottom)

Figure 18 shows the comparison of provided and corrected tidal water level measurements. The data indicate the maximum tidal range occurs at the port as expected. The tidal range reduces with distance inland and also due to shallow water effects as the channels get narrower and the water depth decreases. A high tidal range is maintained in the larger river channels to the north at Amrita, Eloor and Mulavukadu. The smallest tidal range occurs in the south at Kakkanad which also correlates to the smaller size of the tidal channel and greater distance from the open ocean.

4.1.3 Storm Surge

The west coast of India facing the Arabian Sea is less susceptible to cyclonic storm surges compared to the east coast on the Bay of Bengal. Nevertheless, cyclones have been recorded in the past that bring the potential effects of storm surges generated by low pressure and wind setup.

The peak storm surge estimate for Cochin is 1.6m (Gonnert et al., 2001), which is a residual that would be applied to the normal astronomical tide. This implies the levels in **Table 21** Column (3) would increase by 1.6m if storm surge were taken into account.

4.1.4 Climate Change

Climate change will impact both rainfall intensity and frequency as well as sea levels. In the Fifth Assessment Report (AR5) of IPCC (IPCC, 2014), climate change impacts were defined based on a set of four scenarios called Representative Concentration Pathways (RCPs). They relate to the approximate total radiative forcing in the year 2100. It includes one mitigation scenario (RCP2.6), two stabilization scenarios (RCP4.5 and RCP6.0), and one "business as usual" scenario (RCP8.5).

A recent regional study for Tamil Nadu (Ramachandran et al., 2017) provides details of projected Sea Level Rise (SLR) under different RCP's based on IPCC AR5. These are tabulated in Table for Kanyakumari District, at the southern tip of India (about 150Km south of Kochi).

Table 23: Projected sea level rise (m) for different RCP scenarios (m)

RCP	2050	2075	2100
2.6	0.19	0.28	0.38
4.5	0.21	0.36	0.52
8.5	0.23	0.47	0.81

4.2 Flood Levels 2018

Kochi has experienced severe floods in the past, the most recent occurred in August 2018 when large parts of Kerala state were affected in the worst flooding in almost 100 years (State Relief Commissioner, Disaster Management, 2018). Kochi city itself received a 24 hour rainfall of 182mm but rainfall in the eastern hill catchments was much higher than average. As a result, many dams upstream of the city and in other parts of Kerala opened the floodgates, which gave rise to very large river flows including in the Periyar River north of the city. The severity of flood was increased by high tide due to perigean spring tides for the period of 11th to 15th, August 2018.

In order to get a sense of the effects of river flooding in the study area a survey was undertaken to record the high water marks from the 2018 flood event, as shown in **Figure 19**. These have been recorded against CD datum. The survey reinforced the perception that flooding in Kochi was mainly caused by high water levels in the Periyar river to the north with flood levels at the northern end of Edappally canal reaching 3.94m CD. Water levels decreased downstream (to the west) to 2.06 m CD at the head of the Chilavanoor canal and 1.75 m CD at the head of the Thevara-TP canal.

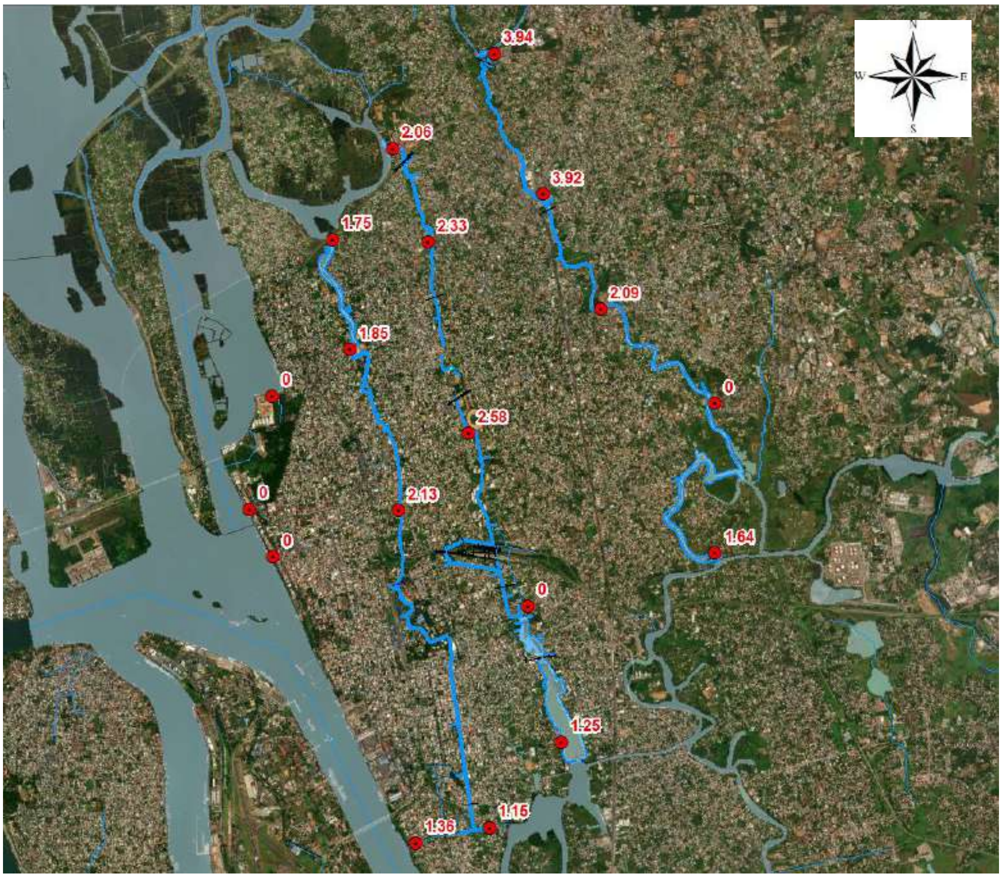


Figure 19: 2018 Flood mark survey (levels shown in CD)

Peak flood levels at the southern ends of the canals were less, but also indicated decreasing trend from inland to the sea, reflecting high flows originating in the Chithrappuzha catchment. The peak river level at the southern end of the Edappally canal was 1.64 m CD, decreasing to 1.25 m CD at the end of the Chilavanoor canal and 1.15m CD at the end of the Thevara-TP canal.

No flooding was recorded on the lagoon side of the city west of the canals due to the proximity to the sea outfall.

4.3 River flows

There is no available data on flows in the rivers that drain into the Kochi Lagoon. The floods of 2018 show that in extreme conditions (1:100 year or worse) widespread flooding of the city can occur. However extreme river flood events that inundate the city cannot be accommodated in the design of the canals which are focused on ensuring adequate stormwater drainage from the local city catchments under a range of "normal" or "moderate flood" river conditions. Since the elevated effects of river flows on the local tide levels cannot be ascertained it is prudent to design the canal stormwater capacity for higher-than-normal tide levels to account for some additional increases due to high river discharges. It is apparent also from the 2018 flood marks that the northern ends of the canals are more susceptible to elevated river levels than the southern ends.

5. Boundary Conditions

5.1 Canal design parameters

The canal design levels are shown in **Table 24** and illustrated in **Figure 20**. The canal bed level is designed to 0.9m below CD. In the final design configuration shutters (gates) will be constructed at the canal ends to prevent the ingress of high river or tide levels. During this time, pumping may be required to evacuate stormwater runoff entering the canals. The top shutter level is proposed to be 1.65m MSL. This is 0.25m above the current HAT and approximately the same as the land levels adjacent to the shutters.

Table 24: Canal design levels

Level	CD (m)	MSL (m)
Dredge level	-0.9	-1.5
MSL	0.6	+0.0
Mean level of the sea	+0.8	+0.2
MHHW	+1.1	+0.5
HAT	+1.40	+0.8
Top of shutter	+1.65	+1.05

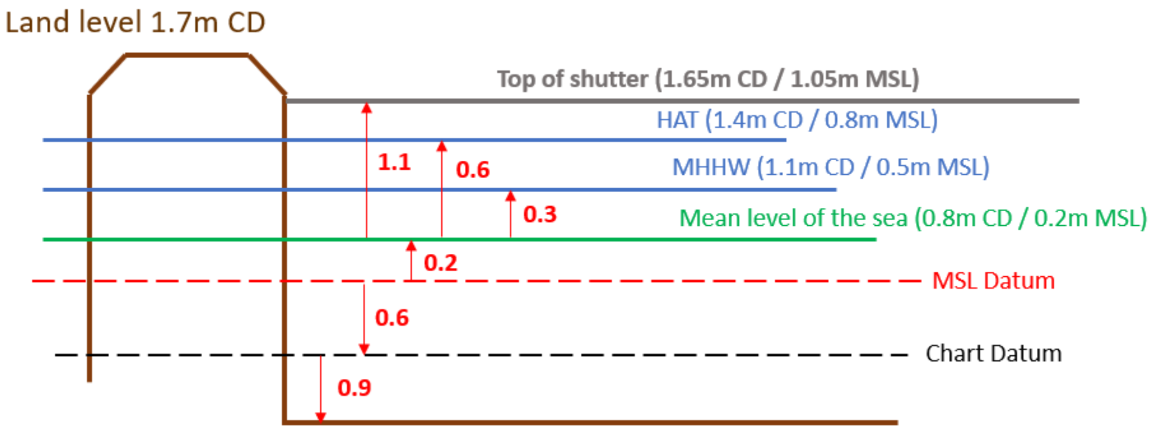


Figure 20: Canal design levels and tide levels

The average land levels at the ends of the canals are listed in **Table 25.** Some additional flood protection works will be required to tie the new shutter regulators into higher ground so that a flood protection level of 1.65m CD (plus freeboard) can be achieved. Imposing boundary conditions higher than the top of shutter level is not appropriate as that would represent a situation where flooding is occurring due to external influences such as high river flood, storm surge of combination of these (i.e. not due to canal drainage capacity). The top of shutter level therefore represents the maximum feasible boundary water level condition.

Table 25: Approximate Land levels at ends of canals

	CD (m)		MSL (m)	
Canal	**North end**	**South end**	**North end**	**South end**
Edappally	1.5	1.5	0.9	0.9
Chilavanoor	1.6	1.7	1.0	1.1
Thevara-TP	1.5	1.7	0.9	1.2

5.2 Event combinations

As outlined above there are a number of different physical phenomenon that need to be included in considering the water level boundary conditions to be applied to the canals. Tides are the most important as these represent the “usual” condition in the absence of storm surges, river floods or climate change. From the tide measurements it is evident that the tidal range at the northern canal boundaries (i.e. at Amrita) is roughly the same as at the port. On the other hand the water level range at Kakkanad in the south is around half that of the port which may have implications for Edappally canal. Given the close proximity to the sea for Chilavanoor and Thevara-TP it is expected the tidal level range here will also closely match that at the Port. The relative timing of the high and low waters at either end of Edappally canal (at Amrita and Kakkanad) is not known as no simultaneous measurements are available. In the absence of more detailed tidal measurements, a conservative approach is adopted where tide levels above the mean level of the sea are assumed to reflect that of the Port gauge at all canal ends simultaneously.

Storm surges of the magnitude indicated above (1.6m) will result in widespread flooding of Kochi and is not an event that can be considered with the context of the present drainage design.

Climate change induced sea level rise is a consideration that needs to be factored into the design. Referring to **Table 26**, two cases may be considered.

1) Worst case (RCP 8.5) to 2050: +0.23m to be added to tide level.
2) Medium worst case (RCP 4.5) to 2100: +0.52m to be added to tide level (assuming the worst-case initial trajectory in 2050 can be mitigated by 2100).

As mentioned above the effect of river flows on tide levels at the canal boundaries cannot be quantified as there are no concurrent tide and flow records. Obviously as seen from the events of 2018 widespread flooding can occur from the surrounding rivers. During smaller flood events, it can be expected that tide levels will be elevated due to these flows and therefore an allowance should be made for these conditions. Higher flood levels would be expected at the northern ends of the canals (influenced by the Periyar river) compared to the south end. In addition, the Edappally canal would be most affected due to its location further inland away from the sea.

The following assumptions in **Table 26** are therefore made with regard to conditions where high river flows are considered (levels to be added to tide level). These increments were based on observations from the 2018 flood where it was apparent that the maximum flood levels would be in the north east area due to proximity to Periyar River (at northern end of Edappally canal) with flood levels being lower moving westward to the sea and in the southern part. Additional increment such as 0.5m, assigned to Edappally north is the maximum practical flood allowance as anything higher would represent extensive inundation of the large part of the city. It has been seen from the model that the low-lying areas in the catchment where ground level is lower than the water level at the boundary are prone to flooding under the influence of the boundary conditions even if the canals are not overflowing.

Table 26: Additional water level increments (m) to be added to allow for river flood conditions

Canal	North end (m)	South end (m)
Edappally	0.50	0.35
Chilavanoor	0.30	Nil
Thevara-TP	0.25	Nil

Based on the above considerations, the following combinations of tide, river flow and rainfall are considered, with existing climate and climate change to 2050 (RCP 8.5). One further condition is included for climate change to 2100 (RCP 4.5), see **Table 27**.

Table 27: Boundary condition combinations

ID	Condition	Tide (MSL)	Tide (CD)	+River	Rainfall	+Climate Change
Ex1	Normal (Mean tide)	0.2	0.8	Nil	50yr	Nil
Ex2	High tide (MHHW)	0.5	1.1	Nil	25 and 50yr	Nil
Ex3	HAT	0.8	1.4	Nil	25yr	Nil
Ex4	River flood @ MHHW	0.5	1.1	Table 36	25yr	Nil
CC1	Normal (Mean tide)	0.2	0.8	Nil	50yr	+0.23
CC2	High tide (MHHW)	0.5	1.1	Nil	25 and 50yr	+0.23
CC3	HAT	0.8	1.4	Nil	25yr	+0.23
CC4	River flood @ MHHW	0.5	1.1	Table 36	25yr	+0.23
CC5	High tide (MHHW)	0.5	1.1	Nil	25yr	+0.52

6. Hydrological Assessment

6.1 Approach

The purpose of the hydrological analysis is to compute the local stormwater inflows to the canal system from the various design rainstorms derived in the previous section. These flood hydrographs are then used in the subsequent hydraulic analysis assessing the peak flood levels under existing and restored canal conditions.

In this analysis, the stormwater hydrographs are estimated through the HEC HMS software. As the canal catchments are ungauged, no flow data was available for calibration of the model. Therefore in order to cross check the HEC-HMS modelling the peak flow estimates are compared against the Rational Method which is traditionally used in urban stormwater design.

6.2 Delineation of Sub basins

Delineation of sub basins for Edappally, Chilavanoor and Thevara-Thevara Perandoor (Thevara-TP) combined catchment was done in the GIS module of HEC HMS software. The land levels were derived from a global DEM (ALOS PALSAR DEM of 10.2m resolution) There are 13 sub basins for Edappally catchment (having a total area of 15.2 km^2). The existing terrain of Edappally canal is sloping in opposite directions with a ridge at 2.5km downstream of the starting point Muttar. The slope of Edappally, Chilavanoor and Thevara-TP canals are attached as **Annexure 8**.

For Chilavanoor Canal, the catchment flow drains in opposite directions. There are two basins, the Changadampokku thodu draining towards the north and Karanakodam thodu draining towards the south. There are 7 sub basins for the downstream Changadampokku catchment (total area of 4.67 Km^2) and 5 sub basins for the upstream Karanakodam catchment (3.38 Km^2). The two basins were separately modelled in HEC HMS.

The Thevara-TP combined catchment contains three basins, two of flowing towards Thevara in the south and one flowing north towards Perandoor. The catchment areas of Thevara-TP downstream, Thevara-TP upstream Perandoor and Thevara-TP middle are 7.75, 2.68 and 1.77 Km^2, respectively. There are 14 sub basins altogether for the combined catchment. **Figure 21** shows the delineated sub basins for the Edappally, Chilavanoor and Thevara-TP combined catchments.

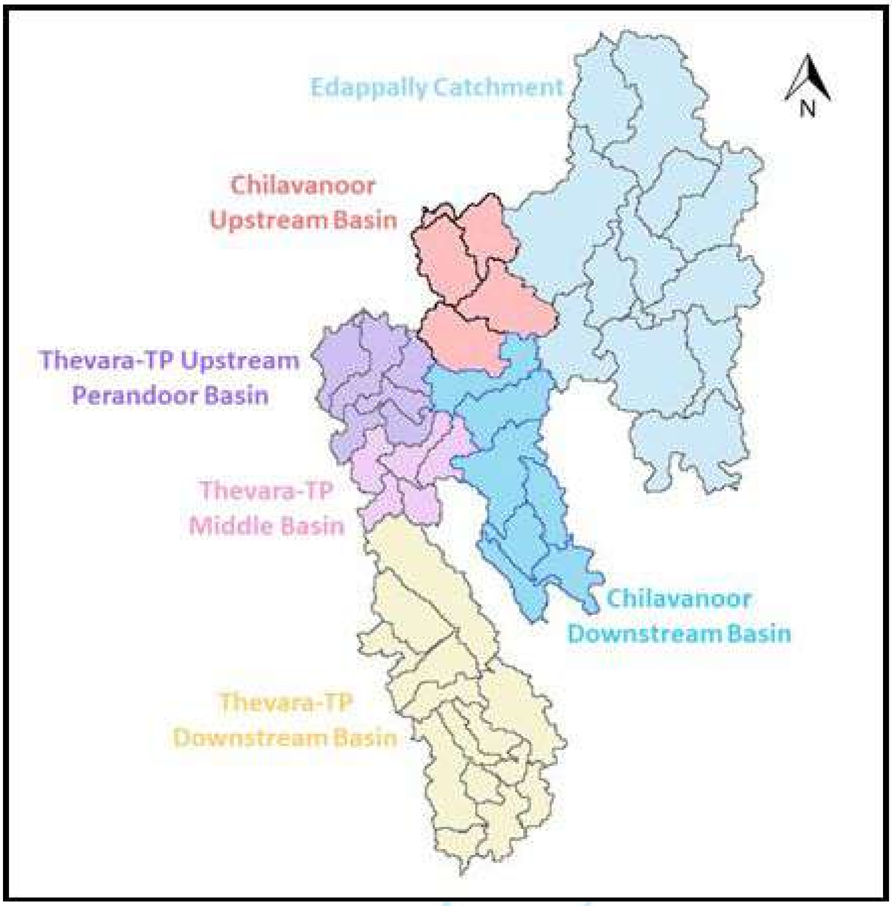


Figure 21: Catchments of Edappally, Chilavanoor and Thevara-TP with sub basins

6.3 HEC HMS Hydrological Model

The hydrological response of the canal catchments was modelled using HEC HMS. The program was developed by the US Department of Defense, Army Corps of Engineers in order to manage the rivers, harbors, and other public works under their jurisdiction. It has found wide acceptance by many researchers and practitioners since its public release in 1995.

Different options for modelling the various physical processes are available in the software. In this analysis, the peak discharge in each basin is modelled by SCS Curve Number method and SCS Unit Hydrograph method. The routing through different junctions is done by Lag method. Curve numbers for each sub basin and lag time are the inputs given to the basin model. The Curve Number (CN) ranges from 0-100 and is indicative of the volume of rainfall that is transformed to runoff, with a CN of 100 representing 100% runoff. CN's are dependent on land use and soil type. It is assumed for this study that the soil type is homogenous and therefore CN is dependent on land use only.

As Kochi is a highly urbanized environment there is little variation in the CN values. The CN for Edappally based on the land use classification was generally taken as 73. A sample calculation for Edappally catchment is shown in **Table 28**.Two of the sub basins of Edappally catchment exhibited slightly different land use patterns and a CN value 76 was specifically calculated for these sub catchments. The detailed calculation is given in **Annexure 7 (sheet1)**.

For Chilavanoor the CN adopted is 78 and for Thevara and Thevara-Perandoor combined catchments a CN of 76 was adopted. The detailed calculation is also given in **Annexure 7 (sheet2 &sheet3)**.

Table 28: Curve number Calculation- Edappally

Curve number for various land use classification							
Residential %	**Commercial %**	**Public and semipublic %**	**Roads %**	**Parks & Open spaces %**	**Unclassified land %**	**Dry cultivation %**	**Industrial**
73	3	6	8	1	6	0	3
71	85	69	98	69	61	61	85
Curve no average	**73**						

Lag time is taken as $\mathrm{Tlag} = 0.6\mathrm{Tc}$

Where, Tc is the time of concentration for the sub basin [18], computed from the Kirpich (7) formula, see 6.4.2.

Hyetographs derived from the IDF curves were specified as the rainfall input for rainfall for each sub-basin and for different return periods of 5, 10, 25, 50 and 100 years. The HEC-HMS model was run for 3 days with an execution time step of 1 minute.

The peak discharge in each sub basin is compared with the peak discharge obtained through rational method. The detailed calculation of comparison of results is given in **Annexure 7 (sheet1,2&3)**.

A sample hydrograph output from HEC-HMS for Edappally catchment for 10 year return period is shown in **Figure 22**. It may be noted that the element Sb13 is the last sub basin, element R1 is the last reach and Sink-1 is the outlet for the Edappally catchment. The HEC HMS project files for all the canal catchments (Edappally, Chilavanoor downstream, Chilavanoor upstream, Thevara TP downstream, Thevara-TP upstream Perandoor, Thevara-TP middle) are attached as **Annexure 9**.

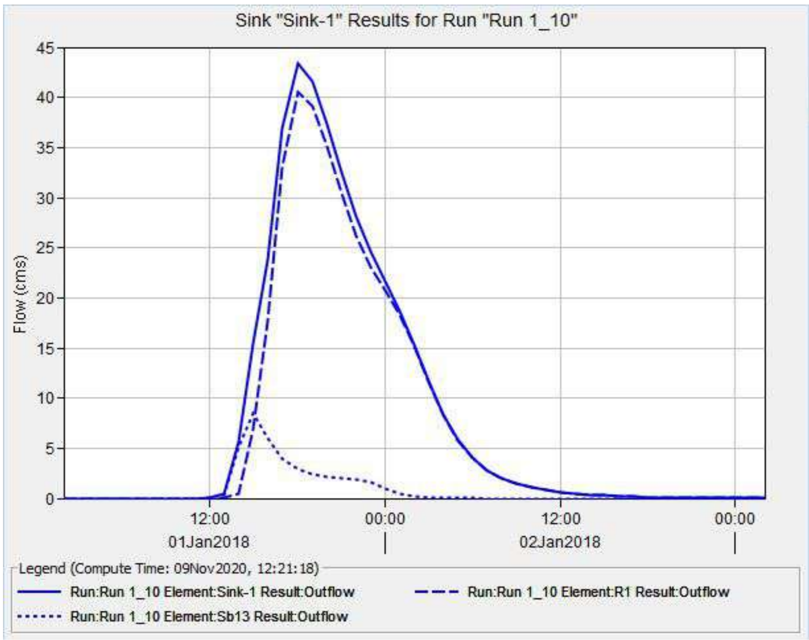


Figure 22: Example HEC-HMS output for Edappally basin 10years ARI

6.4 Rational Method

The Rational Method provides a means of estimating the peak catchment discharge of a certain return period, with the rainfall duration equal to the time of concentration for catchments less than 25km^2. The peak discharge is a function of the average rainfall rate during the time of concentration, and rainfall intensity is assumed constant during rainfall.

The Rational Formula for estimation of peak runoff is:

$$Q = \mathrm{CIA}/360$$

where, Q = Peak runoff in m^3 /s, C = Runoff coefficient, I = Rainfall Intensity (mm/hr.) for the estimated time of concentration and design Return Period and A = Drainage area, in ha.

The runoff coefficient, time of concentration, and the rainfall intensity are calculated as follows.

6.4.1 Runoff Coefficient, C

The runoff coefficient is the fraction of rainfall that is converted to form the peak runoff. The value may range between 0 (no runoff) and 1 (perfectly impervious), but in practice, between 0.1 and 0.95. It is affected by a variety of conditions such as rainfall intensity, infiltration, ground cover and slope, interception by trees and vegetation, surface and depression storage, antecedent rainfall and soil moisture, shape of drainage basin, overland flow velocity, storm frequency, etc. Values of run off coefficients are given for different land use conditions as shown in **Table 29**(Chow et al., 1988). Composite runoff coefficients are computed when the drainage area consists of more than one type of land use type. The choice of C requires good judgment as per the existing land use.

Table 29: Values of Runoff coefficient C in Rational Formula

Land use		Runoff co-efficient
Lawns		
Sandy soil	Flat 2%	0.05 - 0.1
	Average 2-7%	0.1 - 0.15
	Steep 7%	0.15 - 0.2
Heavy soil	Flat 2%	0.13 - 0.17
	Average 2-7%	0.18 - 0.22
	Steep 7%	0.25 - 0.35
Business		
Downtown		0.7 - 0.95
Neighborhood areas		0.5 - 0.7
Residential		
Single family		0.3 - 0.5
Multi units, Detached		0.4 - 0.4
Multi units, Attached		0.4 - 0.75
Suburban		0.25 -0.4
Apartment dwelling areas		0.5 - 0.7
Industrial		
Light		0.5 - 0.8
Heavy		0.4 - 0.9
Parks, Cemeteries		0.1 - 0.25
Playgrounds		0.2 - 0.35
Railroad yards		0.2 - 0.4
Unimproved areas		0.1 - 0.3
Streets		

The land use pattern of the IURWTS catchment is of a mixed pattern. The runoff coefficient is calculated based on the distribution of areas having different land use pattern as per the table issued on the Land use pattern of Kochi corporation, Kalamassery, Thrikkakkara and Thripunithura municipalities. The land use pattern with percentage for Kochi corporation is in given in **Table 30**. Existing net percentage in Table 30 refers to the percentage excluding water bodies.

Table 30: Existing Land use Pattern- Kochi Corporation

Sl.No.	Land use category	Land Area in Ha	Existing % (Gross)	Existing % (Net)
1	Residential	5040.93	53.13	73.07
2	Commercial	211.64	2.23	3.07
3	Public& Semi Public	444.8	4.69	6.45
4	Industrial	173.5	1.83	2.51
5	Transportation	553.58	5.83	8.02
6	Park & Open Spaces	66.68	0.7	0.97
7	Other (SEZ and Unclassified area)	397.3	4.19	5.76
8	Paddy Land / Wet Land	441.02	4.65	
9	Agriculture / Dry cultivation	10.22	0.11	0.15
10	Water Bodies	2148.33	22.64	
	Total	9488	100	100

Source: Land use survey updated by the department of Town and Country Planning in 2009

The runoff coefficient for Edappally based on the land use classification was taken as 0.39. A sample calculation for Edappally catchment is shown in **Table 31.** Sub basins exhibiting entirely different land use pattern were assigned with C values specifically calculated for such sub catchments and the values adopted for 0.29 and 0.33. The detailed calculation is given in **Annexure 7 (Sheet1**).

For Chilavanoor the runoff coefficient adopted was 0.36 and for Thevara and Thevara-Perandoor combined catchments a runoff coefficient of 0.35 was adopted. The detailed calculation is also given in **Annexure 7 (Sheet 2 & Sheet3)**.

Table 31: Run off coefficient C calculation- Edappally

C value for various land use classification							
Residential %	Commercial %	Public & semipublic %	Roads %	Parks & Open spaces %	Unclassified land %	Dry cultivation %	Industrial
73	3	6	8	1	6	0	3
0.35	0.7	0.4	0.8	0.2	0.2	0.2	0.5
C average	**0.39**						

6.4.2 Time of Concentration, Tc

The time of concentration, T_c, is the duration it takes for runoff to travel from the farthest point in the drainage area to the point of interest. There are numerous empirical formula for T_c available. In this analysis, the Time of Concentration is obtained from Kirpich(7) formula,

$$Tc = (\frac{0.87xL^3}{H})^{0.385}$$

Where L is the distance from the farthest point to the outlet in km, H is the total fall in the level from the critical point to the outlet in m. Tc is calculated separately for each sub basin based on the value of L and H. Detailed calculation is shown in the subbasin wise comparison of the model and rational method which is attached as **Annexure 7 (Sheets 1,2&3)**.

6.4.3 Rainfall Intensity, I

The rainfall intensity I, for the desired return period and for the chosen time of concentration, T_c, is taken from the IDF values developed for the catchment region.

6.5 Results Summary

Comparisons of the peak discharges computed from HEC-HMS for each sub-basin and return period with the Rational Method estimates are shown in **Table 32**, **Table 33** and **Table 34** and the scatter plots for the same are shown in **Figure 23**, **Figure 24** and **Figure 25** respectively.

Table 32: Comparison of results of Model with Rational method- Sub basin wise- Edappally

Results from HEC HMS Model and Rational- Comparison - 1hr hyetograph											
Peak discharge m^3/s											
Sub basin	Area Km^2	IDF5 HEC	IDF5 Rat.	IDF10 HEC	IDF10 Rat.	IDF25 HEC	IDF25 Rat	IDF50 HEC	IDF50 Rat.	IDF100 HEC	IDF100 Rat.
1	2.0	4.6	4.7	5.6	5.4	6.8	6.3	8.2	6.9	9.4	7.6
2	1.1	4.9	5.2	6.1	5.9	7.6	6.7	9.0	7.4	10.3	8.0
3	0.7	3.8	4.9	4.8	5.6	6.1	6.3	7.2	6.8	8.3	7.3
4	1.2	5.4	4.6	6.8	5.3	8.4	6.2	10.0	6.8	11.5	7.4
5	1.2	5.2	4.9	6.6	5.6	8.2	6.5	9.8	7.1	11.2	7.7
6	0.9	4.5	5.2	5.7	5.8	7.0	6.7	8.4	7.3	9.6	7.9
7	0.8	3.9	5.2	4.9	5.9	6.2	5.0	7.4	7.2	8.6	7.8
8	0.8	3.7	4.9	4.6	5.5	5.8	5.2	7.0	6.8	8.1	7.3
9	2.5	6.5	8.3	8.0	9.5	9.8	8.3	12.3	12.2	14.1	13.3
10	0.1	0.6	0.6	0.7	0.7	0.9	0.8	1.1	0.8	1.2	0.9
11	0.7	4.3	4.1	5.4	4.6	6.8	5.2	7.9	5.7	9.0	6.1
12	1.6	5.9	6.1	7.3	6.9	9.0	8.1	10.9	8.9	12.6	9.7
13	1.5	6.8	5.8	8.5	6.6	10.6	7.7	12.6	8.4	14.5	9.2
Total	**15.21**										

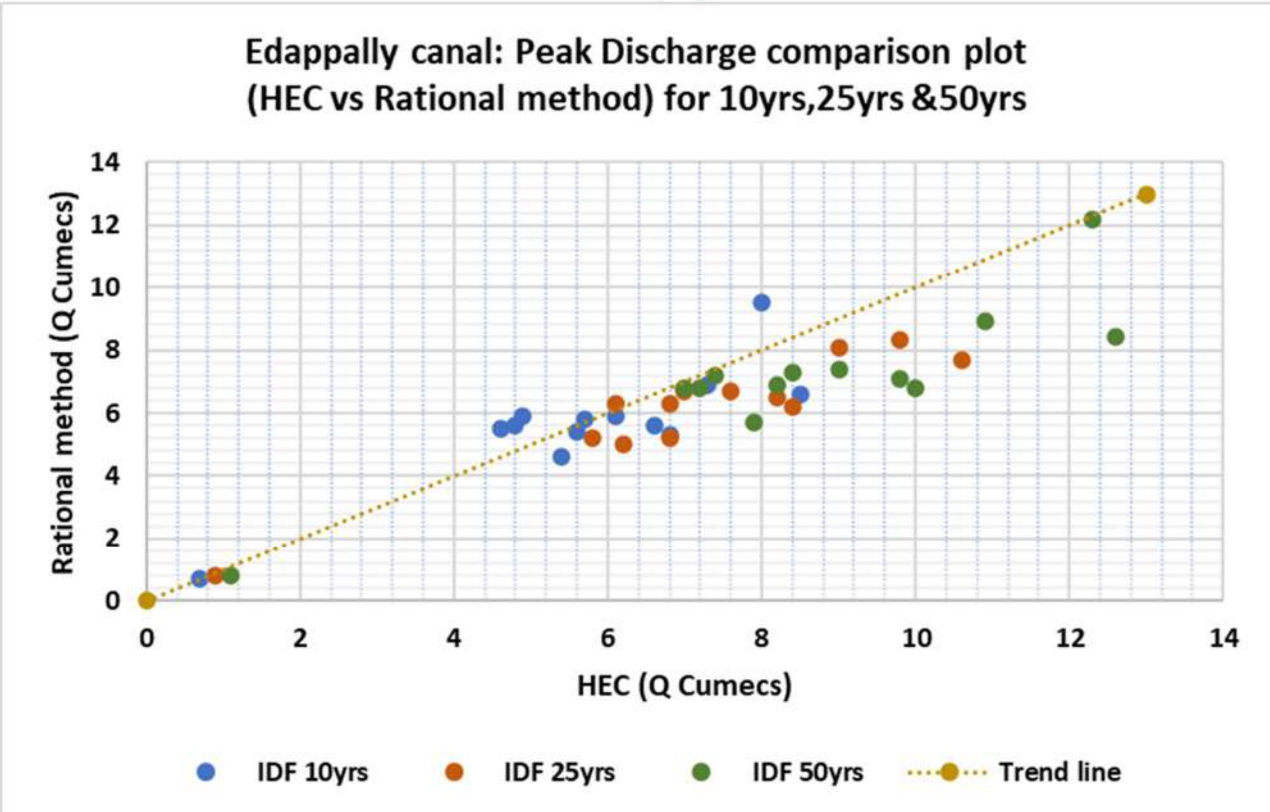


Figure 23: Edappally Canal Peak Discharge Comparison Plot

Table 33: Comparison of results of Model with Rational method- Sub basin wise- Chilavanoor

Results from HEC HMS Model and Rational- Comparison - 1hr hyetograph											
Peak discharge m^3/s											
Sub basin	Area Km^2	IDF5 HEC	IDF5 Rat.	IDF10 HEC	IDF10 Rat.	IDF25 HEC	IDF25 Rat	IDF50 HEC	IDF50 Rat.	IDF100 HEC	IDF100 Rat.
Downstream											
Sb1	0.83	4.4	5.54	5.3	6.19	7.3	7.02	8.2	7.63	9.3	8.24
Sb4	0.79	4.7	5.55	5.7	6.19	7.8	7.00	8.6	7.61	9.9	8.21
Sb5	0.53	3.6	3.91	4.3	4.35	6	4.92	6.6	5.33	7.5	5.75
Sb6	0.52	3.7	3.83	4.5	4.27	6.1	4.83	6.8	5.23	7.8	5.64
Sb10	1.07	5.3	5.64	6.4	6.36	8.4	7.28	9.5	7.95	10.9	8.63
Sb13	0.43	3	3.17	3.7	3.53	5.1	3.99	5.6	4.33	6.4	4.67
Sb14	0.50	3.5	3.69	4.3	4.11	5.9	4.64	6.5	5.03	7.5	5.43
Upstream											
S1	0.62	4.4	4.57	5.3	5.09	7.3	5.75	8	6.24	9.2	6.73
S2	0.94	4.7	5.61	5.6	6.30	7.3	7.17	8.3	7.81	9.4	8.45
S3	0.89	4.3	5.31	5.2	5.97	6.8	6.79	7.7	7.40	8.8	8.00
S4	0.80	4.2	5.34	5.1	5.97	7	6.76	7.8	7.35	9	7.94
S5	0.13	0.9	0.96	1.1	1.07	1.5	1.21	1.7	1.31	1.9	1.41
Total	**8.05**										

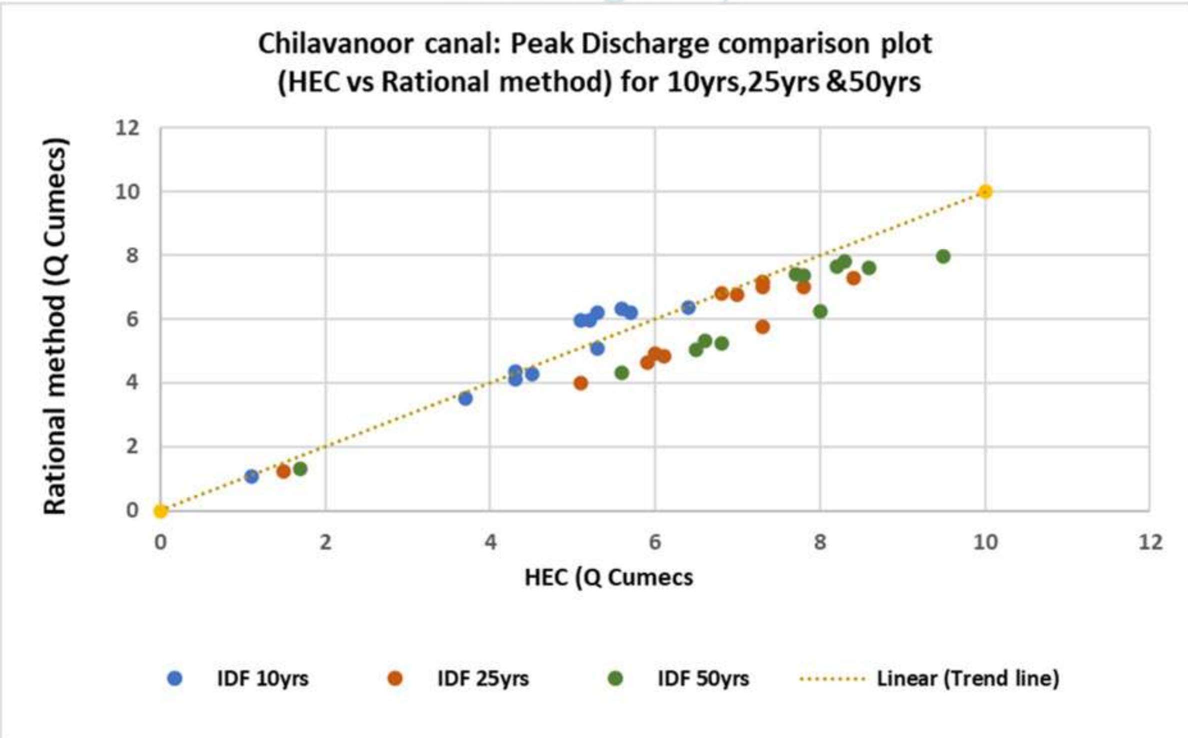


Figure 24: Chilavanoor Canal Peak Discharge Comparison Plot

Table 34: Comparison of results of Model with Rational method – Thevara-TP

Results from HEC HMS Model and Rational- Comparison - 1hr hyetograph											
Peak discharge m^3/s											
Sub basin	Area Km^2	IDF 5 HEC	IDF 5 Rat.	IDF 10 HEC	IDF 10 Rat.	IDF25 HEC	IDF25 Rat.	IDF50 HEC	IDF50 Rat.	IDF100 HEC	IDF 100 Rat.
Down Stream basin											
Sb1	1.55	6.0	5.7	7.3	6.6	9.9	7.6	11.4	8.4	13.1	9.2
Sb2	2.14	8.2	7.9	10.1	9.1	13.6	10.5	15.7	11.6	18.1	12.7
Sb4	2.00	7.7	7.4	9.4	8.5	12.8	9.8	14.7	10.9	16.9	11.9
Sb5	0.96	4.1	4.7	5.0	5.3	6.6	6.1	7.6	6.7	8.8	7.3
Sb7	0.31	1.8	2.3	2.2	1.8	3.1	2.8	3.5	3.1	4.1	3.4
Sb8	0.79	3.5	5.3	4.3	5.9	6	6.6	6.8	7.3	7.9	7.8
Upstream basins Perandoor & middle											
Sb1	0.38	3.9	2.8	4.7	3.1	6.6	3.5	7.4	3.8	8.5	4.1
Sb2	0.65	4.5	4.8	3.0	5.3	4.2	6.0	4.7	6.5	5.4	7.1
Sb4	0.33	2.1	2.4	2.6	2.7	3.6	3.1	4.0	3.3	4.6	3.6
Sb6	0.68	4.0	5.0	5.0	5.0	6.9	6.3	7.7	6.8	8.8	7.4
Sb8	0.64	3.8	4.7	4.7	5.3	6.5	5.9	7.2	6.4	8.3	6.9
S2	0.81	4.3	5.4	5.2	6.0	7.1	5.1	7.9	7.4	9.1	8.0
S5	0.30	2.0	2.2	2.4	2.5	3.3	2.7	3.7	3.0	4.3	3.3
S6	0.66	4.0	4.9	4.8	5.4	6.7	6.1	7.5	6.6	8.7	7.2
Total	**12.20**										

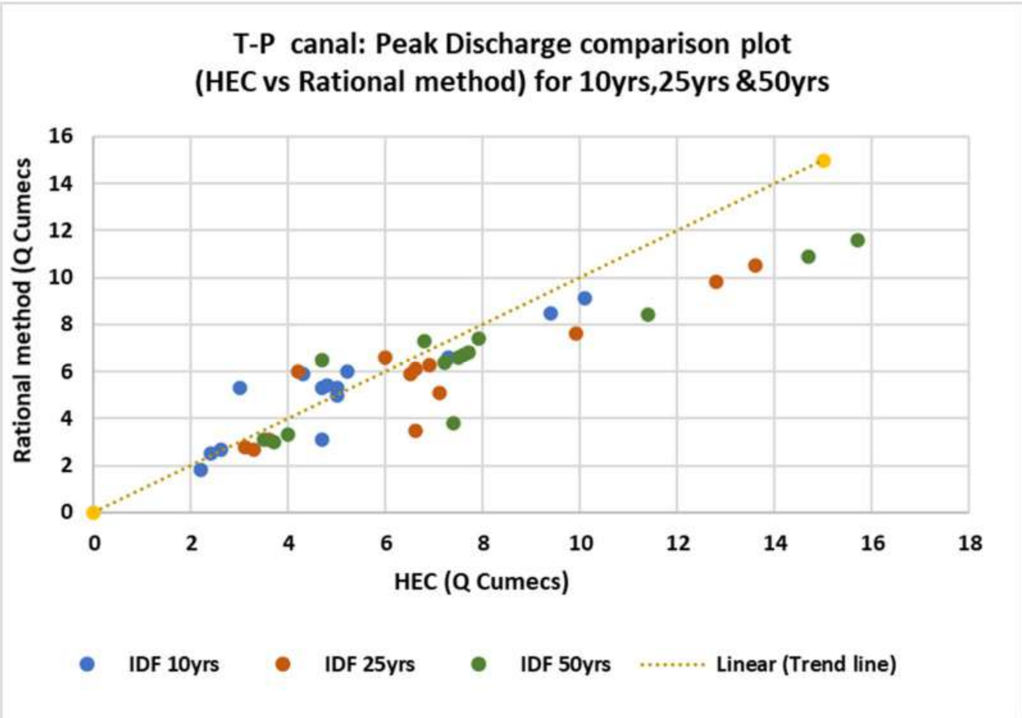


Figure 25: TP Canal Peak discharge Comparison Plot

As the two methods differ in the approach a perfect correlation cannot be expected in all cases. However, the results are comparable and show the HEC-HMS peak discharges are generally somewhat higher than the Rational Method estimates, which provides a degree of conservatism in the hydraulic analysis.

7. Hydraulic Modelling

Hydraulic modelling of the canals has been undertaken based on a one-dimensionalhydrodynamic approach using HEC-RAS unsteady flow analysis. Separate models were developed for each canal representing the existing unrestored and the final restored condition. The merged DEMs of LIDAR and bathymetry survey data (see Section 2.1) were used to develop the river cross sections and floodplain geometries for the model utilizing the RAS Mapper GIS facility. Background map layers from the acquired orthophotos and Google satellite images were overlaid on the terrain layer to make sure that the DEM was correctly aligned with the canal banks.

The RAS geometry file included the river, bank lines, edge lines and cross sections. Bridges and other cross structures were also imported as shape files and model structures created at the corresponding locations. The geometry data was finally checked and edited in the HEC-RAS geometric data editor.

Unsteady flow analysis was carried out for all the canals. Catchment runoff hydrographs generated from HEC-HMS were introduced as lateral inflows from the respective sub basins. The boundary conditions at the open ends of the canals were defined as static water levels as per the specifications in **Table *27***. Simulations were carried out for all combinations of boundary conditions, storm return periods and canal condition (unrestored and restored).

7.1 Model Extent

The extent of the 1D hydraulic modelsfor the three canals, Edappally, Chilavanoor and Thevara-Perandooris shown in **Figure 26** to **Figure 28**. The canal, overbanks, cross sections, and cross structures are indicated in the figures.The floodplain extent in the models is limited to the available LiDAR coverage which is a width of 125m on either side of the canal.

7.2 Model Development

7.2.1 Existing condition

Cross section extraction

The merged 0.5m DEM comprising floodplain LIDAR levels and existing canal bathymetry was used to represent the canal geometry. Using RAS Mapper cross-sections were extracted from the DEM and included in the model geometry. Cross sections were taken perpendicular to the direction of flow spanning the entire DEM extent.The cross sections were processed and checked to define the bank stations, downstream reach lengths (distance between cross-sections) and Manning's "n". Manning's n values applied were assessed from the orthophotos.The channel section of the Edappally canalwas assigned a Manning number of 0.075 reflecting the large degree of encroachment and vegetation growth in the canal and along the banks. The Chilavanoor and Thevara canals are slightly less overgrown and were assigned a Manning n of 0.06. The overbank sections generally comprise high density housing and other urban infrastructure and were assigned a Manning number of 0.20 in all cases.

Structures

The 1D HEC-RAS model, has the option to include the flow around bridges and other cross structures. These structures may have some influence on flow dynamics due to the contraction and expansion of the flow around the structures. The model computes the energy losses due to contraction and expansion of the flow, as well as due to submergence of the structure. The energy equation (standard step method) is used to calculate the head loss through the bridge. The head loss calculations start with standard step calculation from downstream of the bridge section to just inside of the bridge at the downstream end. Then it computesthe head loss through the bridge and the last step calculation is from the bridge to cross section upstream. This method requires Manning's values for friction losses and contraction and expansion coefficients for transition losses. Contraction and expansion coefficients are taken as 0.3 and 0.5 respectively at the contraction reach of the flow approaching the bridge, where there is high turbulence. The contraction and expansion coefficients at the expansion reach at downstream cross section where the flow expands, are taken as 0.1 and 0.3, respectively. Bridges and cross structures were imported in the map layer of the RAS mapper and created at the respective locations in the geometric data editor for all the three canals.

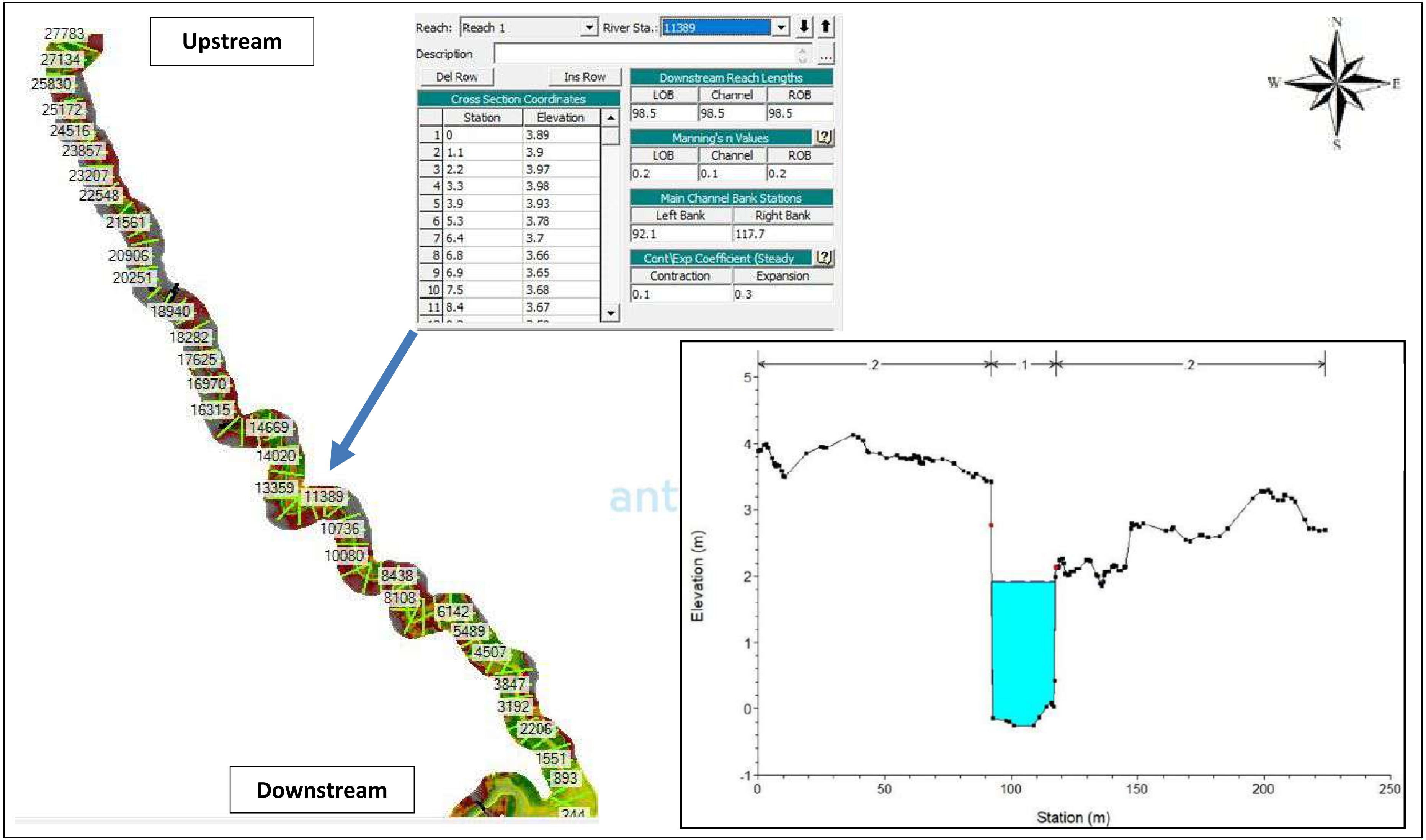


Figure 26: Geometry of Edappally Canal(HEC-RAS Model)

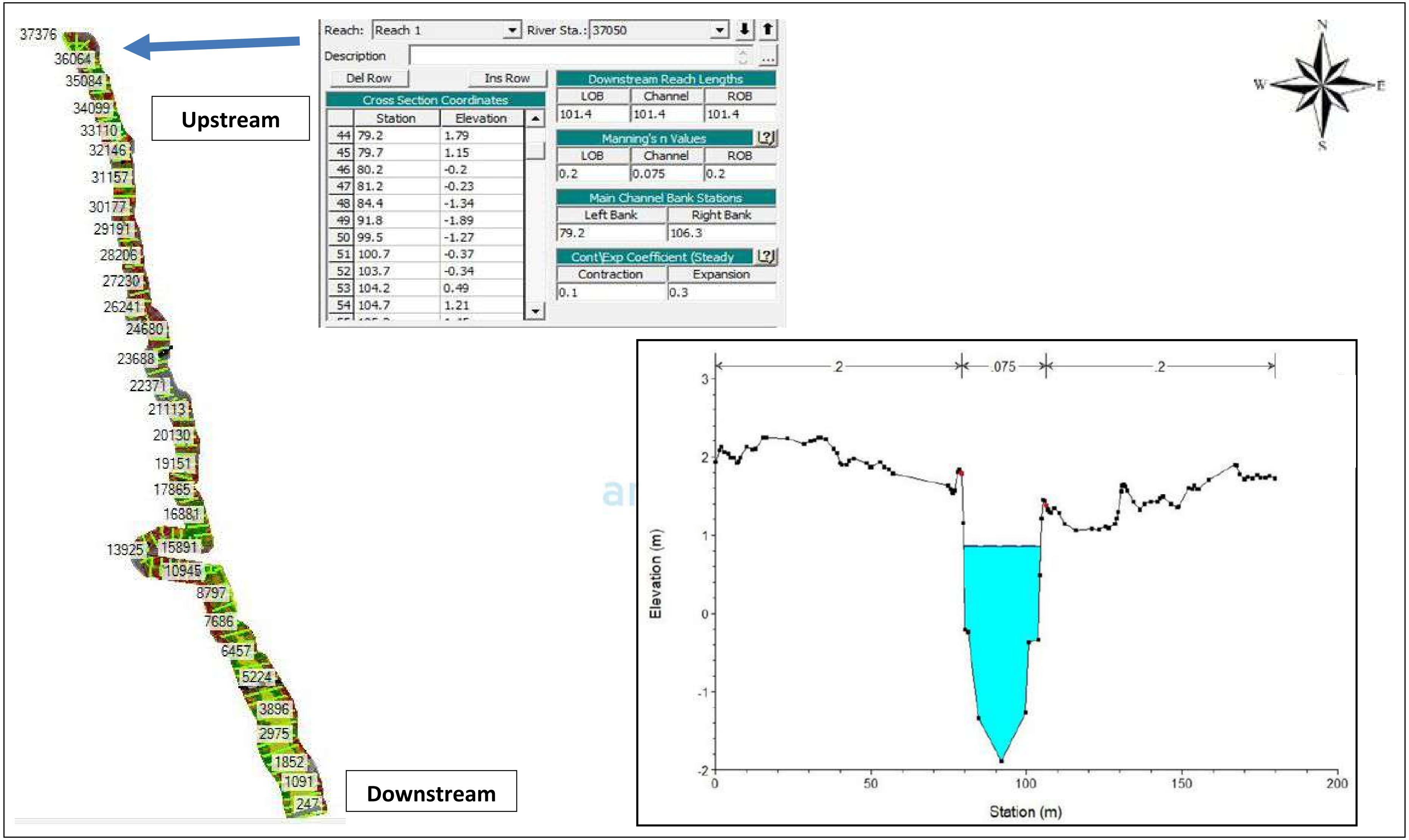


Figure 27: Geometry of Chilavanoor Canal (HEC-RAS Model)

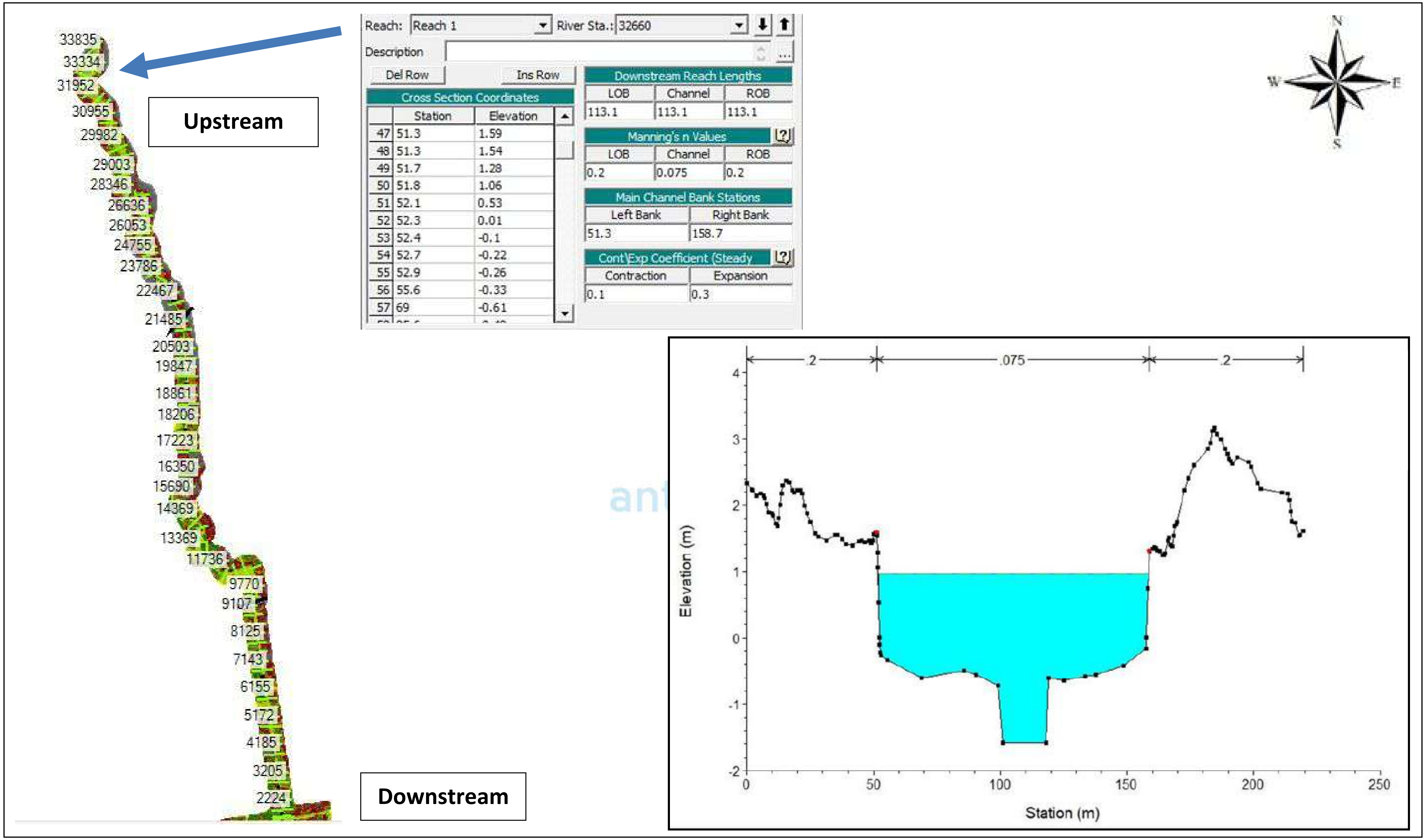


Figure 28: Geometry of Thevara- Perandoor Canal (HEC-RAS Model)

Catchment Inflow boundaries

Catchment stormwater runoff hydrographs from HEC-HMS were specified as lateral flowsinputs from each of the sub basins. The flow from the sub basins is given as lateral input at the respective locations or junctions. The inflow from the sub catchmentsfor Edappally canal is shown in**Figure 29**.

Edappally Catchment

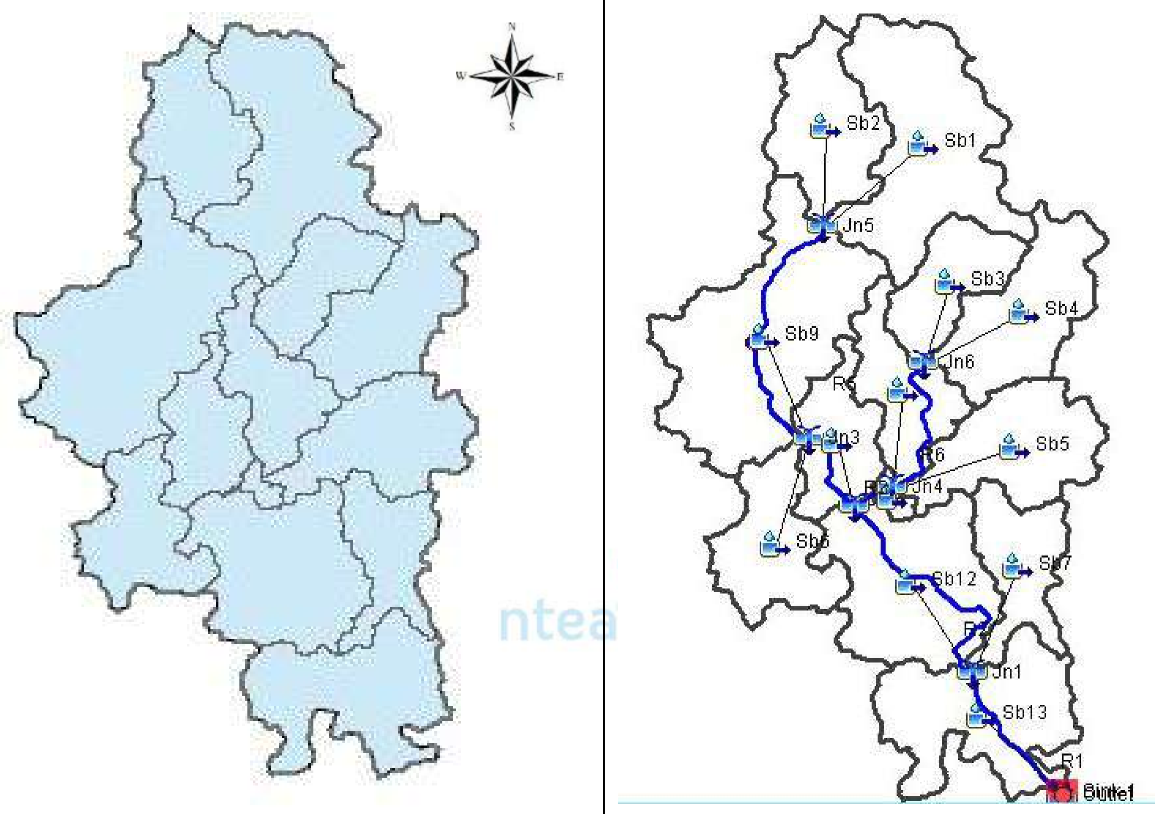
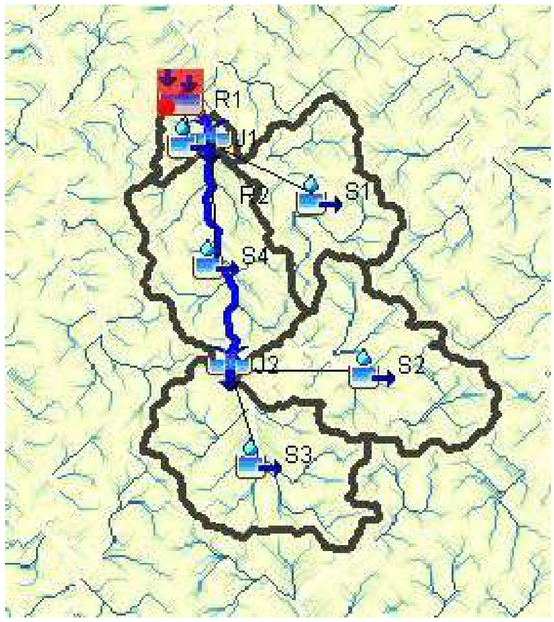


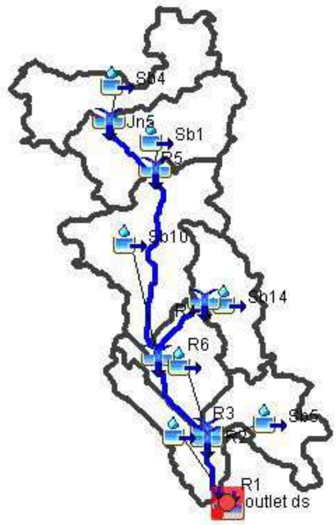
Figure 29: Edappally Catchment input details

For the Chilavanoor catchment, the sub basins upstream and downstream parts is shown in**Figure 30**.

Chilavanoor catchment



Chilavanoor upstream catchment

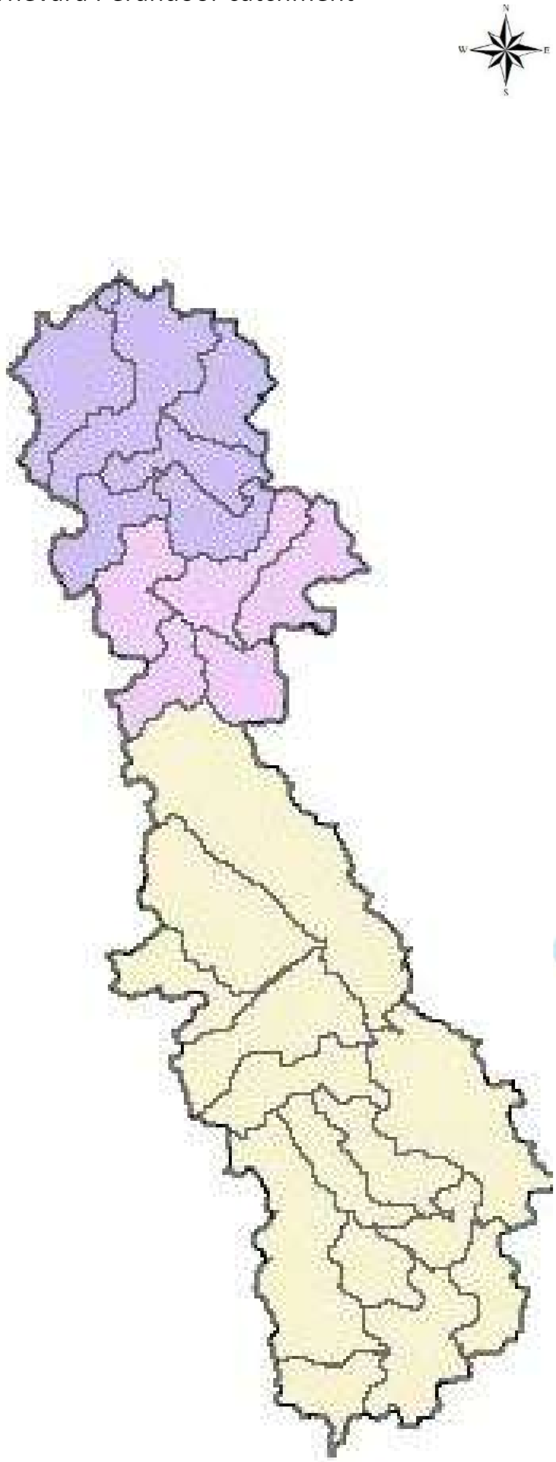


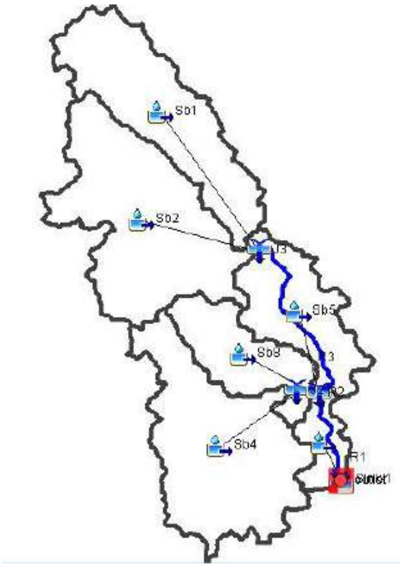
Chilavanoor downstream catchment

Figure 30: Chilavanoor Catchment input details

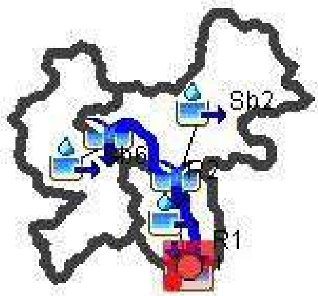
For the Thevara-Perandoor catchment, the sub basins upstream, downstream and middle partsis shown in**Figure 31**.

Thevara Perandoor catchment

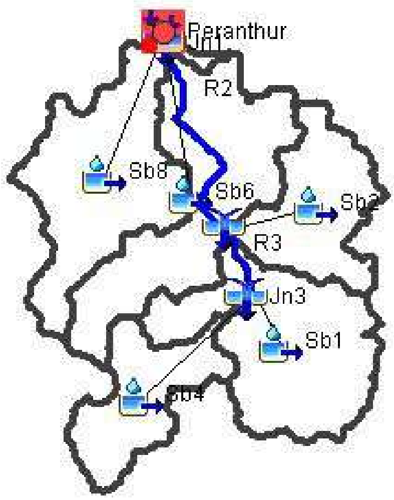




Thevara- Perandoor downstream catchment



Thevara- Perandoor middle catchment



Thevara – Perandoor upstream catchment

Figure 31: Thevara Perandoor Catchment input details

External water level boundaries

External boundary conditions in the form of static water levels are applied at the open ends of each canal as per **Table 26** and **Table 27**.

7.2.2 Improvedcondition

The merged data of LIDAR and Bathymetry generated under the restored condition was used for the analysis. In the improved or restored condition, the cross structures are removed, the canal is widened to a width of 16.5m and a minimum bed level of -0.9m CD was maintained. Where the existing bed level was less than -0.9m CD no changes to the bed level were made but a minimum width of 16.5m was maintained. The same lateral inflows and external boundary water levels applied to the existing condition are defined in for the restored condition simulations. To reflect the cleaned and restored condition the channel sections were assigned a Manning's n value of 0.03. The Manning number for the overbank urbanized floodplain areas remained unchanged at 0.20.

The simulations undertaken for the un-restored condition were repeated for the restored condition to allow a direct comparison of the improvements from the results.

7.3 Flood Routing under Existing Climate Condition

The following series simulations were carried out for each of the three canals for the unrestored and restored conditions under existing **(Ex)** climate. The details are tabulated in**Table 35**.

1) **Ex 1**: Simulation with 50 years storm event with boundary condition at normal mean sea level at 0.8m CDat both external boundaries for existing and restored conditions of all the canals
2) **Ex 2**: Simulation with 25 years storm eventwith high tide condition of 1.1m CDat both external boundariesfor existing and restored conditions of all the canals.
3) **Ex 3**: Simulation with 25 years storm eventwith highest astronomic tide (HAT) level of 1.4m CDat both external boundaries for existing and restored conditions of all the canals.
4) **Ex 4**: Simulation with 25 years storm eventwith river flood condition of 1.6m CD at north end and 1.45m CD at south end for existing and restored conditions of Edappally canal, Chilavanoor canal north end at 1.4m CD and south end at 1.1m CD, Thevara- Perandoor north end at 1.25m CD and south end at 1.1m CD.

Table 35: Details of Simulation Boundary Conditions

Run ID	Storm event (ARI, years)	Edappally		Chilavanoor		Thevara- Perandoor	
		Upstream Water level (m CD)	Downstream Water level (m CD)	Upstream Water level (m CD)	Downstream Water level (m CD)	Upstream Water level (m CD)	Downstream Water level (m CD)
Ex 1	50	0.8	0.8	1.1	1.1	1.1	1.1
Ex 2	25	1.1	1.1	1.1	1.1	1.1	1.1
Ex 3	25	1.4	1.4	1.4	1.4	1.4	1.4
Ex 4	25	1.6	1.45	1.4	1.1	1.25	1.1

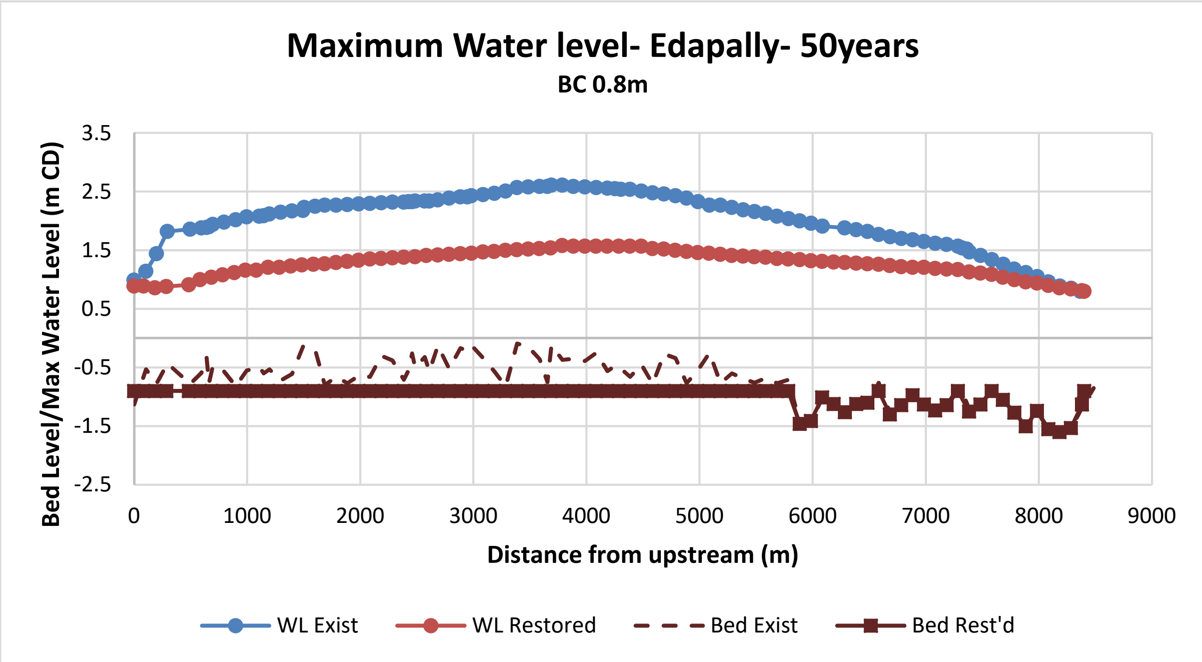
7.3.1 Edappally Canal

The maximum water level profiles for existing and restored conditions for Ex 1-4 and are shown in**Figure 32**. The figures also indicate the existing and restored canal bed levels. A comparison of the results of maximum water levels and corresponding flooded areas for the existing and restored conditions are tabulated in **Table 36**. The water profiles indicate that under all modelled conditions maximum water levels are reached roughly midway along the canal and that stormwater runoff from the canals exits at both ends.

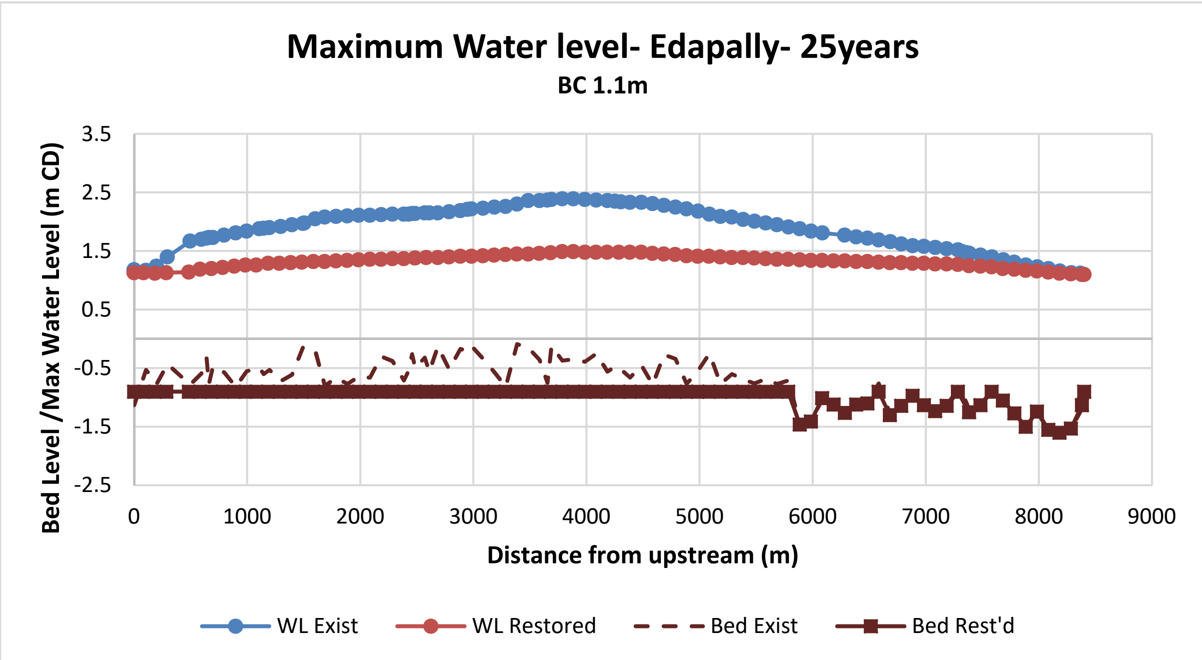
There is a general decrease in the peak water levels and flooded areas in the restored condition, as expected. The maximum decrease occurs for Ex2 (MHHW) condition with a 25 year storm event, where the water level is reduced by 1.11m in the restored condition. A similar reduction of 1.03m is observed in the Ex1 (normal tide and 50 years storm). In Ex3 (HAT) case, the reduction is 0.76m. In the river flood simulation (Ex4) the reduction in water level is a minimum of 0.7m as the water levels are mainly driven by the net flow from the applied boundary condition. The maximum flooded area reduction is observed in Ex1 at 50%. The reduction in flooded area for Ex 2 and Ex 3 are 44% and 30% respectively. In the river flood simulation of Ex 4, the flood area reduction is found to be minimum of 18%.

Table 36: Max. water levels and flooded areas in Edappally Canal Existing and Restored conditions

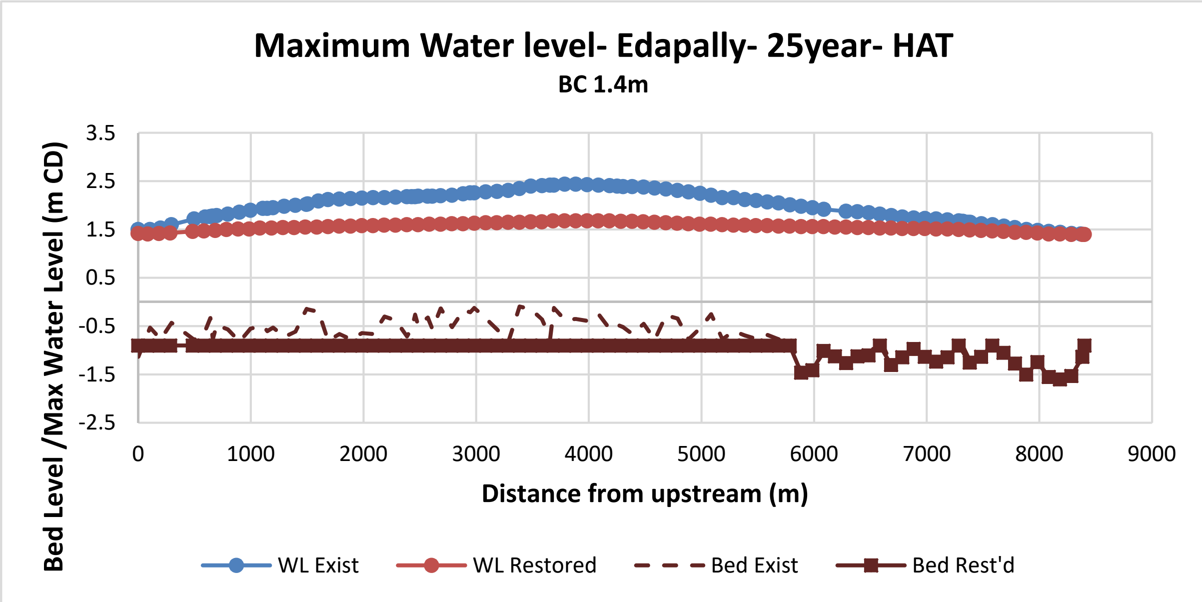
Condition	Maximum water level m CD		Flooded Area (ha)	
	Existing	Restored	Existing	Restored
Ex - 1	2.61	1.58	78.11	39.08
Ex - 2	2.39	1.48	79.81	44.98
Ex - 3	2.44	1.68	89.78	62.72
Ex - 4	2.45	1.75	83.78	68.41



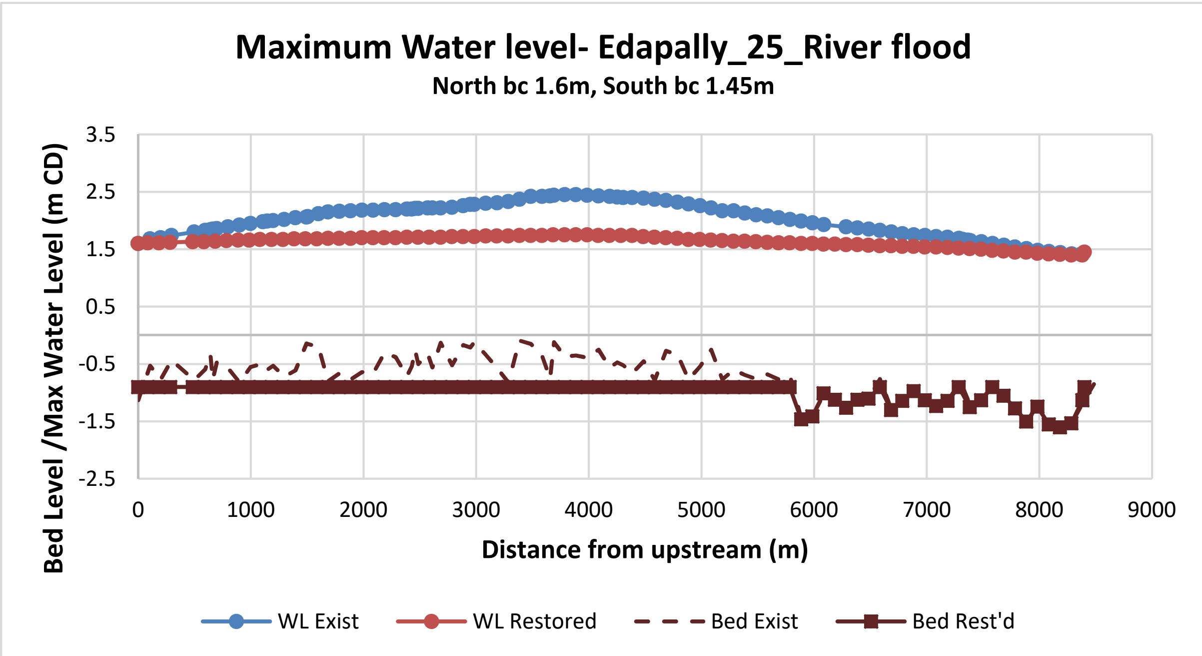
Ex 1:Existing and Restored conditions with 50 years flow data and BC at 0.8m CD



Ex 2: Existing and Restored conditions with 25 years flow data and BC at 1.1m CD



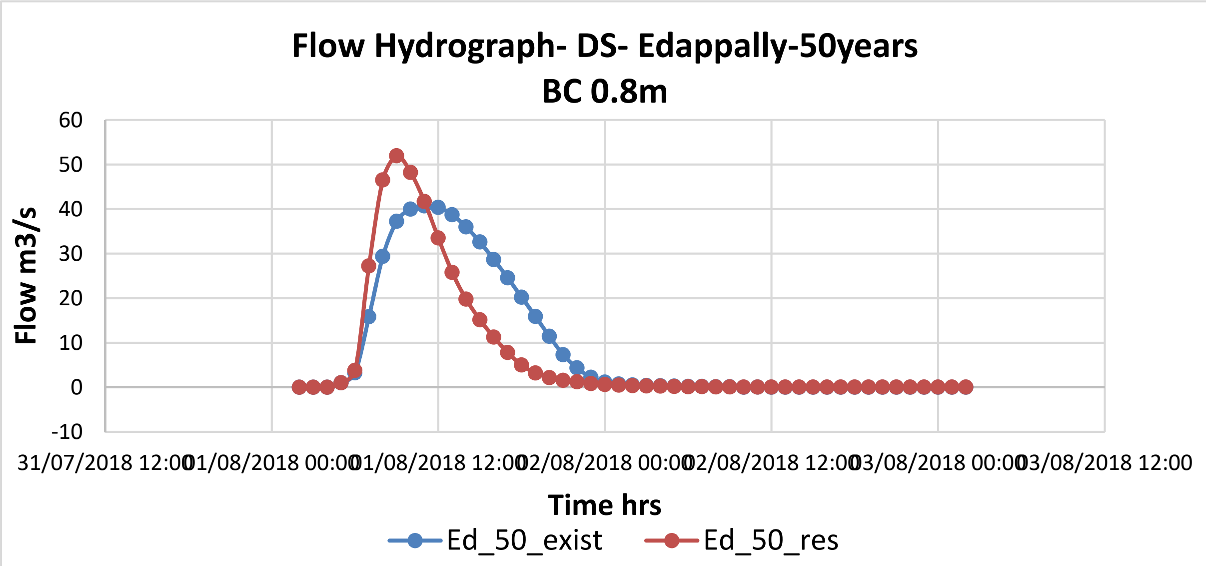
Ex 3: Existing and Restored conditions with 25 years flow data and BC at 1.4m CD



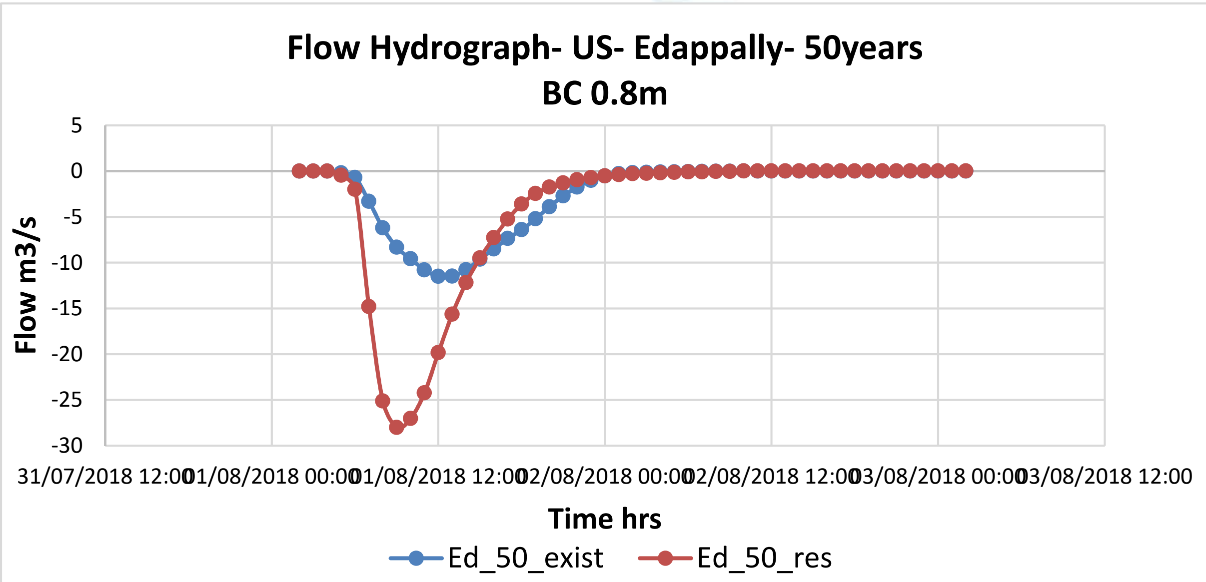
Ex 4: Existing and Restored conditions with 25 years flow data with North BC at 1.6m CD and South BC at 1.45m CD.

Figure 32: Edappally canal-Maximum water levels for existing and restored stage under different boundary conditions

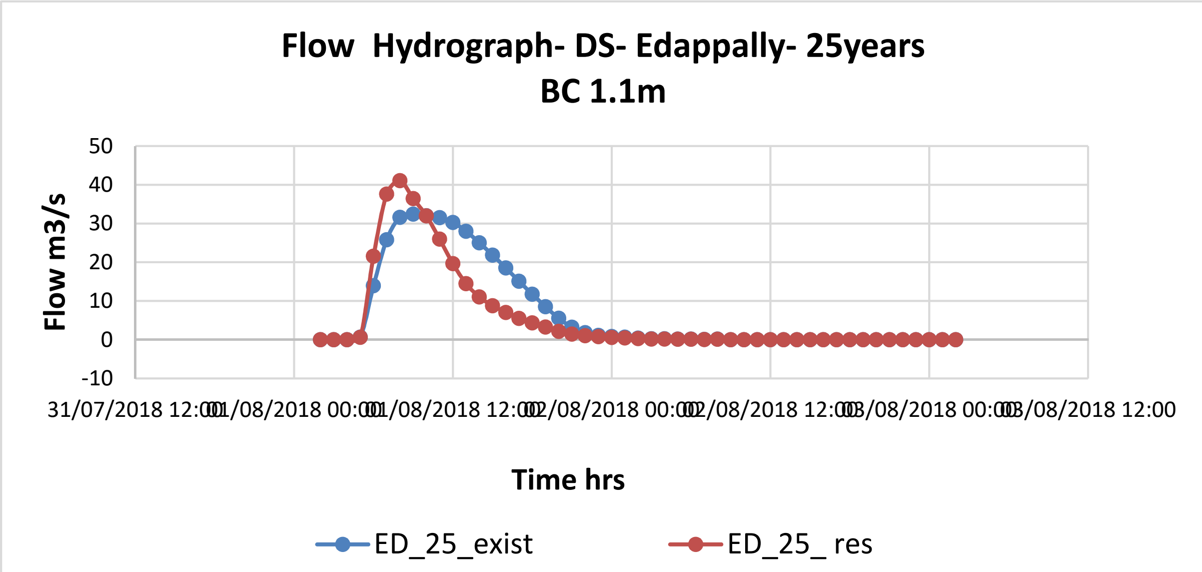
The flow hydrographs at downstream and upstream end of Edappally canal for the simulation Ex 1-4 are shown in **Figure 33**.



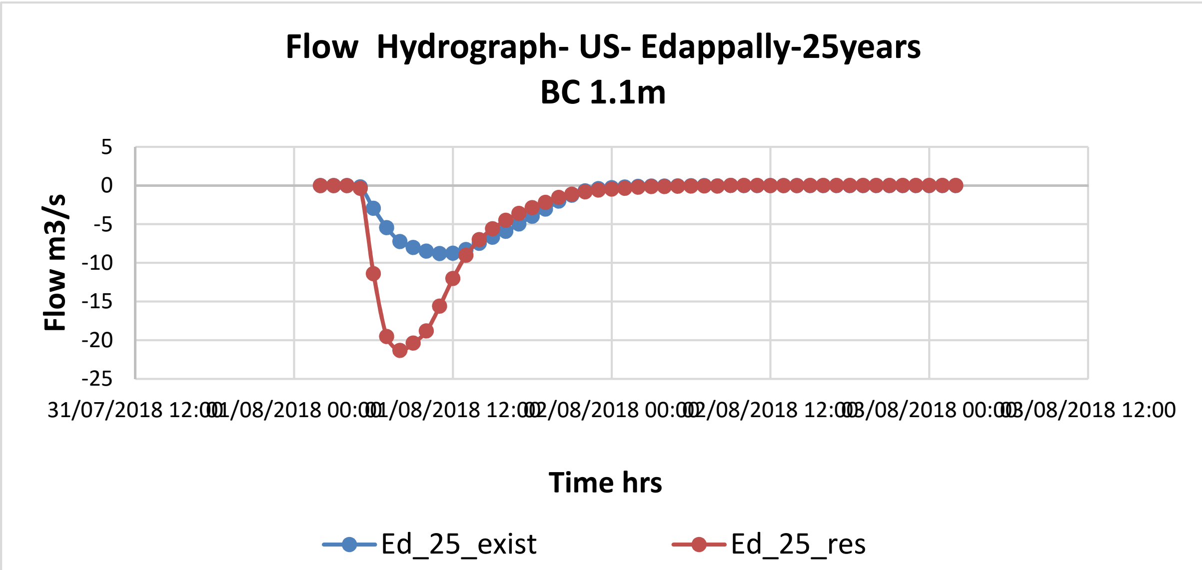
Flow hydrograph- Edappally- Downstream for Ex 1, 50 years flow data and BC 0.8m CD



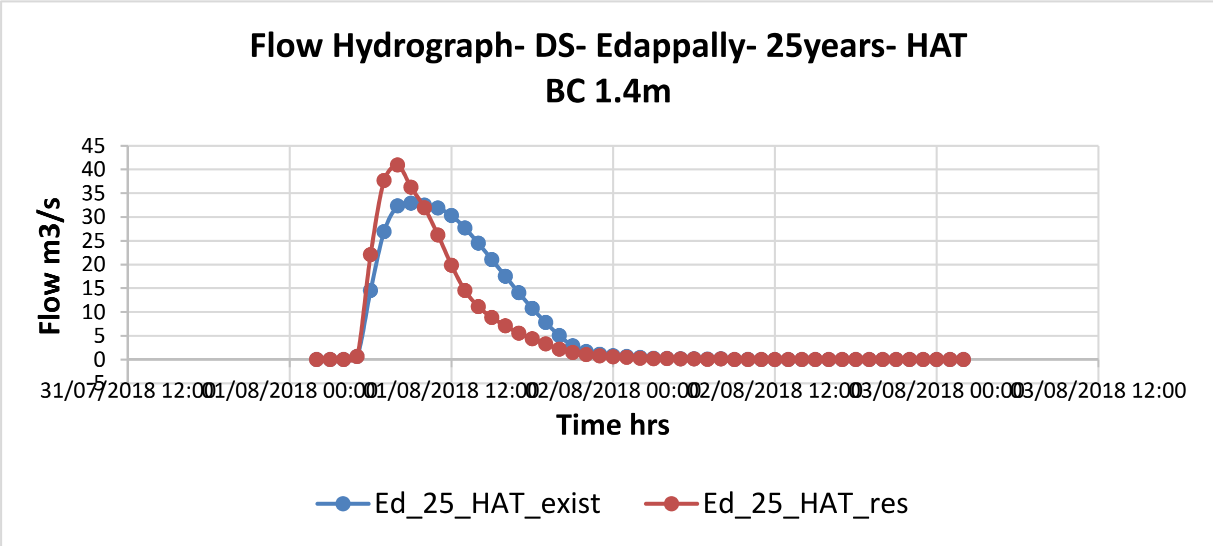
Flow hydrograph- Edappally- Upstream for Ex 1, 50 years flow data and BC 0.8m CD



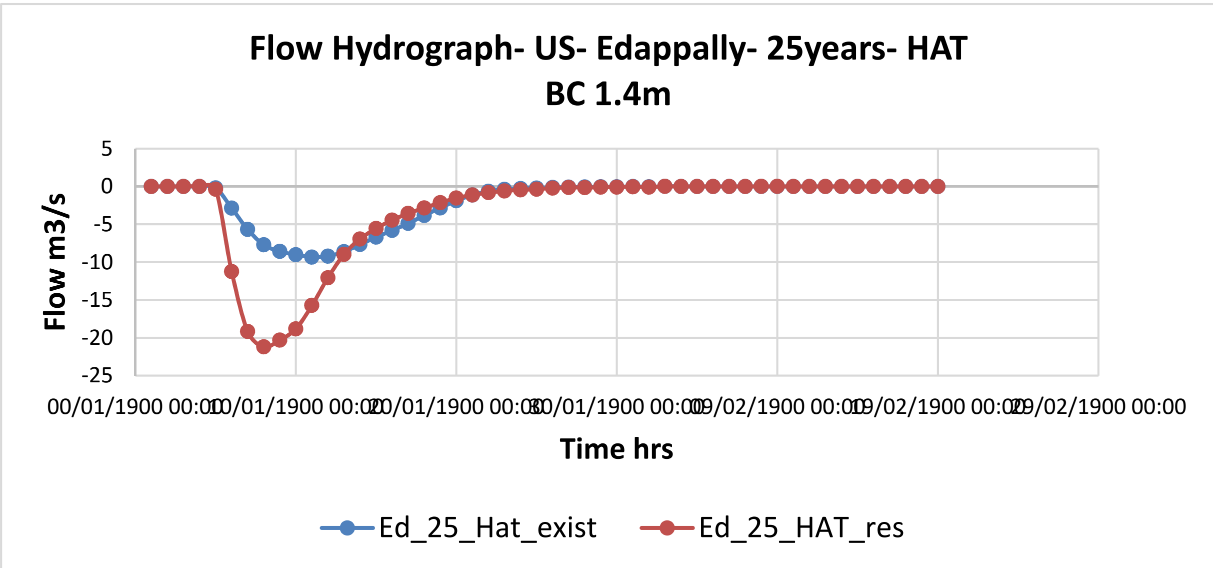
Flow hydrograph- Edappally- Downstream for Ex 2, 25 years flow data and BC 1.1m CD



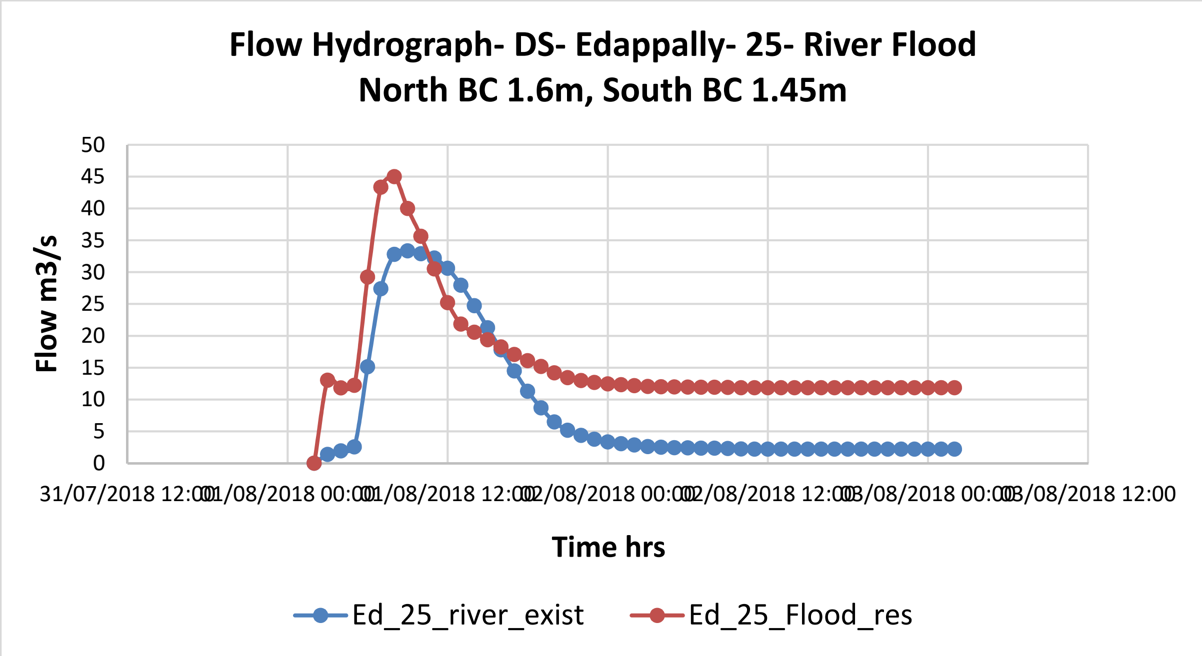
Flow hydrograph- Edappally- Upstream for Ex 2, 25 years flow data and BC 1.1m CD



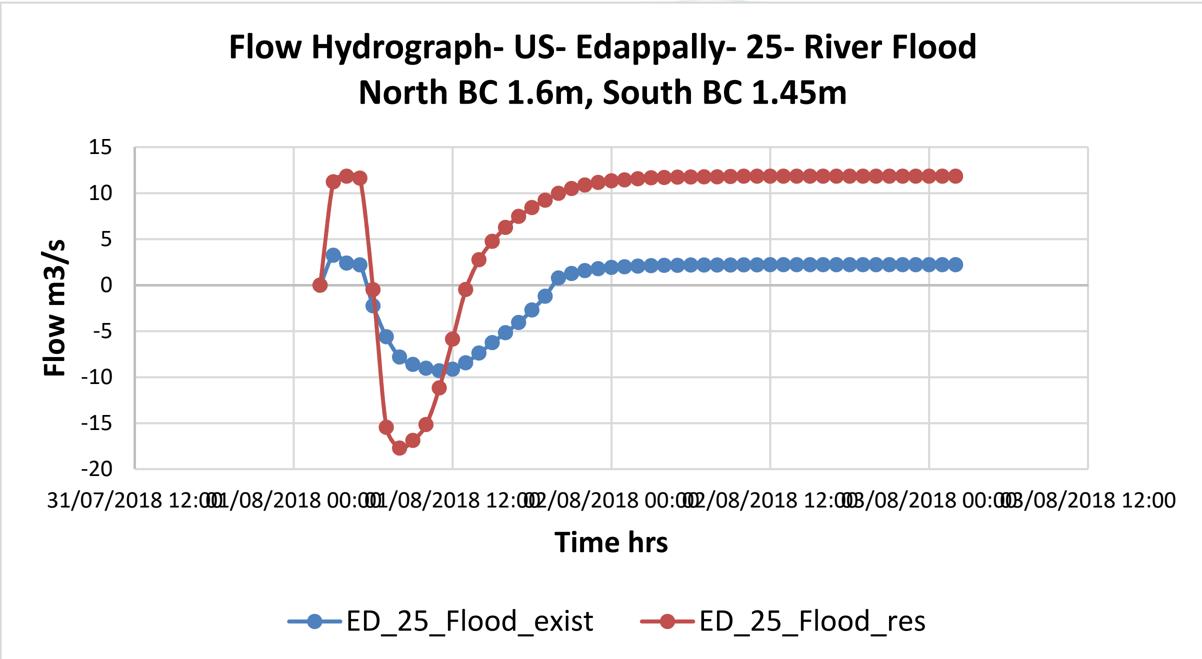
Flow hydrograph- Edappally- Downstream for Ex 3, 25 years flow data and BC 1.4m CD



Flow hydrograph- Edappally- Upstream for Ex 3, 25 years flow data and BC 1.4m CD



Flow hydrograph- Edappally- Downstream for Ex 4, 25 years flow data with North BC at 1.6m CD and South BC 1.45m CD



Flow hydrograph- Edappally- Upstream for Ex 4, 25 years flow data with North BC at 1.6m CD and South BC 1.45m CD

Figure 33:Edappally canal: Flow hydrograph for simulations Ex 1-4

A comparison of the flow hydrographs for Runs **Ex1** to **Ex3** shows that under the restored condition the total outflow is more than in the existing condition. This is due to water being trapped in the canal in the existing condition by the irregular channel bed levels, in particular the large “humps” at station 7100 seen on the longitudinal profiles. When this is removed in the restored condition it can be seen the outflows increase. The total volume of outflow in the restored condition has been checked and found to equal that of the HEC-HMS runoff inflow, as would be expected. Negative flow at upstream side indicates that the flow is in the opposite direction towards upstream.

In run **Ex-4** there is a net flow from north to south due to the higher river level imposed at the northern end (to represent a river flood situation). The residual flow of around 11.84m^3/s out of the southern downstream end of the canal can be seen toward the end of the simulation.

Flood Plain mapping

Flood maps have been generated for Ex 1-4 conditions for all the canals.The maximum mapped flood extent is restricted to the LiDAR coverages, i.e., approximately 125m on either side of the canal.

Sample maximumwater surface elevationmap of Edappally canalfor Ex3 existing and restored conditions (25-year storm and HATwater level boundary of +1.4m CD) are shown in**Figure 34** and **Figure 35**.A mapindicating the reduction in flood depths between existing and restored conditions is shown in**Figure 36**. Areas which are flooded in the existing condition, but no longer flooded in the restored condition are shown in **Figure 37**. Area calculation is done in Arc GIS based on the number of pixels of the flooded area and the cell size of the DEM.

Flood maps of all simulations for Ex-1to Ex-4 for existing and restored conditions for Edappally, Chilavanoor and Thevara- Perandoor canals are given as **Annexure 10**. Plots of water level and flow hydrographs at downstream and upstream of all the canals are given as **Annexure 11**.

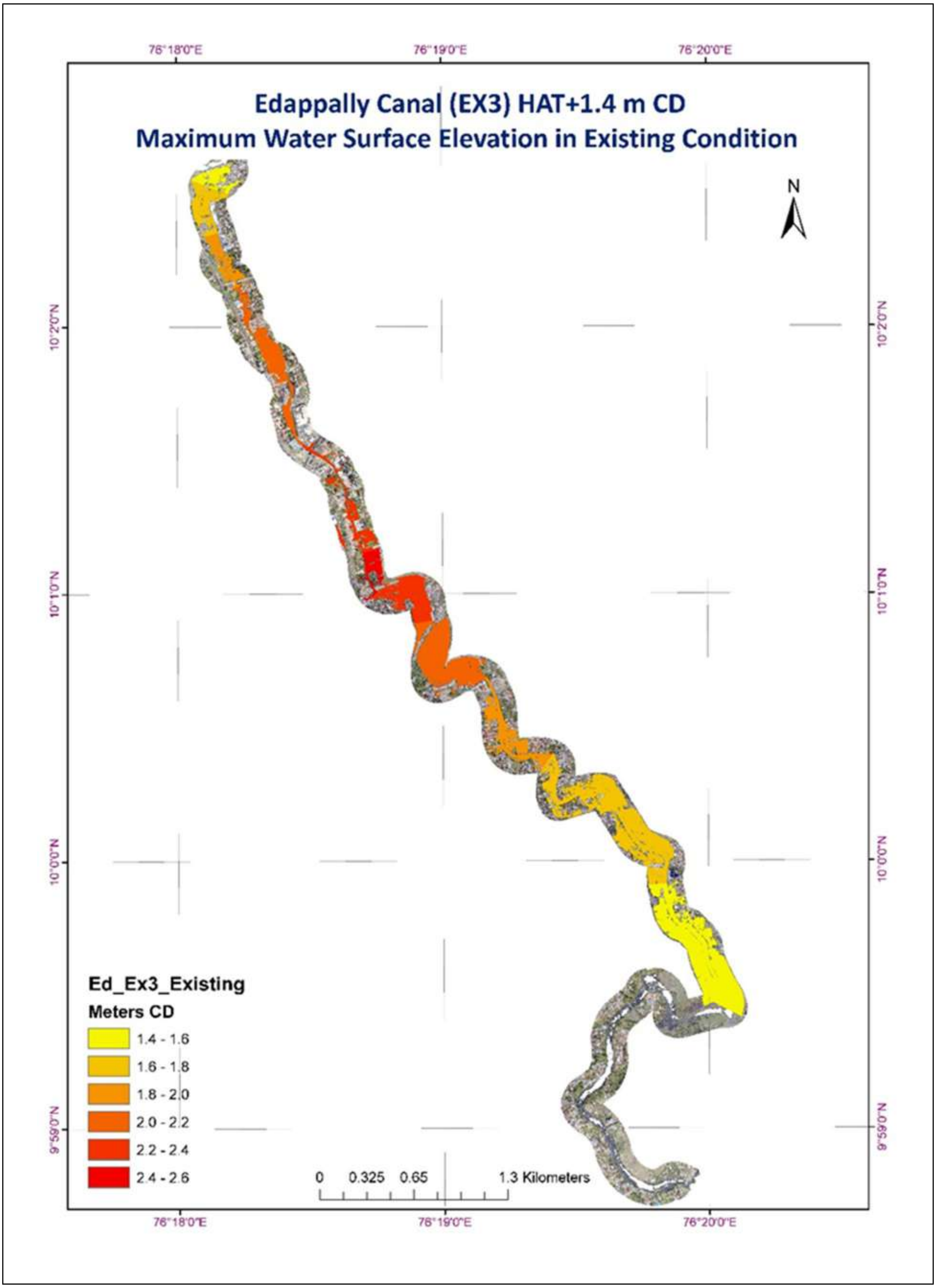


Figure 34: Maximum water surface elevation Existing condition- Ex 3- Edappally Canal

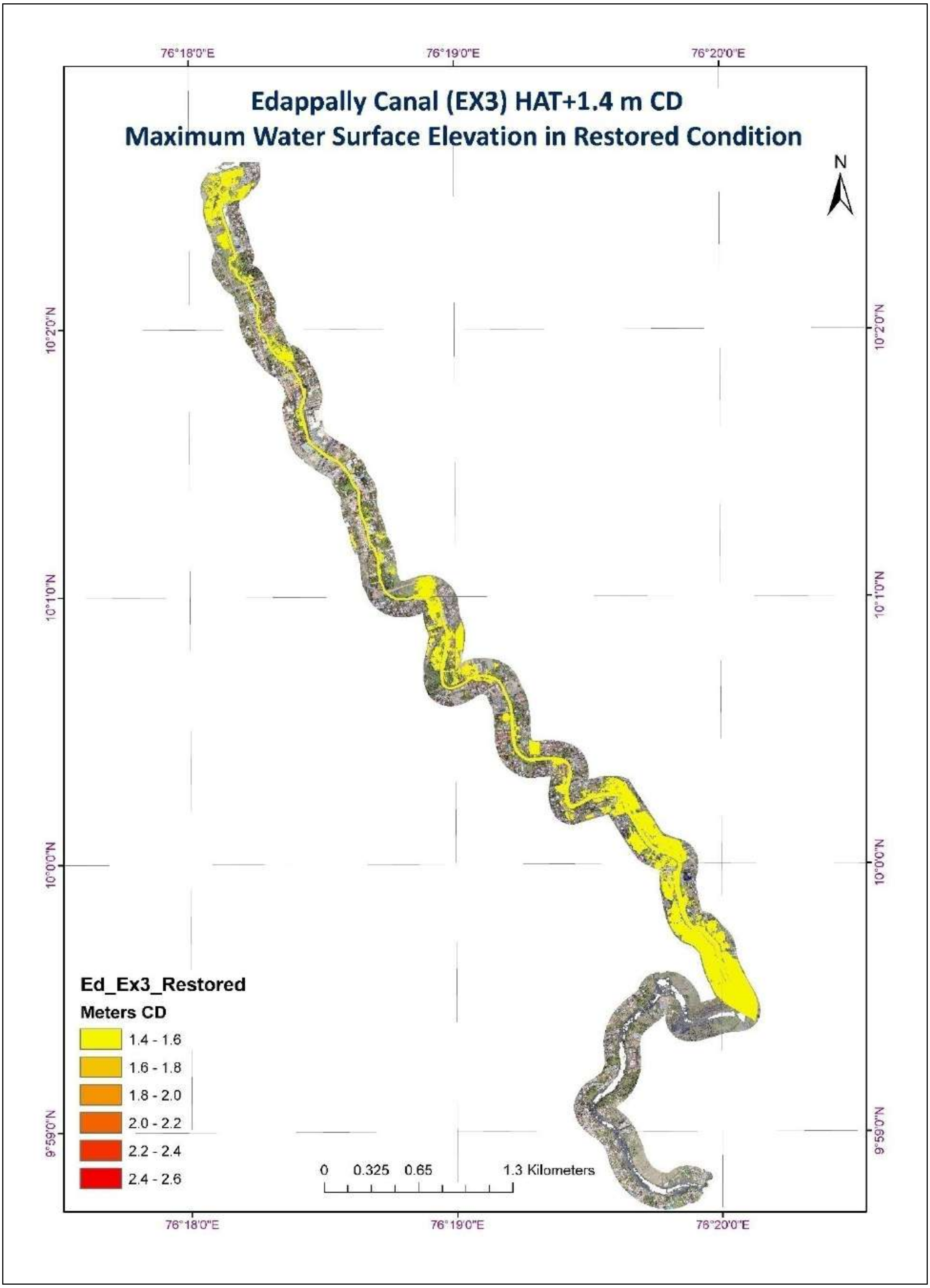


Figure 35: Maximum water surface elevation Restored condition- Ex 3- Edappally Canal

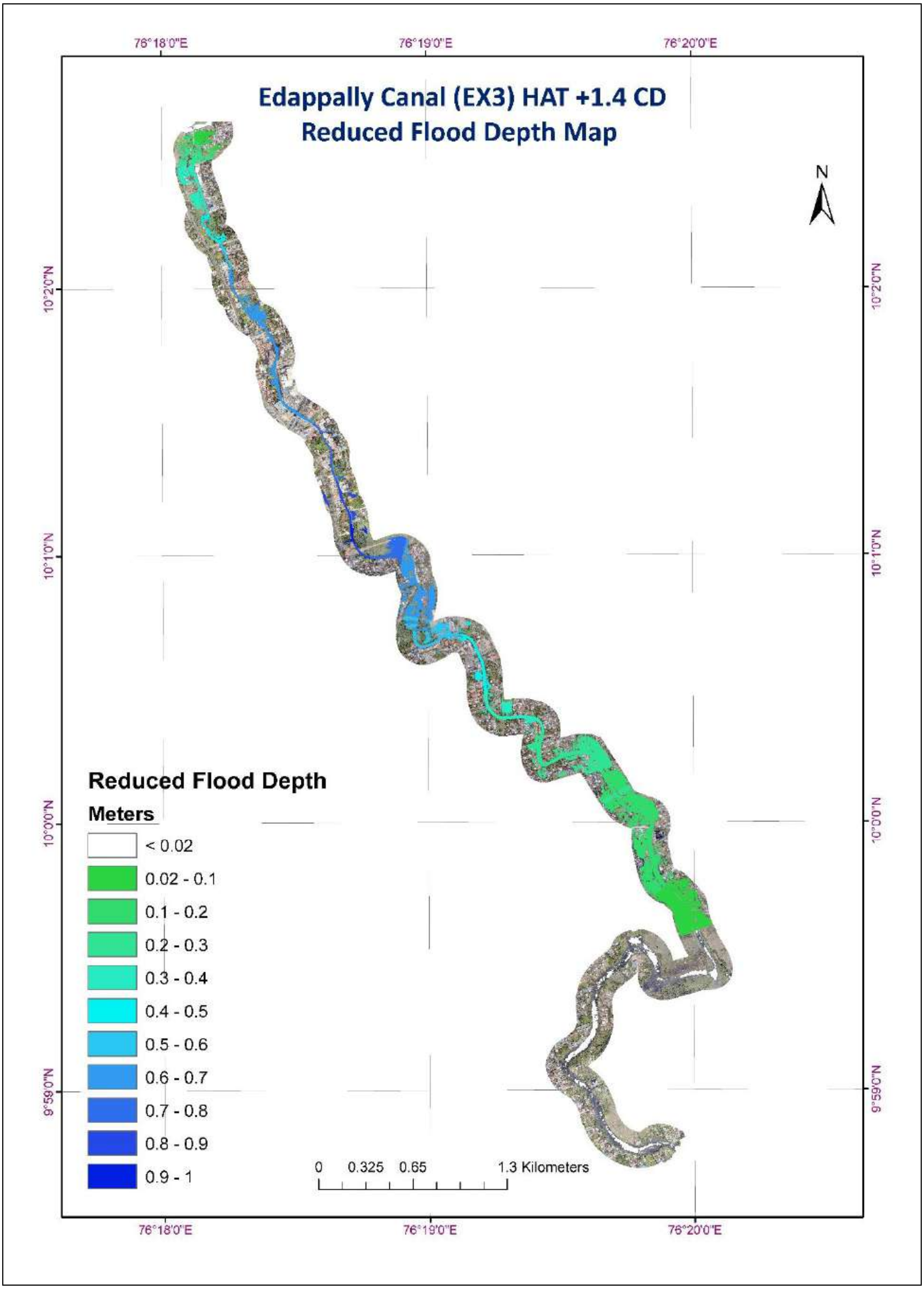


Figure 36: Reduced Flood depth- Ex 3- Edappally Canal

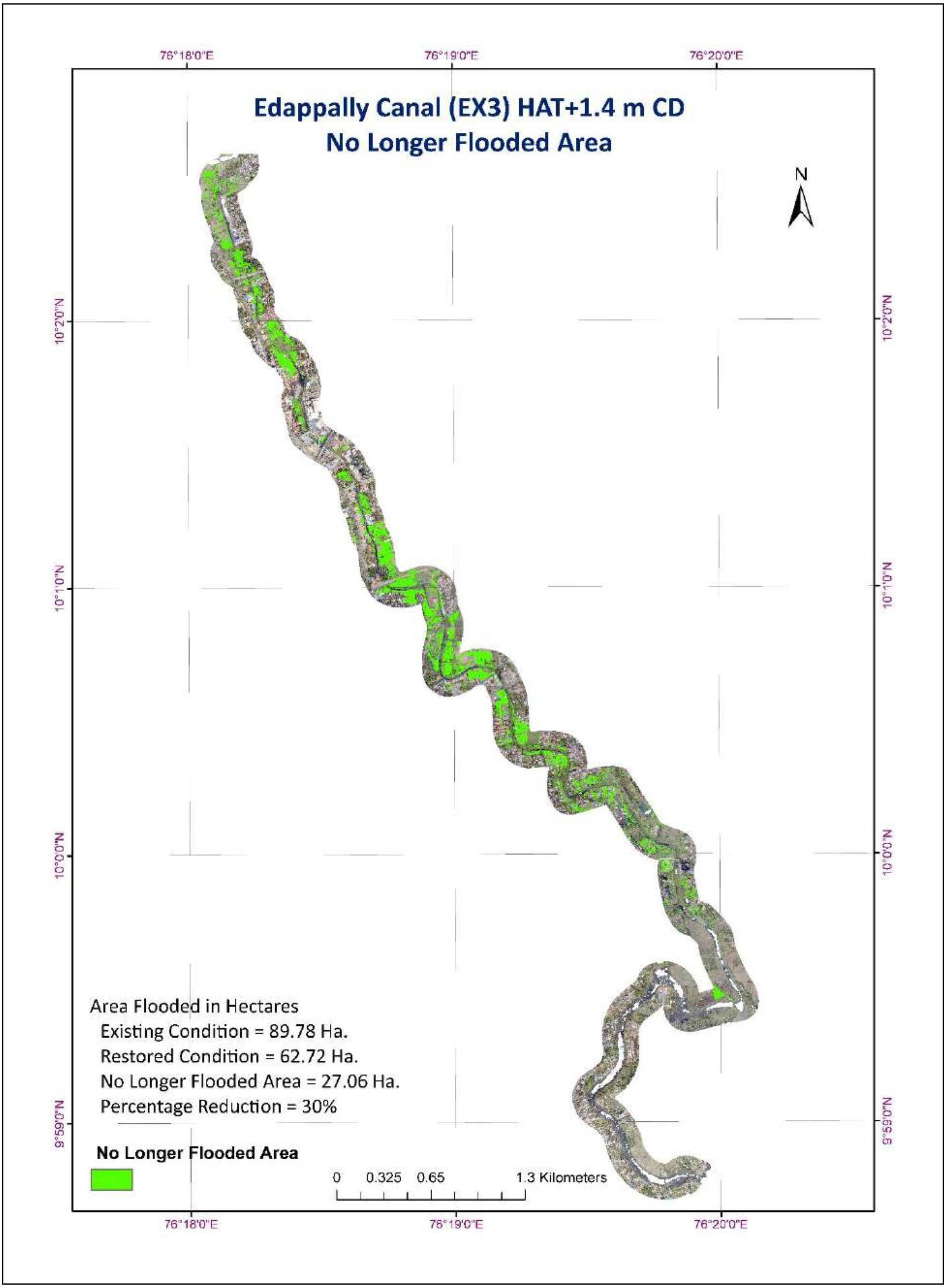


Figure 37: No longer Flooded area- Ex 3- Edappally Canal

7.3.2 Chilavanoor Canal

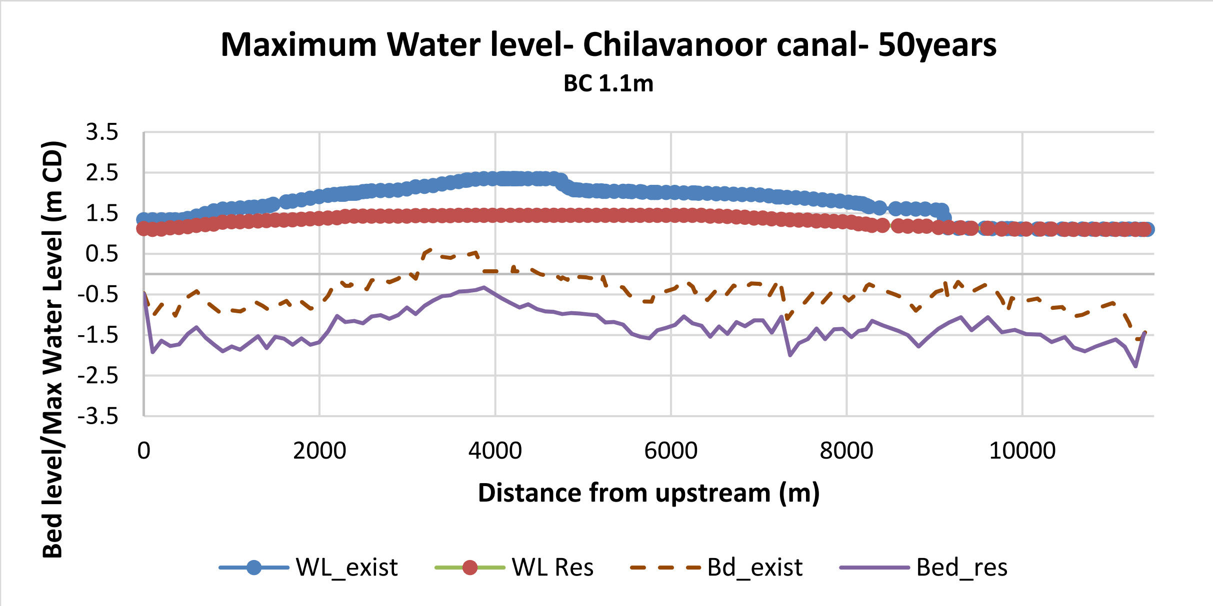
For the Chilavanoor canal, the canal sections are wider and deeper compared to Edappallyand there is need for cross section and terrainmodification especially at thesections between station chainages 3000m and 4500m. The difference in geometry between the existing and restored geometry isthe removal of the structures and the modification of the cross sections and terrain at the narrow sections.

The maximum water levels andflooded areas for existing and restored conditions for runs Ex 1-4 are tabulated in**Table 37**and are shown in**Figure 38.**

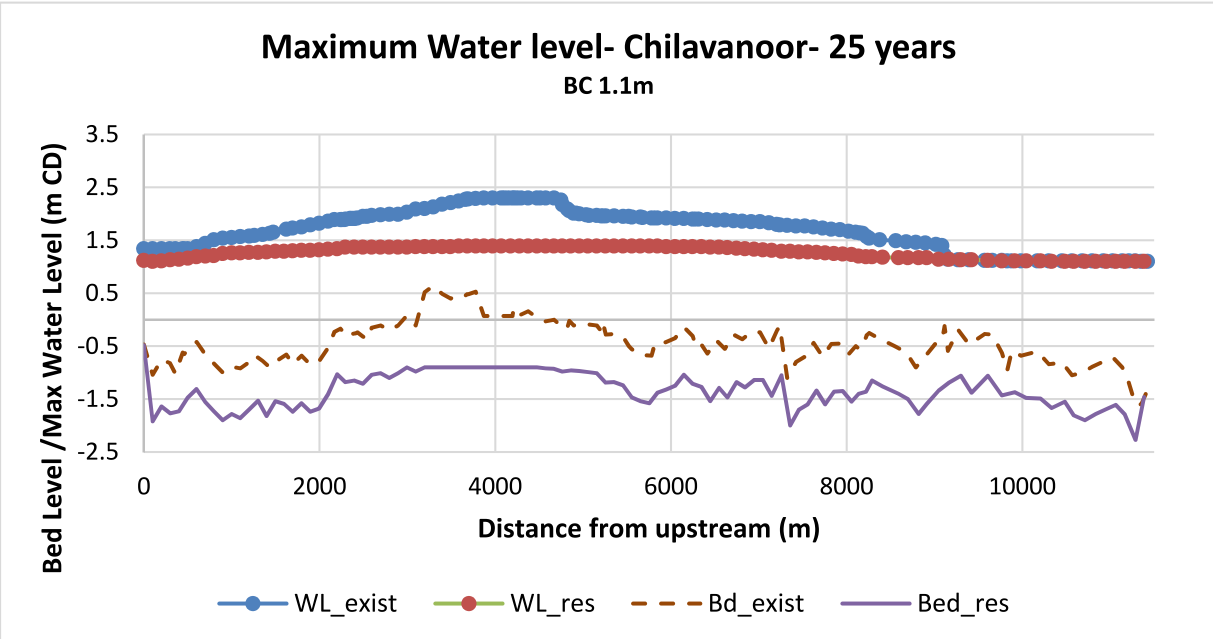
The maximum reduction in water level between existing and restored conditions is observed for Ex 1(50 years storm event) at 0.95m. Under high tide conditions, for Ex 2, with 25 years storm, the reduction in water level is found to be 0.91m. For Ex 3 with HAT boundary conditions and for Ex 4 of river flood conditions, the reduction in water level is found to be 0.7m and 0.77m respectively. The maximum reduction in flooded area is found to be 31% for Ex1 and the minimum reduction in flooded area is 18% for Ex3. For Ex2 and Ex 4, the corresponding reductions in flooded area are 28% and 22% respectively.

Table 37: Maximum water levels in Chilavanoor Canal Existing and Restored conditions

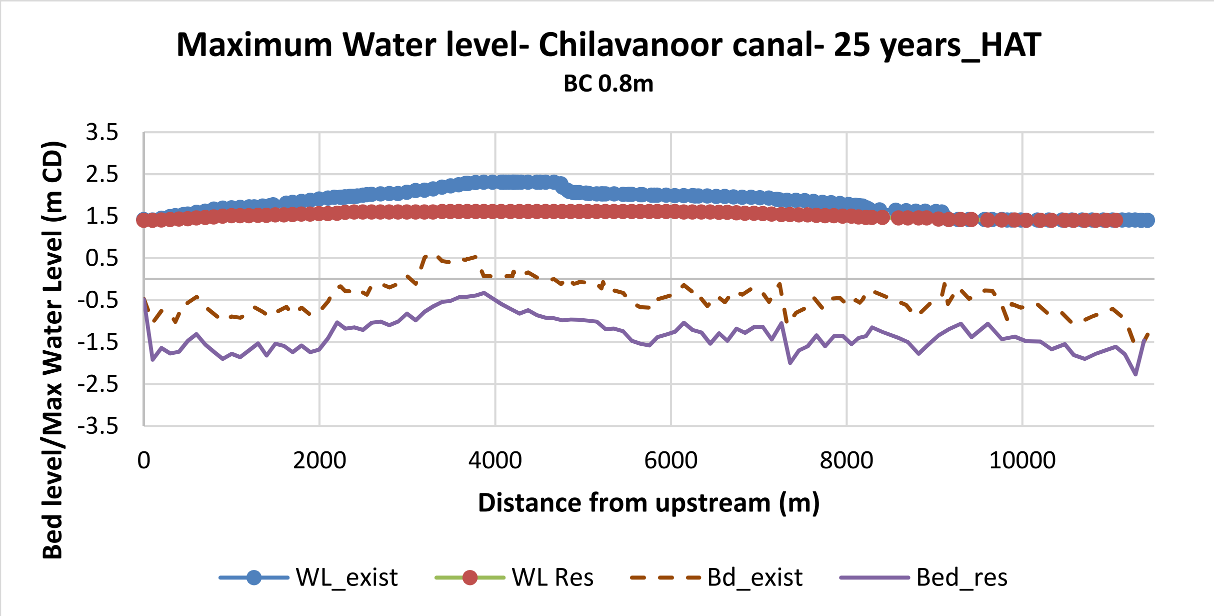
Condition	Maximum water level m CD		Flooded area (ha)	
	Existing	Restored	Existing	Restored
Ex 1	2.35	1.45	92.89	63.73
Ex 2	2.3	1.39	106.86	76.98
Ex 3	2.31	1.61	153.62	126.33
Ex 4	2.3	1.53	121.88	95.58



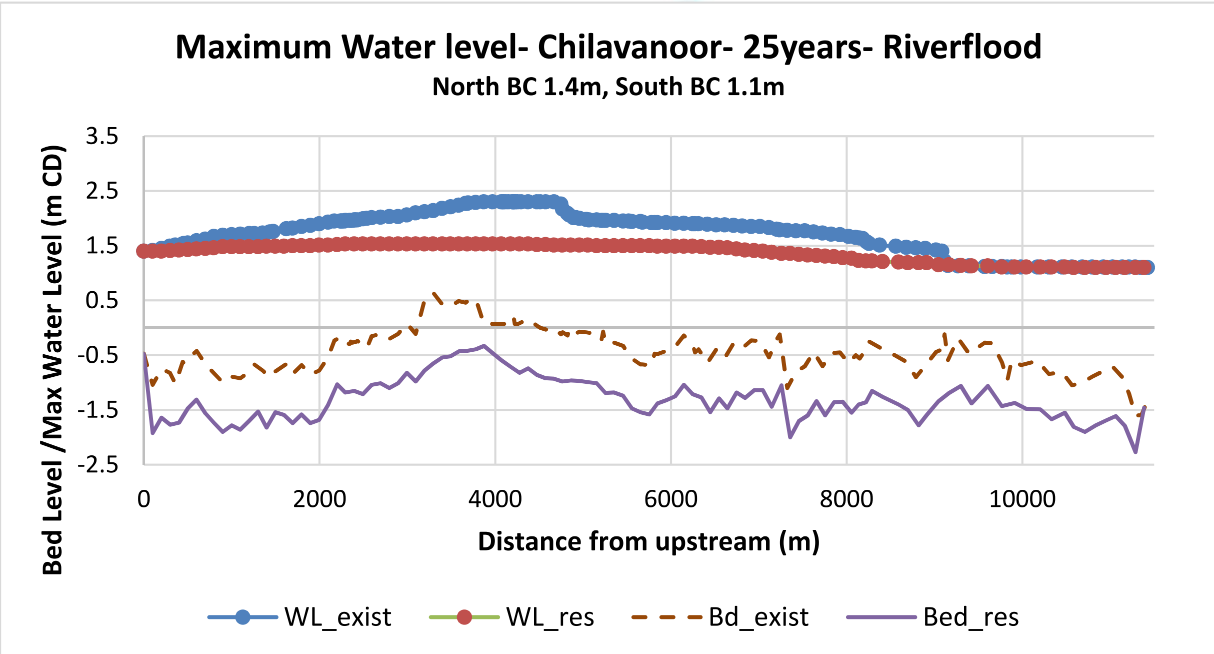
Ex 1 : Maximum water level- Chilavanoor Canal Existing and Restored conditions with 50 years flow data and BC at 1.1m CD



Ex 2 : Maximum water level- Chilavanoor Canal Existing and Restored conditions with 25 years flow data and BC at 1.1m CD



Ex 3 : Maximum water level- Chilavanoor Canal Existing and Restored conditions with 25 years flow data and BC at 1.4m CD



Ex 4 : Maximum water level- Chilavanoor Canal Existing and Restored conditions with 25 years flow data with North BC at 1.4m CD and South BC at 1.1m

Figure 38:Chilavanoor canal-Maximum water levels for existing and restored stage under different boundary conditions

The flow hydrographs at downstream and upstream end of Chilavanoor canal after simulation for Ex 1-4 is given in **Annexure 11**.

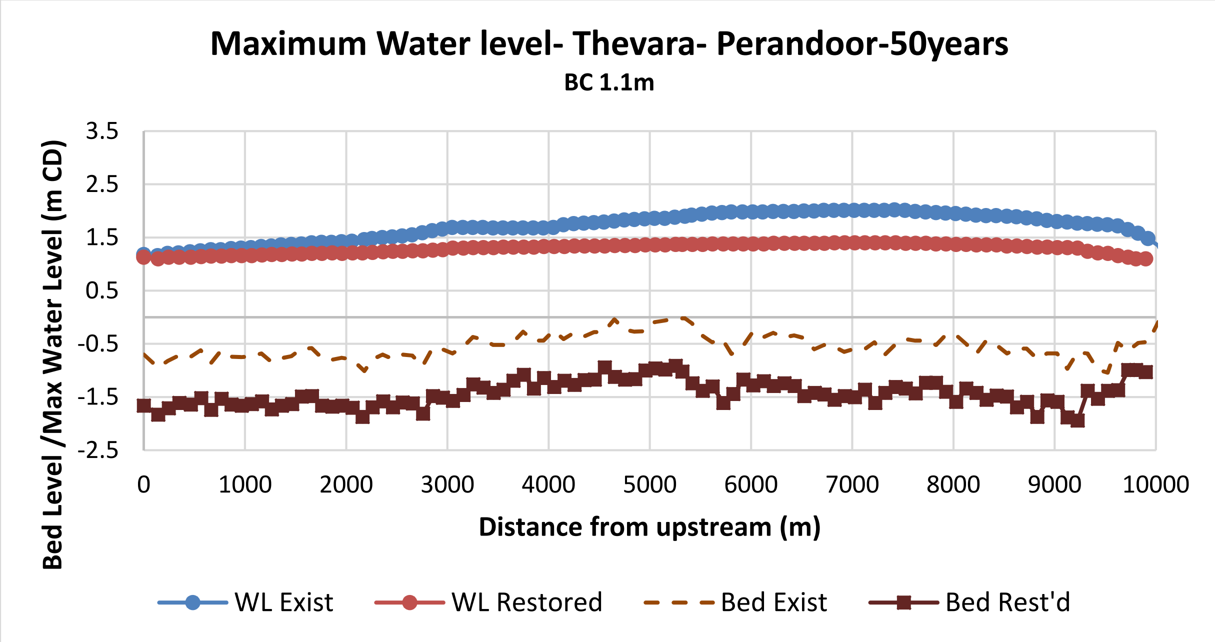
7.3.3 Thevara-Perandoor Canal

For the Thevara_Perandoor canal, modifications to the restored bathymetry are widening of the canal to 16.5m and removal of the cross structures.The maximum water levels for existing and restored conditions for **Ex 1-4**are tabulated in **Table 38**and are shown in **Figure 39**.

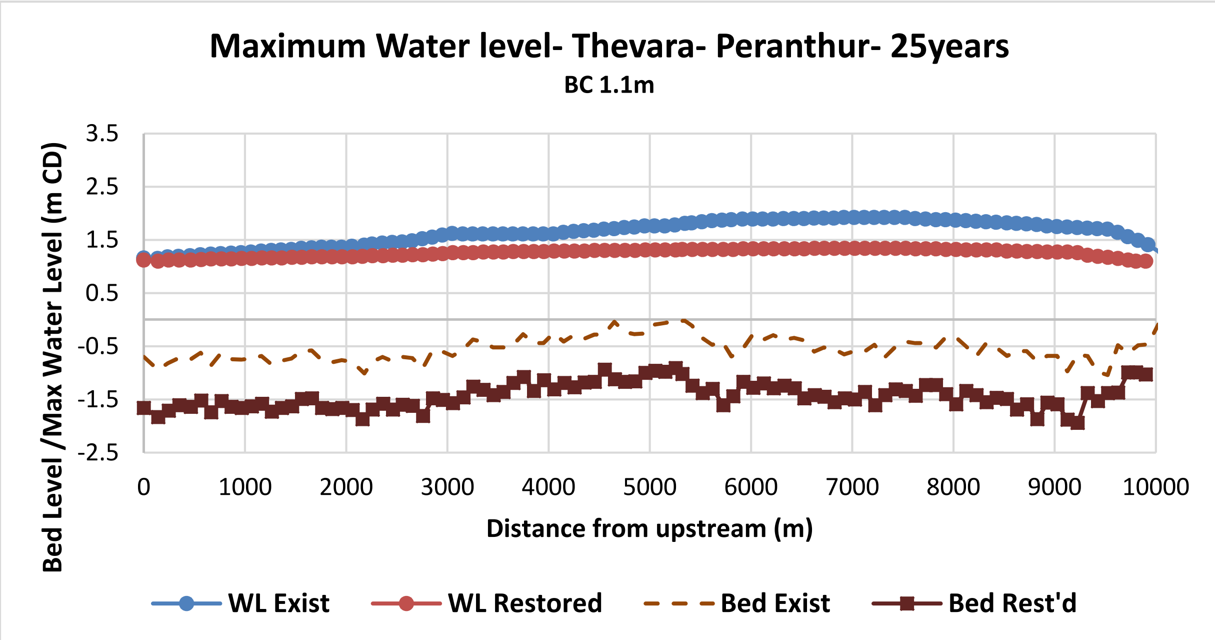
The maximum reduction in water levels between existing and restored conditions is observed for Ex1 (external boundary condition at 1.1m CD and 50 years return period flood)as 0.61m. Under high tide conditions, for Ex 2, with the 25 year storm event, the maximum water level reduction is 0.58m in the restored condition. For Ex 3 (HAT boundary conditions and 25 year storm) the maximum water level obtained for existing conditions of Thevara- Perandoor canal is 2.00m whereas it has reduced by 0.43m in the restored stage. In Ex 4, with river flood conditions keeping the north and south boundaries of the Thevara-Perandoor canal at 1.25m CD and 1.1m CD respectively, the maximum water level in the existing case is 2.01m and in the restored condition, it has been reduced by 0.61m.The maximum reduction in flooded area is found to be 48% for Ex1. For Ex 2, 3 and 4, the reduction in flooded area is found to be 43%, 27% and 38% respectively.

Table 38: Maximum water levels in Thevara- Perandoor Canal Existing and Restored conditions

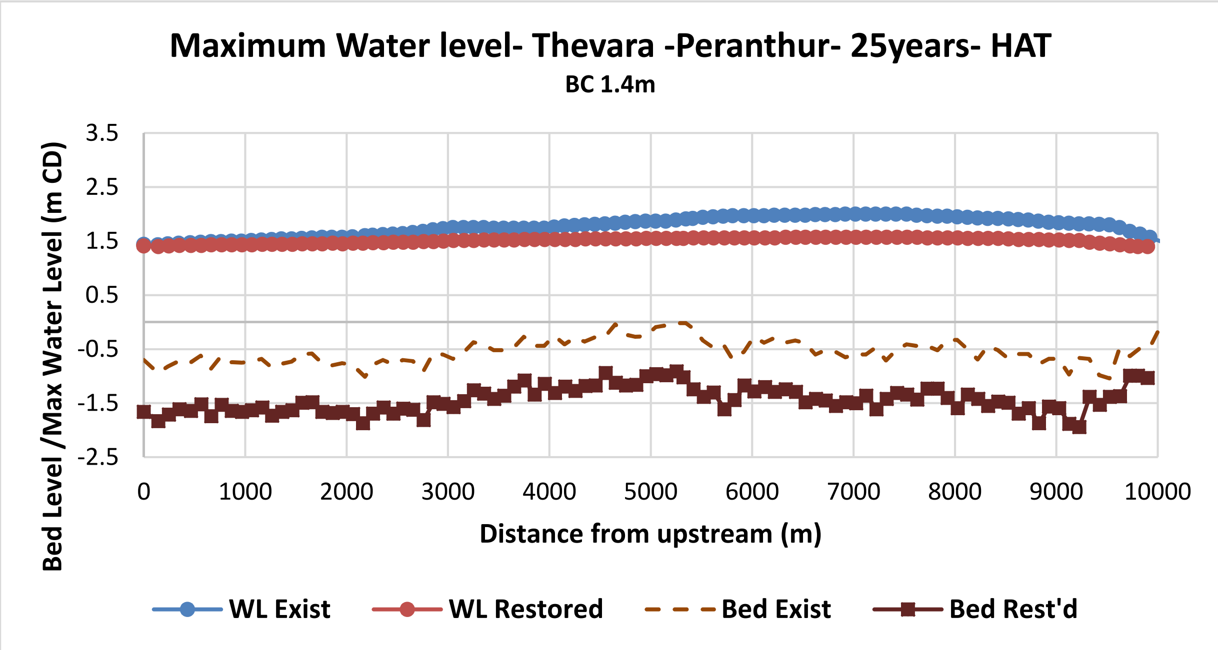
Condition	Maximum water level m CD		Flooded Area (ha)	
	Existing	Restored	Existing	Restored
Ex 1	2.01	1.4	58.74	30.32
Ex 2	1.92	1.34	64.97	36.92
Ex 3	2.00	1.57	97.36	70.70
Ex 4	1.93	1.41	72.82	44.92



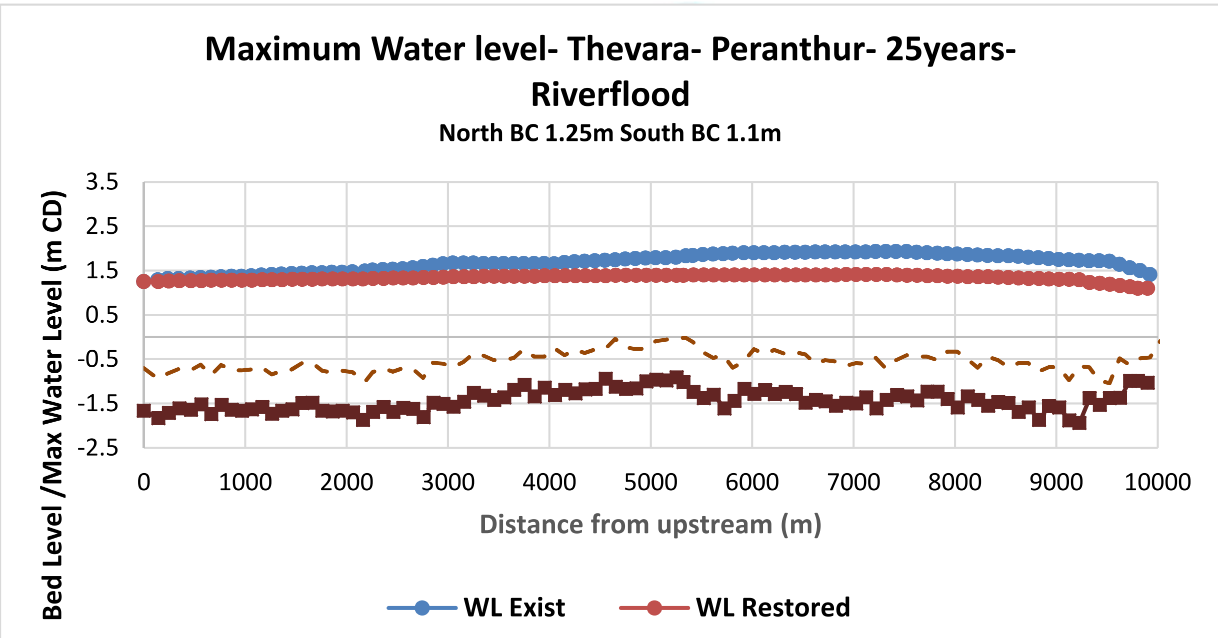
Ex 1 : Maximum water level- Thevara_ Perandoor Canal Existing and Restored conditions with 50 years flow data and BC at 1.1m CD



Ex 2 : Maximum water level- Thevara_ Perandoor Canal Existing and Restored conditions with 25 years flow data and BC at 1.1m CD



Ex 3 : Maximum water level- Thevara_ Perandoor Canal Existing and Restored conditions with 25 years flow data and BC at 1.4m CD



Ex 4 : Maximum water level- Thevara_ Perandoor Canal Existing and Restored conditions with 25 years flow data, North BC at 1.25m CD and South BC at 1.1m CD

Figure 39: Thevara Perandoor canal-Maximum water levels for existing and restored stage under different boundary conditions

The flow hydrographs for Thevara Perandoor canal at downstream ad upstream for **Ex 1-4**are given in **Annexure 11**.

7.4 Discussion of results

The abstract of the flood simulation results is given in **Table 39**, and the flood maps for all canals are also given as **Annexure 10**.

Table 39: Details of Flood simulation results

Exercise 1	**50yrs return period (+0.8m CD for Edappally, 1.1m CD for Chilavanoor and TP)**			
Canals	Reduced flood depth (range)	No longer flooded area/% reduction	Max. water surface elevation (CD existing)	Max. water surface elevation (CD Restored)
Edappally	0.02m-1.03m	39.03 ha./50%	0.8m -2.61m	0.8m-1.58m
Chilavanoor	0.02m-0.95m	29.16ha./31%	1.1m-2.35m	1.1m-1.45m
T-P canal	0.02m-0.61m	28.43ha./48%	1.1m-2.01m	1.1m-1.4m
Exercise 2	**25yrs return period (MHHW+1.1CD)**			
Canals	Reduced flood depth (range)	No longer flooded area/% reduction	Max. water surface elevation (CD existing)	Max. water surface elevation (CD Restored)
Edappally	0.02m-1.1m	34.83ha/44%	1.1m-2.39m	1.1m-1.48m
Chilavanoor	0.02m-0.91m	29.88ha./28%	1.1m-2.3m	1.1m-1.39m
T-P canal	0.02m-0.58m	28.05ha./43%	1.1m-1.92m	1.1m-1.34m
Exercise 3	**25yrs return period (HAT+1.4CD)**			
Canals	Reduced flood depth (range)	No longer flooded area/% reduction	Max. water surface elevation (CD existing)	Max. water surface elevation (CD Restored)
Edappally	0.02m-0.76m	27.06ha./30%	1.4m-2.44m	1.4m-1.68m
Chilavanoor	0.02m-0.7m	27.29ha./18%	1.4m-2.31m	1.4m-1.61m
T-P canal	0.02m-0.43m	26.66ha./ 27%	1.4m-2.00m	1.4m-1.57m
Exercise 4	**River flood condition (Northern side+1.60m CD and southern side +1.45 m CD)**			
Canal	Reduced flood depth (range)	No longer flooded area/% reduction	Max. water surface elevation (CD existing)	Max. water surface elevation (CD Restored)
Edappally	0.02m-0.7m	15.37ha./18%	1.1m-2.45m	1.1m-1.75m

Exercise 4	River flood condition Northern side (+1.4m CD and southern side +1.1mCD)			
Canal	Reduced flood depth (range)	No longer flooded area/% reduction	Max. water surface elevation (CD existing)	Max. water surface elevation (CD Restored)
Chilavanoor	0.02m-0.77m	26.3ha./22%	1.1m-2.3m	1.1m-1.53m
Exercise 4	**River flood condition Northern side (+1.25m CD and southern side +1.1mCD)**			
Canal	Reduced flood depth (range)	No longer flooded area/% reduction	Max. water surface elevation (CD existing)	Max. water surface elevation (CD Restored)
T-P canal	0.02m-0.52m	27.9ha./38%	1.1m-1.93m	1.1m-1.41m

Hydraulic modelling of the three canals shows that drainage from local stormwater runoff occurs in both directions, to the north and south of each canal. When the same water level is imposed at each end of the canal, only outward flow is observed. In the asymmetrical case representing a river flood condition (Ex 4), a net north to south flow in the canal occurs as expected with the stormwater flood event superimposed. This results in a reversal of flow at the northern end of the canal at the peak of the runoff.

Restoring the canal through widening and deepening to a minimum of -0.9m CD results in reduced flood levels in all cases. The maximum reductions occur in Edappally canal where the current flow capacity is the most constrained and which therefore benefits the most from the restoration.In contrast, smaller reductions in flood level are seen in Thevara- Perandoor canal where modifications to the canal bathymetry in the restored condition are more modest.

The maximum water level in the different modelled scenarios for Edappally Canal in the existing case is found to be 2.61m for 50 year flow condition whereas it has considerably reduced to 1.58m in the restored condition. For the Chilavanoor canal, the maximum existing water level is found to be 2.35m for 50 year flow condition, whereas the same for the restored state is 1.45m. For the Thevara-Perandoor Canal also, the maximum water level has occurred for 50year flow conditions as 2.01m for the existing conditions whereas for restored condition the level is 1.4m. It has been seen that the flood water levels have been reduced in the restored condition for all the three canals. It is also found that the maximum water level in the restored condition is within the proposed canal height level in Ex 1 and Ex 2 for all the canals.For HAT and river flood conditions, water level is within the restored canal cross section for most of the sections and side protection is needed only for a few sections.

The maximum water level in the canals in the restored conditionand reductions in peak water level and flooded area is summarized in **Table 40**. The flow in the canals is governed by the tidal currents.The velocity of the tidal currents as per COPT data (https://cochinport.gov.in/climate-tidal-info), vary from 3knots (1.54m/s) in non monsoon periods to 5.5knots(2.185m/s) in monsoon periods. The maximum depth available excluding freeboard in the canals is 2.25m.Forthe maximum flood discharge estimated for the canals, and assuming an average tidal velocityin the canals, the dimension required to contain the flood flow in the canals isgiven in **Table 41**.

Table 40: Maximum Water level in the Canals and Maximum Reductions from Restoration

Canal	Maximum restored water level (m CD)	Maximum flood level reduction from existing (m)	Maximum flooded area reduction (%)
Edappally	1.75	1.11	50
Chilavanoor	1.61	0.95	31
Thevara- Perandoor	1.57	0.61	48

Table 41: Max. Discharge and Dimension required in the canals

Canal	Maximum Discharge (m^3/s)	Average Tidal velocity (m/s)	Depth excluding freeboard (m)	Width required (m)
Edappally	54.5	2.185	2.25	11.09
Chilavanoor	43.9	2.185	2.25	8.93
Thevara- Perandoor	49.9	2.185	2.25	10.15

Channel bathymetry modification and removal of cross structures has resulted in improved flow patterns in the canals. In the case of Edappally especially the drainage of stormwater runoff from the canals occurs faster and is more complete compared to the present situation where it appears stormwater remains trapped by high points in the canal, preventing complete drainage.Based on the hydraulic studies performed, it is revealed that when the bottlenecks of the existing conditions are removed, no flooding is seen to occur in the restored condition in most of the canal cross sections.At certain stretches of the three canals, side protection is proposed where one side of the canal banks are at a lower level.

Low points in the floodplain at the ends of the canals will be subjected to regular flooding due to high tide or river levels irrespective of any canal restoration works. Reducing flooding in these areas would require additional flood protection works such as embankments or flood walls.

Based on the hydraulic modelling of the three canals, the maximum water surface elevation anticipated for the restored state of canal is 1.75m CD. The top level of the shutter of the gate is fixed at 1.65m CD and it is found that the maximum simulated water level at the gate locations is 1.6m CD in the worst case.

8. General Limitations

Hydrological and hydraulic modelling studies require accurate and extensive data sets in order to provide robust predictions of the flow regime under different forcing conditions. Data is required for both developing the models and for validating their predictive capabilities.

The hydrological modelling was used to derive catchment runoff hydrographs and has been based on a HEC-HMS hydrological model. The forcing rainstorm data was based on a statistical analysis of 16 years of observed hourly rainfall from the Kochi Naval base rain gauge. Due to gaps in the data this was infilled and extended based on daily modelled data from IMD, using an empirical relation between maximum daily and sub-daily rainfall depths.

The main limitations relating to the hydrological modelling are as follows:

- The 16 years of observed rainfall is a relatively short period on which to base more rare storm events. Extrapolation to 20-25 years would generally regarded as acceptable however there is increasing uncertainty when considering less frequent 50 or 100 year events. For the purposes of this project the main interest is in the 25 year event and therefore this is not a major issue.
- The infilling and extrapolation of the 16 years of observed hourly data was based on daily data using an empirical formulation. This was considered necessary especially to include the major rainstorm events of 2018 and 2019, for which unfortunately hourly rainfall data was not available. The results of the IDF analysis only displays small changes (increases in rainfall depth) compared to the values based on the 16 years of observation only, and therefore no significant issues are flagged here.
- The IDF tables have been used to derive a synthetic rainfall profile (hyetograph) using a well-accepted (alternating bar) method. As the shortest observed duration was one hour, this is reflected in the hyetograph.
- The hydrological model cannot be validated due to the absence of recorded flow data, and therefore peak flow estimates have been compared to a standard Rational Method assessment as a cross check for gross errors.

The hydraulic study has been carried out with an extensive topographical data set, incorporating details of the canal bathymetry and LiDAR derived floodplain levels. The main limitations relating to the hydraulic model are as follows:

- The LiDAR data was restricted to 125m each side of the canal which is therefore the maximum extent of the cross sections represented in the model. Floods which reach these extents are therefore artificially constrained which may result in modelled water levels being higher than may otherwise occur. Additionally, flood extents may be larger than those indicated on the flood maps.
- There is limited information with which to formulate appropriate boundary conditions in the rivers which bound each end of the canals. There is sufficient tidal level data which has been used to assess the levels due to tides but there is no information regarding the influence of river flows, apart from flood markers retrieved from the 2018 flood. Therefore, the effect of river flow influences has been estimated.
- While tidal amplitudes are well established there is no data on the relative timing of high and low tide conditions at the ends of the canals. As these levels control the flows from the canals the assumed simultaneous equivalence of tidal water level boundaries (in Ex1 to Ex3) is most likely not realistic but is neverthelessa conservative assumption.
- There is no flow data against which the combined hydrological / hydraulic model can be validated.
- The model boundary conditions imposed at the canal ends are the most influential factor in determining the flood levels in the interior canal areas. As described above these are set based on a number of assumptions. The model is best considered as a comparative tool to determine the relative effects of changes to the canal bathymetries that will be applied as part of the restoration program.

9. Conclusions

This study has been undertaken to assess the impacts of restoration works to the Kochi canal system, namely the Edappally, Chilavanoor and Thevara -ThevaraPerandoor canals. Hydraulic modelling is not possible for Market canal as it is a manmade canal with a length of only 660m and a catchment cannot be generated in the modelling process. The major canals studied serve as the main trunk stormwater drainage system for large parts of Kochi city and discharge into the large lagoon network that surrounds the city. Water level and flow in the canals are therefore controlled by the river and tide levels in the lagoon receiving waters, as well as the quantity of stormwater entering the channels.

The restoration works will deepen the canals to a minimum of -0.90m CD and widen them to 16.5m, in order to permit a dual use for flood mitigation and navigation. The existing canals are in various stages of disrepair, limiting their ability to effectively discharge stormwater runoff from the adjoining catchments. In particular Edappally canal shows the highest degree of dilapidation.

The investigations reported in this study have utilized hydrological and hydraulic models to determine the flood levels and associated flooded areas in the canal and adjoining floodplains for both existing (unrestored) conditions and compared these to the fully restored conditions. Models require significant amounts of physical data in order to accurately represent the real world conditions.

For the hydrological modelling, 16 years of hourly rainfall data from Kochi naval station was available, covering the period 1993-2015. This data included a number of years with significant gaps and also did not cover the two most recent years of high rainfall in 2018 and 2019. Subsequently this record was infilled and extended using daily rainfall data from IMD (1975-2019), using an empirical formulation to derive the sub-daily rainfall totals. This extended rainfall recorded was then statistically analyzed to produce Intensity-Duration-Frequency (IDF) tables covering rainstormdurations from 1 to 24 hours and return periods from 5 to 100 years. The IDF relations were used to derive 24 hour design storm hyetographs for the hydrological modelling.

The hydraulic modelling requires detailed topographical data of the canals and adjoining floodplain. Canal bathymetries were provided from detailed cross section surveys taken every 15m along the canals. This was supplemented with drone flown LiDAR surveys covering the floodplain extending 125m on either side of the canals. The combined dataset was merged into a single high resolution (0.5m) digital elevation model (DEM) that was used to generate the cross section data for the model representing the current conditions.

As the canals drain into much larger water bodies, the water levels in these systems form important controls on the drainage from the canals. To the north of the canal system, the Periyar river (catchment area 5398 km^2 divides into many distributaries as it windsits way to the Kochi Lagoon. One of the distributaries forms a small loop in the river at Muttar and meets the northern boundary of the Edappally canal. Another loop of the distributary meets the northern boundaries of the Chilavanoor and Thevara-TP canals. On the southern side the Edappally canal connects to the small Chitrapuzha River before joining the Kochi lagoon, which also receives outflows from the Chilavanoor and Thevara canals.

The water levels in the bounding lagoon system are influenced by both sea level conditions (tide, storm surge and mean sea level) as well as river flows. Extensive tide measurements were available from the lagoon mouth at the Kochi Port gauge (2007-2019), and additional short-term measurements were carried out for the study and used to assess the tidal conditions at the ends of the canals. The Kochi gauge record indicated a rising trend of the mean level of the sea, (increasing at 1.5mm/year) with the current level approximately 0.20m above the MSL datum (or 0.8m above Chart Datum, CD).

In contrast little information was available regarding the effects of river flows. Peak water levels recorded during the record-breaking floods of 2018 were surveyed however, which indicates that flood levels were higher in the north (affected by Periyar flows) and inland, compared to the southern rivers.

Through an assessment of the tide data and taking into account the effects of river flows, a set of 4 different boundary conditions were derived to assess the impacts of restoration under different storm event (25 and 50 year ARI) and tide / river level conditions(MSL, MHHW, HAT and river flood coinciding with MHHW). (see **Table *26*** and **Table *27***)

While storm surge is a possibility for Kochi it is likely that in an extreme event large parts of the city would become inundated and overwhelm the canals regardless of their condition (existing or restored). Therefore such a case is not considered in the present study.

Climate change is predicted to lead to increased sea levels and have been included in the modelling by assuming an increase of +0.23m by 2050 and +0.52m by 2100.

Under the existing climate conditions the combined hydrological and hydraulic models were used to assess the impacts of the proposed restoration works on peak water levels and changes to flooded areas for these 4 different scenarios:

1) **Ex 1**: 50 year storm event with normal mean sea level at 0.8m CD and at high tide 1.1m CD

2) **Ex 2**: 25 years storm event withhigh tide (MHHW) condition of 1.1m CD.
3) **Ex 3**: 25 years storm event with highest astronomic tide (HAT) level of 1.4m CD.
4) **Ex 4**: 25 year storm event with river flood condition of 1.6m CD (north) 1.45m CD (south) for Edappally canal, Chilavanoor canal north: 1.4m CD and south: 1.1m CD, and Thevara-Perandoor north: 1.25m CD and south 1.1m CD

The model results indicate significant reductions in flood levels and associated flooded areas in all cases. The largest reductions occur in Edappally canal with 1.11m reduction in peak water level and 50% reduction in flooded area (Scenario Ex2). This result is expected as Edappallyincorporates the most extensive restorations in terms of cross section enlargement and reduction of Manning roughness. Maximum reductions in Chilavanoor and Thevara-Perandoor occur in Scenario Ex 1 and are less than Edappallybut also significant (0.95m and 0.61m respectively). The associated reductions in flooded areas are 31% and 48%.

Based on model outcome, the canal width of maximum 11.09m and with a uniform depth of 2.25 m as detailed in **Table 41** is adequate enough to carry maximum flood discharge of its catchment. Low points in the floodplain at the ends of the canals will be subjected to regular flooding due to high tide or river levels irrespective of any canal restoration works. Reducing flooding in these areas would require additional flood protection works such as embankments or flood walls.

The study results are subjected to a number of limitations. The most important are:

- As the LiDAR data was restricted to 125m each side of the canal this also is the maximum extent of the cross sections in the model. Floods which reach these extents are therefore artificially constrained which may result in modelled water levels being higher than may otherwise occur. Additionally flood extents may be larger than those indicated on the flood maps.
- Water levels in the canals are controlled by the river and tide levels applied at each canal boundary.The timing of the tides and effect of river flows is not known and therefore these conditions have been assumed.
- The models have not been calibrated due to an absence of observed flow or water level data in the canals. However the hydrological modelling has been cross checked against an alternative flood estimation method and found to be largely consistent, if somewhat conservative.

Given the importance but also the uncertainties in the boundary conditions the model is best considered as a comparative tool to determine the relative effects of changes to the canal bathymetries that will be applied as part of the restoration program. In this regard the modelling has clearly shown the benefits in flood level and area reductions that can be expected from the proposed restoration of the canals.

Validated

17/08/2021

References

1. Aziz, Z., Ray, I., Paul, S., 2018. The Role of Waterways in Promoting Urban Resilience: The Case of KochiCity. Report for Indian Council For Research On International Economic Relations.
2. Central Public Health and Environmental Engineering Organization (CPHEEO), 2019. Manual on storm water design systems. Report for Government of India, Ministry of Housing and Urban Affairs.
3. Chow, V.T., Maidment, D.R., Mays, L.W., 1988. Applied hydrology. McGraw-Hill, New York.
4. Gonnert, G., Dube, S., Murty, T., Siefert, W., 2001. Global Storm Surges - Theory, Observations and Applications. German Coastal Engineering Research Council.
5. IPCC, 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.
6. Kumar, P.K.D., 2006. Potential Vulnerability Implications of Sea Level Rise for the Coastal Zones of Cochin, Southwest Coast of India. Environmental Monitoring and Assessment 123, 333–344. https://doi.org/10.1007/s10661-006-9200-2
7. Mani Murali, R., Dinesh Kumar, P.K., 2015. Implications of sea level rise scenarios on land use /land cover classes of the coastal zones of Cochin, India. Journal of Environmental Management 148, 124–133. https://doi.org/10.1016/j.jenvman.2014.06.010
8. Oak Ridge National Laboratory, Cochin University of Science of Technology, 2003. Possible Vulnerabilities of Cochin, India.pdf. Report for USAID.
9. Ram Babu, Tejwani, K.K., Agrawal, M.C., Bhusan, L.S., 1979. Rainfall intensity-duration-return period equations & nomographs of India, CSWCRTI, ICAR, Dehradun, India. CSWCRTI, ICAR, Dehradun, India.
10. Ramachandran, A., Saleem Khan, A., Palanivelu, K., Prasannavenkatesh, R., Jayanthi, N., 2017. Projection of climate change-induced sea-level rise for the coasts of Tamil Nadu and Puducherry, India using SimCLIM: a first step towards planning adaptation policies. J Coast Conserv 21, 731–742. https://doi.org/10.1007/s11852-017-0532-6
11. Revichandran, C., Srinivas, K., Muraleedharan, K.R., Rafeeq, M., Amaravayal, S., Vijayakumar, K., Jayalakshmy, K.V., 2012. Environmental set-up and tidal propagation in a tropical estuary with dual connection to the sea (SW Coast of India). Environ Earth Sci 66, 1031–1042. https://doi.org/10.1007/s12665-011-1309-0
12. Sowmya, K., John, C.M., Shrivasthava, N.K., 2014. Urban flood vulnerability zoning of Cochin City, Southwest coast of India, using remote sensing and GIS. Natural Hazards 75. https://doi.org/10.1007/s11069-014-1372-4
13. State Relief Commissioner, Disaster Management, 2018. Kerala Floods Memorandum #2.
14. Strikwerda, M., 2004. Cochin Estuary Morphological Modelling&Coastal Zone Management. TU Delft.
15. MarCom WG 121: Harbour Approach Channels - Design Guidelines (2014) | PIANC.
16. https://coms.events/pianc-panama/data/full_papers/full_paper_375.pdf
17. Shivakumar. J. Nyamathi, AnilaArelt (2013). Modelling of Short Duration Rainfall IDF Equation for Bangalore City. International Conference and Exhibition on Integrated Water, Wastewater, and Isotope Hydrology – 2013, ISSN: 2319-9873, Journal of Engineering and Technology, Vol 2. RRJET, Issue 3.
18. Hydrology National Engineering Handbook, United States Department of Agriculture Natural Resources Conservation Service, Part 630, https://directives.sc.egov.usda.gov/.
19. Handbook for design of Flood protection Anti erosion measure and river draining works. CWC-Flood Management Organization. New Delhi . Dec-2011
20. Cochin Port Trust data - https://cochinport.gov.in/climate-tidal-info

About Antea Group

From city to countryside, from air to water: Antea Group's engineers and consultants have been contributing to our living environment in the Netherlands for years now. We design bridgesand roadways and create residential neighborhoods and water structures. But we are also involved in areas such as the environment, safety, asset management and energy. Under the nameOranjewoud, we expanded into an all-round, independent partner for companies and government bodies. As the Antea Group, we also apply this knowledge at a global level. By combiningvaluable knowledge, including on technical matters, with a pragmatic approach, we make solutions attainable and workable. Goal-oriented, with an eye for sustainability. In this way,we anticipate today's questions and tomorrow's answers. Just as we have been for over 60 years now.

Contact information

Project Office, GC-IURWTS,
Antea Group
40/157, First Floor,
Kudiyirickal Building,
Palarivattom. Kochi.682025

India Office: Magnum Towers,
Tower -1, Unit 219-221, 2nd Floor,
Main Golf Course Extension Road,
Sector – 58, Gurgaon – 122011,
Haryana, India.

info.in@anteagroup.com,
www.anteagroup.co.in

VISION

To be a world-class centre of excellence in hydraulic engineering research and allied areas; which is responsive to changing global scenario, and need for sustaining and enhancing excellence in providing technological solutions for optimal and safe design of water resources structures.

MISSION

- To meet the country's need for basic & applied research in water resources, power sector and coastal engineering with world-class standards
- To develop competence in deployment of latest technologies by networking with the top institutions globally, to meet the future needs for development of water resources projects in the country effectively
- To disseminate information, build skills and knowledge for capacity-building and mass awareness for optimization of available water resources

MAJOR FUNCTIONS

- Undertaking specific research studies relating to development of water resources, power and coastal projects
- Consultancy and advisory services to Central and State Governments, private sector and other countries
- Disseminating research findings and promoting/assisting research activities in other organizations concerned with water resources projects
- Contributions to Bureau of Indian Standards and International Standards Organization
- Carrying out basic and applied research to support the specific studies
- Contribution towards advancements in technology through participation in various committees at National and State Levels

The Director,

Central Water and Power Research Station

Khadakwasala, Sinhgad Road, Pune 411 024. Maharashtra

Telephone : +91-20-24103200/ 24381801

Fax : +91-20-24381004

Web : www.cwprs.gov.in

GOVERNMENT OF KERALA

Abstract

LSGD - Prohibition of dumping of waste/garbage and draining of sewage into all the canals under Integrated Urban Regeneration & Water Transport System (IURWTS) Project in Ernakulam District- Orders issued

LOCAL SELF GOVERNMENT (DC) DEPARTMENT

G.O.(Rt)No.823/2020/LSGD Dated,Thiruvananthapuram, 04/05/2020

Read
1. Order of Hon'ble High Court dated 18.10.2019 in WP(C)No.23911/2018
2. G.O(Rt) No. 2466/2019/LSGD dated 06.11.2019
3. Letter No KMRL/IURWTS/GoK/Corres/24-2020 dated 20.02.2020 from the Managing Director, Kochi Metro Rail Limited.

ORDER

As per G.O. read as 2nd paper above Government have prohibited dumping of waste and draining of sewage in to Thevara - Perandoor canal in Kochi, in compliance with the Order of Hon'ble High Court read as 1st paper above.

2) As Kochi Metro Rail Limited (KMRL) has initiated the task of regenerating 5 important canals in Kochi namely, Thevara-Perandoor canal, Thevara canal, Market canal, Edappally canal & Chilavanoor thodu under Integrated Urban Regeneration & Water Transport System (IURWTS) project (Blue Raphsody), the M.D, KMRL as per letter read as 3rd paper above has requested to extend the prohibitory ban on dumping of waste /garbage to all other canals under IURWTS Project in

Ernakulam District.

3) Government have examined the matter in detail and the following orders are issued:-

i. Dumping of all type of waste / garbage and draining of sewage to all other canals under Integrated Urban Regeneration & Water Transport System (IURWTS) project viz. Thevara canal, Market canal, Edappally canal and Chilavanoor thodu is hereby prohibited.
ii. Such actions are liable for prosecution under the relevant sections of Kerala Panchayat Raj Act 1994, Kerala Municipality Act 1994, Kerala Irrigation and Water Conservation (Amendment) Act 2018, Police Act as also the other provisions of Indian Penal Code and such other applicable Statutes, rules and Regulations.
iii. The citizens shall not indulge in the dumping of waste/garbage and filth into Thevara canal, Market canal, Edappally canal & Chilavanoor thodu and also that no sewage or human waste is drained into these canals so as to endanger the lives of fellow citizens.
iv. The Secretary, Kochi Municipal Corporation shall publish this order in Newspapers (both English & Malayalam) having vide circulation in Ernakulam District.
v. The Distict Collector, Ernakulam is authorised to issue detailed instructions to citizens not to indulge in the dumping of waste/garbage and filth and draining of sewage, human waste etc into these canals quoting the relevant provisions of applicable laws, Statutes and Regulations.

By order of the Governor)
BISHWANATH SINHA IAS
PRINCIPAL SECRETARY

To:

The Hon'ble Mayor, Kochi Municipal Corporation (With C/L)
The Managing Director, Kochi Metro Rail Limited.
The Principal Accountant General (A&E) Kerala, Tvm
Accountant General (G&SSA/E&RSA) Kerala, Tvm
The District Collector, Ernakulam
The Member Secretary, Kerala State Pollution Control Board

The Managing Director, Kerala Water Authority
The Managing Director, Kochi Metro Rail Ltd
The Secretary, Kochi Municipal Corporation
The Director, Information & Public Relations Department (for vide publication)
The Executive Director, Information Kerala Mission
S/F
O/C

Forwarded /By order

Signature Not Verified
Digitally signed by SMITHA B CHANDRA
Date: 2020.05.06 12:04:50 IST
Reason: Approved

Section Officer

KOCHI METRO RAIL LIMITED

APPENDIX-1

MILU

AFFIDAVIT

This is to certify that:-, **Sri. Ajith A, Additional General Manager, M/s Kochi Metro Rail Ltd** in Kochi Municipal Corporation of Ernakulam District hereby solemnly state as follows:

1. "No expansion /modernization activity has been implemented in violation of the provision of EIA notification".

2. I hereby give undertaking that the data and information given in the application, enclosures and other documents are true to the best of my knowledge and belief and I am aware that if any part of the data and information submitted is found to be false or misleading at any stage, the project will be rejected and clearance given, if any to the Project will be revoked at our risk and cost.

3. I hereby also submit this undertaking as part of the EIA Report, owning the contents (information and data) of the EIA Report".

4. "There is no litigation pending against the project and/or land in which the project is proposed to be set up (Project: **Integrated Urban Regeneration and Water Transport System**, Owner: **Govt. of Kerala**) and that for any such litigation whatsoever, the sole responsibility will be borne by the Project Proponent."

5. No violation of provisions of EIA Notification Date: 14.09.2006, and amendments made thereafter, circulars and O.M. issued their under.

22/01/2021.

Date: **22.01.2021**

Place: **Kochi**

Ajith. A

Additional General Manager

Kochi Metro Rail Limited

QUALITY COUNCIL OF INDIA
Creating an Ecosystem for Quality

National Accreditation Board for Education and Training

Certificate of Accreditation

WAPCOS Limited, Gurugram

Plot-76-C, Sector-18, Gurugram - 122015, Haryana

*The organization is accredited as **Category-A** under the QCI-NABET Scheme for Accreditation of EIA Consultant Organization, Version 3: for preparing EIA-EMP reports in the following Sectors –*

S. No	Sector Description	Sector (as per) NABET	MoEFCC	Cat.
1	Mining of minerals including opencast / underground mining	1	1 (a) (i)	A
2	Offshore and onshore oil and gas exploration, development & production	2	1 (b)	A
3	River Valley projects	3	1 (c)	A
4	Thermal power plants	4	1 (d)	A
5	Oil & gas transportation pipeline (crude and refinery/ petrochemical products), passing through national parks/ sanctuaries/coral reefs / ecologically sensitive areas including LNG terminal	27	6 (a)	A
6	Airports	29	7(a)	A
7	Industrial estates/ parks/ complexes/areas, export processing Zones (EPZs), Special Economic Zones (SEZs), Biotech Parks, Leather Complexes	31	7 (c)	A
8	Ports, harbours, break waters and dredging	33	7 (e)	A
9	Highways	34	7 (f)	A
10	Aerial ropeways	35	7 (g)	A
11	Building and construction projects	38	8 (a)	B

Note: Names of approved EIA Coordinators and Functional Area Experts are mentioned in RAAC minutes dated Dec 03, 2021 posted on QCI-NABET website.

The Accreditation shall remain in force subject to continued compliance to the terms and conditions mentioned in QCI-NABET's letter of accreditation bearing no. QCI/NABET/ENV/ACO/21/2181 dated Dec 15, 2021. The accreditation needs to be renewed before the expiry date by WAPCOS Limited, Gurugram following due process of assessment.

Sr. Director, NABET Dated: Dec 15, 2021	Certificate No. NABET/EIA/2124/RA 0222	Valid up to April 09, 2024

For the updated List of Accredited EIA Consultant Organizations with approved Sectors please refer to QCI-NABET website.

Appendix-5

KEIL Analysis report

KERALA ENVIRO INFRASTRUCTURE LTD.- LABORATORY

KEIL
Inside FACT -CD Campus, Ambalamedu, Kochi - 682 303
Ph: 0484 2722141, 2722241, 2722341, E-mail: keillaboratory@gmail.com CIN:U24129KL2005PLC017973

'A' GRADE LABORATORY APPROVED BY KERALA STATE POLLUTION CONTROL BOARD

CONCENTRATION LIMIT/CRITERIA FOR ACCEPTANCE OF HAZARDOUS WASTE FOR DIRECT DISPOSAL AT SECURED LANDFILL

Report No: KEIL/QA/HW/2020/122 **Date: 14.10.2020**

Client Name & Address	Sample Code	**3071**
The Team Leader, Antea Group, Palarivattom - 682025	Sample Name	Sludge (Chilavannoor - C2)
	Sample Appearance	Black coloured sludge
	Sample Received on	09.10.2020
	Analysis commenced on	10.10.2020
	Analysis completed on	13.10.2020

Sl. NO.	Parameters Tested	Result	Unit	Test Method (USEPA,SW-846)	Prescribed Limit
Sample as such					
1	pH at 29.4°C	7.21	-	M-9041& 9045	4-12
2	PFLT Test	Pass	-	M-9095	Pass
3	Loss on Drying at 105°C	24.72	%/wt.	M-1010&1020	-
4	Loss on ignition of the dry residue at 550^{0}C	5.7	%/wt.	M-1010&1020	< 20%/wt (for non biodegradable) & < 5 %/wt (for biodegradable)
5	Ash content of the dry residue at 800^{0}C	92.41	%/wt.	-	-
6	Calorific Value	129.58	kcal/kg	IS:1350	< 2500 kcal/kg
Leachate Quality Based on Water Leachate Test:					
1	Hexavalent Chromium	BLQ	mg/L	APHA:3500 Cr-B	< 0.5 mg/L
2	Nickel	BLQ	mg/L	IS:3025 Part 54	< 3 mg/L
3	Zinc	BLQ	mg/L	IS:3025 Part 49	< 10 mg/L
4	Copper	BLQ	mg/L	IS:3025 Part 42	< 10 mg/L
5	Lead	BLQ	mg/L	IS:3025 Part 47	< 2 mg/L
6	Cadmium	BLQ	mg/L	IS:3025 Part 41	< 0.2 mg/L
7	Manganese	BLQ	mg/L	APHA:3111B	-

Result: Sample is suitable for direct disposal in the secured landfill of KEIL.

Sample submitted by customer BLQ – Below Limit Of Quantitation. mg/L = ppm.	The results are related only to the samples submitted for analysis and should not be used for advertisement, evidence or litigation. This certificate shall not be reproduced partially or fully without the approval of the laboratory.	FOR AND ON BEHALF OF KERALA ENVIRO INFRASTRUCTURE LTD - LABORATORY AUTHORISED SIGNATORY

KERALA ENVIRO INFRASTRUCTURE LTD. AMBALAMEDU 682 303 T.S.D.F. PROJECT

KEIL/QA/TR
Issue No: 01, Issue Date: 04.03.2020, Amendment No.:00, Amendment Date: Nil

M. JAYADEVAN
Sr. MANAGER (QA)
KEIL - LABORATORY
Ambalamedu - 682 303

KEIL
KERALA ENVIRO INFRASTRUCTURE LTD.- LABORATORY
Inside FACT -CD Campus, Ambalamedu, Kochi - 682 303
Ph: 0484 2722141, 2722241, 2722341, E-mail: keillaboratory@gmail.com CIN:U24129KL2005PLC017973

'A' GRADE LABORATORY APPROVED BY KERALA STATE POLLUTION CONTROL BOARD

CONCENTRATION LIMIT/CRITERIA FOR ACCEPTANCE OF HAZARDOUS WASTE FOR DIRECT DISPOSAL AT SECURED LANDFILL

Report No: KEIL/QA/HW/2020/123 **Date: 12.10.2020**

Client Name & Address		
The Team Leader, **Antea Group,** **Palarivattom - 682025**	Sample Code	**3072**
	Sample Name	Sludge (Chilavannor – C3)
	Sample Appearance	Black coloured sludge
	Sample Received on	09.10.2020
	Analysis commenced on	09.10.2020
	Analysis completed on	12.10.2020

Sl. NO.	Parameters Tested	Result	Unit	Test Method (USEPA,SW-846)	Prescribed Limit
Sample as such					
1	pH at 30.1°C	7.18	-	M-9041& 9045	4-12
2	PFLT Test	Pass	-	M-9095	Pass
3	Loss on Drying at 105°C	20.35	%/wt.	M-1010&1020	-
4	Loss on ignition of the dry residue at 550°C	18.08	%/wt.	M-1010&1020	< 20%/wt (for non biodegradable) & < 5 %/wt (for biodegradable)
5	Ash content of the dry residue at 800°C	77.90	%/wt.	-	-
6	Calorific Value	390.60	kcal/kg	IS:1350	< 2500 kcal/kg
Leachate Quality Based on Water Leachate Test:					
1	Hexavalent Chromium	BLQ	mg/L	APHA:3500 Cr-B	< 0.5 mg/L
2	Nickel	BLQ	mg/L	IS:3025 Part 54	< 3 mg/L
3	Zinc	BLQ	mg/L	IS:3025 Part 49	< 10 mg/L
4	Copper	BLQ	mg/L	IS:3025 Part 42	< 10 mg/L
5	Lead	BLQ	mg/L	IS:3025 Part 47	< 2 mg/L
6	Cadmium	BLQ	mg/L	IS:3025 Part 41	< 0.2 mg/L
7	Manganese	BLQ	mg/L	APHA:3111B	-

Result: Sample is suitable for direct disposal in the secured landfill of KEIL.

Sample submitted by customer BLQ – Below Limit Of Quantitation. mg/L = ppm.	The results are related only to the samples submitted for analysis and should not be used for advertisement, evidence or litigation. This certificate shall not be reproduced partially or fully, without the approval of the laboratory.	FOR AND ON BEHALF OF KERALA ENVIRO INFRASTRUCTURE LTD - LABORATORY AUTHORISED SIGNATORY

KEIL/QA/TR

Issue No: 01, Issue Date: 04.03.2020, Amendment No.:00, Amendment Date: Nil

M. JAYADEVAN
Sr. MANAGER (QA)
KEIL - LABORATORY
Ambalamedu - 682 303

KEIL
KERALA ENVIRO INFRASTRUCTURE LTD.- LABORATORY
Inside FACT -CD Campus, Ambalamedu, Kochi - 682 303
Ph: 0484 2722141, 2722241, 2722341, E-mail: keillaboratory@gmail.com CIN:U24129KL2005PLC017973

'A' GRADE LABORATORY APPROVED BY KERALA STATE POLLUTION CONTROL BOARD

CONCENTRATION LIMIT/CRITERIA FOR ACCEPTANCE OF HAZARDOUS WASTE FOR DIRECT DISPOSAL AT SECURED LANDFILL

Report No: KEIL/QA/HW/2020/124 **Date: 12.10.2020**

Client Name & Address	Sample Code	**3073**
The Team Leader, Antea Group, Palarivattom – 682025	Sample Name	Edappally –E1
	Sample Appearance	Black coloured sludge
	Sample Received on	09.10.2020
	Analysis commenced on	10.10.2020
	Analysis completed on	12.10.2020

Sl. NO.	Parameters Tested	Result	Unit	Test Method (USEPA,SW-846)	Prescribed Limit
Sample as such					
1	pH at 26.7°C	7.12	-	M-9041& 9045	4-12
2	PFLT Test	Pass	-	M-9095	Pass
3	Loss on Drying at 105°C	28.86	%/wt.	M-1010&1020	-
4	Loss on ignition of the dry residue at 550°C	16.43	%/wt.	M-1010&1020	< 20%/wt (for non biodegradable) & < 5 %/wt (for biodegradable)
5	Ash content of the dry residue at 800°C	81.41	%/wt.	-	-
6	Calorific Value	550.06	kcal/kg	IS:1350	< 2500 kcal/kg
Leachate Quality Based on Water Leachate Test:					
1	Hexavalent Chromium	BLQ	mg/L	APHA:3500 Cr-B	< 0.5 mg/L
2	Nickel	BLQ	mg/L	IS:3025 Part 54	< 3 mg/L
3	Zinc	BLQ	mg/L	IS:3025 Part 49	< 10 mg/L
4	Copper	BLQ	mg/L	IS:3025 Part 42	< 10 mg/L
5	Lead	BLQ	mg/L	IS:3025 Part 47	< 2 mg/L
6	Cadmium	BLQ	mg/L	IS:3025 Part 41	< 0.2 mg/L
7	Manganese	BLQ	mg/L	APHA:3111B	-

Result: Sample is suitable for direct disposal in the secured landfill of KEIL.

Sample submitted by customer BLQ – Below Limit Of Quantitation. mg/L = ppm.	The results are related only to the samples submitted for analysis and should not be used for advertisement, evidence or litigation. This certificate shall not be reproduced partially or fully without the approval of the laboratory.	FOR AND ON BEHALF OF KERALA ENVIRO INFRASTRUCTURE LTD - LABORATORY AUTHORISED SIGNATORY M. JAYADEVAN Sr. MANAGER (QA) KEIL - LABORATORY Ambalamedu - 682 303

KEIL
KERALA ENVIRO INFRASTRUCTURE LTD.- LABORATORY
Inside FACT -CD Campus, Ambalamedu, Kochi - 682 303
Ph: 0484 2722141, 2722241, 2722341, E-mail: keillaboratory@gmail.com CIN:U24129KL2005PLC017973

'A' GRADE LABORATORY APPROVED BY KERALA STATE POLLUTION CONTROL BOARD

CONCENTRATION LIMIT/CRITERIA FOR ACCEPTANCE OF HAZARDOUS WASTE FOR DIRECT DISPOSAL AT SECURED LANDFILL

Report No: KEIL/QA/HW/2020/125 **Date: 14.10.2020**

Client Name & Address	Sample Code	**3074**
The Team Leader, **Antea Group,** **Palarivattom - 682025**	Sample Name	Sludge (Edappalli-E3)
	Sample Appearance	Black coloured sludge
	Sample Received on	09.10.2020
	Analysis commenced on	09.10.2020
	Analysis completed on	14.10.2020

Sl. NO.	Parameters Tested	Result	Unit	Test Method (USEPA,SW-846)	Prescribed Limit
Sample as such					
1	pH at 30°C	7.2	-	M-9041& 9045	4-12
2	PFLT Test	Pass	-	M-9095	Pass
3	Loss on Drying at 105°C	26.31	%/wt.	M-1010&1020	-
4	Loss on ignition of the dry residue at 550^0C	14.97	%/wt.	M-1010&1020	< 20%/wt (for non biodegradable) & < 5 %/wt (for biodegradable)
5	Ash content of the dry residue at 800^0C	84.78	%/wt.	-	-
6	Calorific Value	302.9	kcal/kg	IS:1350	< 2500 kcal/kg
Leachate Quality Based on Water Leachate Test:					
1	Hexavalent Chromium	BLQ	mg/L	APHA:3500 Cr-B	< 0.5 mg/L
2	Nickel	BLQ	mg/L	IS:3025 Part 54	< 3 mg/L
3	Zinc	BLQ	mg/L	IS:3025 Part 49	< 10 mg/L
4	Copper	BLQ	mg/L	IS:3025 Part 42	< 10 mg/L
5	Lead	BLQ	mg/L	IS:3025 Part 47	< 2 mg/L
6	Cadmium	BLQ	mg/L	IS:3025 Part 41	< 0.2 mg/L
7	Manganese	BLQ	mg/L	APHA:3111B	-

Result: Sample is suitable for direct disposal in the secured landfill of KEIL.

Sample submitted by customer BLQ – Below Limit Of Quantitation. mg/L = ppm.	The results are related only to the samples submitted for analysis and should not be used for advertisement, evidence or litigation. This certificate shall not be reproduced partially or fully without the approval of the laboratory.	FOR AND ON BEHALF OF KERALA ENVIRO INFRASTRUCTURE LTD - LABORATORY AUTHORISED SIGNATORY

KERALA ENVIRO INFRASTRUCTURE LTD. LABORATORY AMBALAMEDU 682 303 * T.S.D.F. PROJECT

M. JAYADEVAN
Sr. MANAGER (QA)
KEIL - LABORATORY
Ambalamedu - 682 303

KEIL

KERALA ENVIRO INFRASTRUCTURE LTD.- LABORATORY

Inside FACT -CD Campus, Ambalamedu, Kochi - 682 303
Ph: 0484 2722141, 2722241, 2722341, E-mail: keillaboratory@gmail.com CIN:U24129KL2005PLC017973

'A' GRADE LABORATORY APPROVED BY KERALA STATE POLLUTION CONTROL BOARD

CONCENTRATION LIMIT/CRITERIA FOR ACCEPTANCE OF HAZARDOUS WASTE FOR DIRECT DISPOSAL AT SECURED LANDFILL

Report No: KEIL/QA/HW/2020/126 **Date: 13.10.2020**

Client Name & Address	Sample Code	3075
The Team Leader, Antea Group, Palarivattom - 682025	Sample Name	Sludge (Perandoor P1)
	Sample Appearance	Black coloured sludge
	Sample Received on	09.10.2020
	Analysis commenced on	10.10.2020
	Analysis completed on	12.10.2020

Sl. NO.	Parameters Tested	Result	Unit	Test Method (USEPA,SW-846)	Prescribed Limit
Sample as such					
1	pH at 29.3°C	7.33	-	M-9041& 9045	4-12
2	PFLT Test	Pass	-	M-9095	Pass
3	Loss on Drying at 105°C	25.71	%/wt.	M-1010&1020	-
4	Loss on ignition of the dry residue at 550^{0}C	11.43	%/wt.	M-1010&1020	< 20%/wt (for non biodegradable) & < 5 %/wt (for biodegradable)
5	Ash content of the dry residue at 800^{0}C	83.19	%/wt.	-	-
6	Calorific Value	1142.34	kcal/kg	IS:1350	< 2500 kcal/kg
Leachate Quality Based on Water Leachate Test:					
1	Hexavalent Chromium	BLQ	mg/L	APHA:3500 Cr-B	< 0.5 mg/L
2	Nickel	BLQ	mg/L	IS:3025 Part 54	< 3 mg/L
3	Zinc	BLQ	mg/L	IS:3025 Part 49	< 10 mg/L
4	Copper	BLQ	mg/L	IS:3025 Part 42	< 10 mg/L
5	Lead	BLQ	mg/L	IS:3025 Part 47	< 2 mg/L
6	Cadmium	BLQ	mg/L	IS:3025 Part 41	< 0.2 mg/L
7	Manganese	BLQ	mg/L	APHA:3111B	-

Result: Sample is suitable for direct disposal in the secured landfill of KEIL.

Sample submitted by customer BLQ – Below Limit Of Quantitation. mg/L = ppm.	The results are related only to the samples submitted for analysis and should not be used for advertisement, evidence or litigation. This certificate shall not be reproduced partially or fully, without the approval of the laboratory.	FOR AND ON BEHALF OF KERALA ENVIRO INFRASTRUCTURE LTD - LABORATORY AUTHORISED SIGNATORY

KERALA ENVIRO INFRASTRUCTURE LTD. LANDFILL PROJECT 682 303

M. JAYADEVAN
Sr. MANAGER (QA)
KEIL - LABORATORY
Ambalamedu - 682 303

KEIL
KERALA ENVIRO INFRASTRUCTURE LTD.- LABORATORY
Inside FACT -CD Campus, Ambalamedu, Kochi - 682 303
Ph: 0484 2722141, 2722241, 2722341, E-mail: keillaboratory@gmail.com CIN:U24129KL2005PLC017973

'A' GRADE LABORATORY APPROVED BY KERALA STATE POLLUTION CONTROL BOARD

CONCENTRATION LIMIT/CRITERIA FOR ACCEPTANCE OF HAZARDOUS WASTE FOR DIRECT DISPOSAL AT SECURED LANDFILL

Report No: KEIL/QA/HW/2020/127 **Date: 14.10.2020**

Client Name & Address	Sample Code	3076
The Team Leader, Antea Group, Palarivattom - 682025	Sample Name	Sludge (Perandoor-P3)
	Sample Appearance	Black coloured sludge
	Sample Received on	09.10.2020
	Analysis commenced on	09.10.2020
	Analysis completed on	14.10.2020

Sl. NO.	Parameters Tested	Result	Unit	Test Method (USEPA,SW-846)	Prescribed Limit
Sample as such					
1	pH at 30°C	7.9	-	M-9041& 9045	4-12
2	PFLT Test	Pass	-	M-9095	Pass
3	Loss on Drying at 105°C	32.4	%/wt.	M-1010&1020	-
4	Loss on ignition of the dry residue at 550°C	14.88	%/wt.	M-1010&1020	< 20%/wt (for non biodegradable) & < 5 %/wt (for biodegradable)
5	Ash content of the dry residue at 800°C	82.16	%/wt.	-	-
6	Calorific Value	109.92	kcal/kg	IS:1350	< 2500 kcal/kg
Leachate Quality Based on Water Leachate Test:					
1	Hexavalent Chromium	BLQ	mg/L	APHA:3500 Cr-B	< 0.5 mg/L
2	Nickel	BLQ	mg/L	IS:3025 Part 54	< 3 mg/L
3	Zinc	BLQ	mg/L	IS:3025 Part 49	< 10 mg/L
4	Copper	BLQ	mg/L	IS:3025 Part 42	< 10 mg/L
5	Lead	BLQ	mg/L	IS:3025 Part 47	< 2 mg/L
6	Cadmium	BLQ	mg/L	IS:3025 Part 41	< 0.2 mg/L
7	Manganese	BLQ	mg/L	APHA:3111B	-

Result: Sample is suitable for direct disposal in the secured landfill of KEIL.

Sample submitted by customer BLQ – Below Limit Of Quantitation. mg/L = ppm.	The results are related only to the samples submitted for analysis and should not be used for advertisement, evidence or litigation. This certificate shall not be reproduced partially or fully, without the approval of the laboratory.	FOR AND ON BEHALF OF KERALA ENVIRO INFRASTRUCTURE LTD - LABORATORY AUTHORISED SIGNATORY

KERALA ENVIRO INFRASTRUCTURE LTD. LAB T.S.D.F. PROJECT

M. JAYADEVAN
Sr. MANAGER (QA)
KEIL - LABORATORY
Ambalamedu - 682 303

APPENDIX -6

KERALA STATE POLLUTION CONTROL BOARD
കേരള സംസ്ഥാന മലിനീകരണ നിയന്ത്രണ ബോർഡ്
Pattom P.O., Thiruvananthapuram – 695 004 പട്ടം പി.ഒ., തിരുവനന്തപുരം – 695 004
Phone: 0471- 2312910, 2318153, 54, 55 FAX: 0471 – 2318134, 2318152
E-mail:ms.kspcb@gov.in Web: www.keralapcb.nic.in

PCB/HO/PH-EKM/IURWTS/2021 Date: 12/02/2021

NOTICE

(As per Notification No S.O. 1533 dated 14.09.2006 of the Ministry of Environment & Forests, Government of India)

Kochi Metro Rail Limited (KMRL) have been entrusted the job of special purpose vehicle (SPV) for the implementation of the project 'Integrated Urban Regeneration and Water Transport System (IURWTS)' in Kochi by the government of Kerala. The proposed project envisages the development of the Edappally canal (11.23 km), Thevara- Perandoor canal(9.8 km), Chilavanoor canal (11.15 km), Thevara canal(1.405 km) and Market canal(0.664 km) in Kochi. They have submitted application for environmental clearance to the Ministry of Environmental, Forests and Climate Change and also requested the Board to conduct public hearing. Environmental Public hearing is to be conducted in Ernakulam district in this regard. The summary of details of the proposed project and public hearing are as follows.

Project Proponent	The Additional General Manager-(Civil) Kochi Metro Rail Limited (KMRL) JLM Metro Station,4th floor Kaloor,Erankulam-682017
Location & Activity	Kochi Corporation Kalamassery Municipality Thrikkakkara Municipally Thripunithura Municipality Dredging, Boat Jetties, Sanitary Sewer line & STPs etc.
EIA Consultants	WAPCOS Limited (A Government of India Undertaking) 76 c, Sector 18, Gurgaon -122015, Haryana
Project Cost	168.00 Crores
Environmental issues & likely sources of pollution	Impacts on land, air, noise, water and biological environment
Date, time & venue of public hearing	**16/03/2021at 11:00 am, Collectorate Conference Hall Kakkanad, Ernakulam District ,Kerala**

The local persons who have apprehension about the project can express their concerns orally or in writing during the hearing. They can also attend the hearing on 16/03/2021 from 11:00 am to 03:00 pm either through their mobile phone (by installing Microsoft teams app) or through computer (by visiting teams.microsoft.com)

Meeting Link: https://kochimetro.org/ph-iurwts-project/

The details regarding the project are available for reference at the following offices.

1. District Collectorate, Ernakulam
2. District Industries Centre,Ernakulam
3. District Panchayat Office,Ernakulam
4. Kochi Corporation, Ernakulam
5. Kalamassery Municipality,Ernakulam
6. Thrikkakkara Municipally, Ernakulam
7. Thripunithura Municipality, Ernakulam
8. State Environment Impact Assessment Authority, KSRTC Bus terminal Complex,4th Floor, Thampanoor, Thiruvananthapuram-695001
9. Directorate of Environment & Climate Change, KSRTC Bus terminal Complex, 4th Floor, Thampanoor, Thiruvananthapuram-695001
10. Directorate of Science & Technology, Sasthra Bhavan, Pattom, Thiruvananthapuram
11. Kerala State Pollution Control Board, District Office -1, Ernakulam
12. Kerala State Pollution Control Board, Regional Office, Ernakulam
13. Kerala State Pollution Control Board, Head Office, Pattom, Thiruvananthapuram-695 004

The documents are also available in the Board's website **www.keralapcb.nic.in.**

All concerned persons are welcome to communicate comments on environmental aspects of the project till the date of public hearing to **Sri. Baiju M.A, Chief Environmental Engineer, Regional Office, Kerala State Pollution Control Board, Gandhi Nagar, Ernakulam-682020 (Ph:9447975708, email: pcbdo1publichearing@gmail.com)**

This notice is published in concurrence with the District Collector, Ernakulam

For and on behalf of the
KERALA STATE POLLUTION CONTROL BOARD
Sd/-
MEMBER SECRETARY

KERALA STATE POLLUTION CONTROL BOARD
കേരള സംസ്ഥാന മലിനീകരണ നിയന്ത്രണ ബോർഡ്
Pattom P.O., Thiruvananthapuram – 695 004 പട്ടം പി.ഒ., തിരുവനന്തപുരം – 695 004
Phone: 0471- 2312910, 2318153, 54, 55 FAX: 0471 – 2318134, 2318152
E-mail:ms.kspcb@gov.in Web: www.keralapcb.nic.in

പിസിബി/എച്ച്ഒ/പിഎച്ച്-ഇകെഎം/ഐയുആർഡബ്ല്യുറ്റിഎസ്/2021 തീയതി: 12/02/2021

അറിയിപ്പ്

(കേന്ദ്ര പരിസ്ഥിതി, വനം വകുപ്പ് മന്ത്രാലയത്തിന്റെ 14-09-2006-ലെ എസ്.ഒ നമ്പർ 1533 വിജ്ഞാപന പ്രകാരം പ്രസിദ്ധപ്പെടുത്തുന്നത്.)

കേരളസർക്കാരിന്റെ (IURWTS) 'സംയോജിത നഗര പുനരുജ്ജീവന ജല ഗതാഗത പദ്ധതി' ആവിഷ്കരിക്കാൻ കൊച്ചി മെട്രോ റെയിൽ ലിമിറ്റഡിനെ പ്രത്യേക ഉദ്ദ്യേശവാഹനം (എസ്പിവി) ആയി ജോലി ഏൽപ്പിച്ചിരി ക്കുന്നു. ഇടപ്പള്ളി കനാൽ (11.23 കിലോമീറ്റർ), ചിലവനൂർ കനാൽ (11.15 കിലോമീറ്റർ), തേവര-പേരണ്ടൂർ കനാൽ (9.8 കിലോമീറ്റർ) തേവര കനാൽ (1.405 കിലോമീറ്റർ) മാർക്കറ്റ് കനാൽ (0.664 കിലോമീറ്റർ) എന്നീ അഞ്ച് പ്രധാന ഡ്രെയിനേജ് കനാലുകളിലാണ് ടി പദ്ധതി കേന്ദ്രീകരിക്കുന്നത്. അവർ കേന്ദ്ര പരിസ്ഥിതി, വനം, കാലാവസ്ഥവ്യതിയാന മന്ത്രാലയത്തിന്റെ പാരിസ്ഥിതിക അനുമതി ലഭിക്കുന്നതിനായി അപേക്ഷ സമർപ്പിച്ചിട്ടുണ്ട്. ഇതുമായി ബന്ധപ്പെട്ട് പാരിസ്ഥിതിക അനുമതി ലഭിക്കുന്നതിലേക്കായി പബ്ലിക് ഹിയറിംഗ് നടത്തുവാൻ കേരളസംസ്ഥാന മലിനീകരണ നിയന്ത്രണ ബോർഡിനോട് അഭ്യർത്ഥിച്ചിരിക്കുന്നു. ഇതുമായി ബന്ധപ്പെട്ട് എറണാകുളം ജില്ലയിൽ വച്ച് പബ്ലിക് ഹിയറിംഗ് നടത്തുന്നതാണ്. പ്രസ്തുത പദ്ധതിയെയും പബ്ലിക് ഹിയറിംഗിനെയും സംബന്ധിച്ച വിവരങ്ങൾ ചുവടെ ചേർക്കുന്നു.

അപേക്ഷകൻ	അഡീഷണൽ ജനറൽ മാനേജർ (സിവിൽ) കൊച്ചി മെട്രോ റെയിൽ ലിമിറ്റഡ് (KMRL) ജെഎൽഎൻ മെട്രോ സ്റ്റേഷൻ, നാലാം നില, കലൂർ, എറണാകുളം – 682017
പദ്ധതി പ്രദേശവും മുഖ്യ പ്രവർത്തനങ്ങളും	കൊച്ചി കോർപ്പറേഷൻ, കളമശ്ശേരി മുനിസിപ്പാലിറ്റി, തൃക്കാക്കര മുനിസിപ്പാലിറ്റി, തൃപ്പൂണ്ണിത്തുറ മുനിസിപ്പാലിറ്റി ഡ്രഡ്ജിംഗ്, ജെട്ടിവികസനം, സാനിറ്ററി സീവർ ലൈൻ & എസ്റ്റിപികൾ തുടങ്ങിയവ
ഇ.ഐ.എ കൺസൾട്ടന്റ്	വാപ്കോസ് ലിമിറ്റഡ് 76 സി, സെക്ടർ 18, ഗുഡ്ഗാവ് – 122015 ഹരിയാന, ഫോൺ: 91-124-2397396
പദ്ധതി മൂലധനം	168 കോടി
പരിസ്ഥിതി പ്രശ്നങ്ങളും മലിനീകരണ സാധ്യതകളും	ഭൂതലം, വായു, ജലം, ശബ്ദം, ജൈവ പരിസ്ഥിതിയിലുണ്ടാകുന്ന ആഘാതം.
പബ്ലിക് ഹിയറിംഗിന്റെ തീയതി, സമയം, സ്ഥലം	**16.03.2021 രാവിലെ 11.00 മണി** **കളക്ടറേറ്റ് കോൺഫൻസ് ഹാൾ, കാക്കനാട്, എറണാകുളം**

പദ്ധതിയെക്കുറിച്ച് ആശങ്കയുള്ള സമീപപ്രദേശവാസികൾക്ക് അവരുടെ അഭിപ്രായങ്ങൾ നേരിട്ട് വാക്കാലോ രേഖാമൂലമോ പബ്ലിക് ഹിയറിംഗ് സമയത്ത് അവതരിപ്പിക്കാവുന്നതാണ്. കൂടാതെ 16/03/2021-ാം തീയതി രാവിലെ 11.00 മണിമുതൽ മുതൽ വൈകിട്ട് 3.00 മണിവരെ (Microsoft teams ആപ്ലിക്കേഷൻ ഉള്ള) മൊബൈൽ ഫോൺ അല്ലെങ്കിൽ കമ്പ്യൂട്ടർ (teams.microsoft.com) എന്ന വെബ്സൈറ്റ് മുഖേനയും ഹിയറിംഗിൽ പങ്കെടുക്കാവുന്നതാണ്.

മീറ്റിംഗ് ലിങ്ക്: https://kochimetro.org/ph-iurwts-project/

ഈ പദ്ധതി സംബന്ധിച്ച വിവരങ്ങൾ താഴെ പറയുന്ന ഓഫീസുകളിൽ അറിവിലേയ്ക്കും പരിശോധനയ്ക്കും ലഭ്യമാണ്.

1) ജില്ലാ കളക്ടറുടെ ഓഫീസ്, എറണാകുളം
2) ജില്ലാ വ്യവസായ കേന്ദ്രം, എറണാകുളം
3) ജില്ലാ പഞ്ചായത്ത് ഓഫീസ്, എറണാകുളം
4) കൊച്ചി കോർപ്പറേഷൻ, എറണാകുളം.
5) തൃക്കാക്കര മുനിസിപ്പാലിറ്റി, എറണാകുളം.
6) തൃപ്പൂണിത്തുറ മുനിസിപ്പാലിറ്റി, എറണാകുളം.
7) കളമശ്ശേരി മുനിസിപ്പാലിറ്റി, എറണാകുളം.
8) സ്റ്റേറ്റ് എൻവയോൺമെന്റ് ഇംപാക്ട് അസ്സസ്സ്മെന്റ് അതോറിറ്റി, കെ.എസ്.ആർ.ടി.സി. ബസ് ടെർമിനൽ കോംപ്ലക്സ്, നാലാം നില, തമ്പാനൂർ, തിരുവനന്തപുരം – 695 001
9) പരിസ്ഥിതി-കാലാവസ്ഥ വ്യതിയാന ഡയറക്ടറേറ്റ്, കെ.എസ്.ആർ.ടി.സി. ബസ്ടെർമിനൽ കോംപ്ലക്സ്, നാലാം നില, തമ്പാനൂർ, തിരുവനന്തപുരം – 695 001
10) ശാസ്ത്ര-സാങ്കേതിക ഡയറക്ടറേറ്റ്, ശാസ്ത്ര ഭവൻ, പട്ടം, തിരുവനന്തപുരം
11) കേരള സംസ്ഥാന മലിനീകരണ നിയന്ത്രണ ബോർഡ്, ജില്ലാ ഓഫീസ് – 1, എറണാകുളം.
12) കേരള സംസ്ഥാന മലിനീകരണ നിയന്ത്രണ ബോർഡ്, മേഖലഓഫീസ്, എറണാകുളം.
13) കേരള സംസ്ഥാന മലിനീകരണ നിയന്ത്രണ ബോർഡ്, ഹെഡ്ഓഫീസ്, തിരുവനന്തപുരം – 695 004

ഈ പദ്ധതി സംബന്ധിച്ചുള്ള വിവരങ്ങൾ ബോർഡിന്റെ വെബ്സൈറ്റിൽ (www.keralapcb.nic.in) ലഭ്യമാണ്. പദ്ധതി സംബന്ധിച്ചുള്ള പരിസ്ഥിതി കാര്യങ്ങളിൽ പൊതു ജനങ്ങൾക്കുള്ള അഭിപ്രായങ്ങൾ പബ്ലിക് ഹിയറിംഗ് തീയതി വരെ താഴെ കാണുന്ന വിലാസത്തിൽ എഴുതി അറിയിക്കാവുന്നതാണ്.

ശ്രീ. ബൈജു എം. എ.,
ചീഫ് എൻവയൺമെന്റൽ എഞ്ചിനീയർ, മേഖലാ ഓഫീസ്,
കേരളസംസ്ഥാന മലിനീകരണ നിയന്ത്രണ ബോർഡ്, എറണാകുളം
ഫോൺ: 9447975708, email :pcbdo1publichearing@gmail.com

എറണാകുളം ജില്ലാ കളക്ടറുടെ സമ്മതപൂർവ്വം പ്രസിദ്ധീകരിക്കുന്ന നോട്ടീസ്
കേരള സംസ്ഥാന മലിനീകരണ നിയന്ത്രണ ബോർഡിനു വേണ്ടി,

ഒപ്പ് /-
മെമ്പർ സെക്രട്ടറി

APPENDIX-7

General: 0471- 2312910, 2318153, 2318154, 2318155 Chairman: 2318150 Member Secretary: 2318151
e-mail: ms.kspcb@gov.in, FAX: 2318152 web: www.keralapcb.nic.in

KERALA STATE POLLUTION CONTROL BOARD
കേരള സംസ്ഥാന മലിനീകരണ നിയന്ത്രണ ബോർഡ്
Pattom P.O., Thiruvananthapuram – 695 004
പട്ടം പി.ഒ., തിരുവനന്തപുരം - 695 004

PCB/HO/PH-EKM/IURWTS/2021 Date: 24.03.2021

From
The Member Secretary

To
The Director,
Ministry Of Environment,Forest and Climate Change
Indira Paryavaran Bhavan
Jorbagh Road,New Delhi-110003

Sub: Public hearing for the proposed 'Integrated Urban Regeneration and Water Transport System (IURWTS)' in Kochi by the Government of Kerala – reg.

Ref:
1. Letter no. KMRL/IURWTS/EIA/KSPCB/216-2021 dated 28/01/2021 received on 29/01/2021 from the Additional General Manager-(Civil), Kochi Metro Rail Limited
2. EIA notification Number. S.O.1533 dated 14/09/2006 & amendment thereafter
3. This office letter of even no. dated 30/01/2021
4. Public Hearing conducted on 16/03/2021 at 11.00 am at Collectorate Conference Hall,Kakkanad,Ernakulam

Sir/Madam,

The Additional General Manager-(Civil), Kochi Metro Rail Limited has requested the Board vide letter referred 1st to conduct public hearing for obtaining Environmental clearance for 'Integrated Urban Regeneration and Water Transport System (IURWTS)' in Kochi.The project proponent has submitted the draft EIA report and Environmental Management Plan along with Executive Summaries in English & Malayalam. Copies of draft EIA report and Environmental Management Plan along with Executive Summaries in English & Malayalam were made available to the concerned offices.

The notices (English & Malayalam) regarding the public hearing with details of the project were published on 13/02/2021 in Ernakulam edition of Mathrubhumi, Malayala Manorama and The New Indian Express.

The Public hearing in connection with the proposed project was conducted on **16/03/2021 at 11.00 a.m. at Collectorate Conference Hall, Kakkanad, Ernakulam** through physical and online mode. Proceedings of the public hearing is forwarded herewith for information and further necessary action.

Yours faithfully,

MEMBER SECRETARY

Encl:

1. Copy of letter referred (1) above
2. Notices in English and Malayalam
3. Minutes in English and Malayalam
4. Attendance list
5. Copy of Power Point Presentation
6. Representation submitted by the public
7. Audio/Video recordings of the public hearing

Copy to:

1. The Additional General Manager-(Civil),
   Kochi Metro Rail Limited,
   JLN Metro Station, 4th Floor,
   Kaloor, Ernakulam-682 017
   } with copy of proceedings
2. The Chief Environmental Engineer,
   Regional Office, Ernakulam
3. The Environmental Engineer,
   District Office-1, Ernakulam

കൊച്ചി മെട്രോ റെയിൽ ലിമിറ്റഡിന്റെ സംയോജിത നഗര പുനരുജ്ജീവന ജല ഗതാഗത പദ്ധതിക്കായുള്ള പാരിസ്ഥിതിക അനുമതി നൽകുന്നതുമായി ബന്ധപ്പെട്ട് 16.03.2021 തീയതിയിൽ എറണാകുളം കളക്ടറേറ്റ് കോൺഫറൻസ് ഹാളിൽ നടന്ന പൊതുതെളിവെടുപ്പിന്റെ മിനിറ്റ്സ്

എറണാകുളം ജില്ലയിലെ 5 കനാലുകൾ പുനരുജ്ജീവിപ്പിക്കുന്നതിനും, കനാൽ സംവിധാനങ്ങളിലൂടെ ഉൾനാടൻ ജലഗതാഗതം മെച്ചപ്പെടുത്തുക, റെയിൽ മെട്രോ, വാട്ടർ മെട്രോ എന്നിവയുടെ സംയോജനത്തോടെ ഒരു ഇന്റർ കണക്റ്റിവിറ്റി നടത്തുകയും കൂടാതെ കനാലുകളുടെ നവീകരണവും പുനസ്ഥാപനവും നഗര പുനരുജ്ജീവനവും അതുവഴി സംയോജിത നഗര പുനരുജ്ജീവന ജല ഗതാഗത പദ്ധതി നടപ്പിലാക്കുകയും ആണ് പദ്ധതിയുടെ ലക്ഷ്യം. EIA നോട്ടിഫിക്കേഷൻ പ്രകാരം പ്രസ്തുത പദ്ധതി Schedule No. 7E "A"-യിൽ ഉൾപ്പെടുന്നതിനാൽ പാരിസ്ഥിതിക അനുമതി ലഭിക്കുന്നതിനായി പബ്ലിക്ക് ഹീയറിഗ് നടത്തേണ്ടതുണ്ട്

ബഹു: ജില്ലാ കളക്ടറുമായി കൂടിയാലോചിച്ച് 16.03.2021 തീയ്യതിയിൽ പൊതുതെളിവെടുപ്പ് കളക്ടറേറ്റ് കോൺഫറൻസ് ഹാളിൽ നടത്തുവാൻ നിശ്ചയിക്കുകയും, 2021 ഫെബ്രുവരി 15 ന് പ്രമുഖ പ്രാദേശിക ദിനപത്രങ്ങളിലും, ദേശീയ ദിനപത്രങ്ങളിലും പൊതുതെളിവെടുപ്പിനെ സംമ്പന്ധിച്ച് വിശദാംശങ്ങൾ (സ്ഥലം, തീയ്യതി, സമയം എന്നിവ) പൊതുജനങ്ങളെ അറിയിച്ചു കൊണ്ടും, പദ്ധതിയെ കുറിച്ചുള്ള പൊതുജനാഭിപ്രായം ആരാഞ്ഞു കൊണ്ടും പത്രങ്ങളിൽ പരസ്യം നല്കുകയുണ്ടായി. ഹീയറിഗിൽ പങ്കെടുത്തു വരുടെ പേരുവിവരം **അനുബന്ധം–1** ആയി ഉൾപ്പെടുത്തുന്നു.

ബഹുമാനപ്പെട്ട എറണാകുളം ജില്ലാ ഡെവലപ്പ്മെന്റ് കമ്മീഷണർ ശ്രീമതി. അഫ്സാന പർവീൺ ഐ.എ.എസ് അവർകളുടെ അദ്ധ്യക്ഷതയിൽ പൊതുതെളിവെടുപ്പ് 16.03.2021 തീയതിൽ 11.00 മണിക്ക് ആരംഭിച്ചു. കേരള സംസ്ഥാന മലിനീകരണ നിയന്ത്രണ ബോർഡ്, എറണാകുളം മേഖല ചീഫ് എൻവയോൺമെന്റൽ എൻജിനീയർ ശ്രീ. എം.എ ബൈജു യോഗത്തിൽ സംബന്ധിക്കാനെത്തിയ എല്ലാവരെയും സ്വാഗതം ചെയ്തു. തുടർന്ന് ബഹുമാനപ്പെട്ട ജില്ലാ ഡെവലപ്പ്മെന്റ് കമ്മീഷ്ണർ

പദ്ധതിയെക്കുറിച്ചും, പബ്ലിക്ക് ഹിയറിംഗിനെക്കുറിച്ചുമുള്ള നടപടിക്രമങ്ങൾ വിശദീകരിച്ചു. ഹിയറിംഗിനായി ഫെബ്രുവരി 13-ാം തീയതി പത്രങ്ങളിൽ അറിയിപ്പ് നൽകിയിരുന്നതാണ് എന്നും EIA നോട്ടിഫിക്കേഷൻ പ്രകാരം പബ്ലിക്ക് ഹിയറിഗ് നടത്തുന്നതിനായി അപേക്ഷ സമർപ്പിച്ച തീയതി മുതൽ 45 ദിവസത്തിനകം നടപടിക്രമങ്ങൾ പൂർത്തീകരിച്ച് കേന്ദ്ര വനം, പരിസ്ഥിതി മന്ത്രാലയത്തിന് മിനിറ്റ്സ് സഹിതം സമർപ്പിക്കേണ്ടതാണെന്നും. ആയതിനാൽ മുൻ നിശ്ചയിച്ച പ്രകാരം ഹിയറിംഗ് നടത്തേണ്ടതുണ്ട് എന്നും ഹിയറിംഗിൽ പദ്ധതിയുമായി ബന്ധപ്പെട്ട പൊതുജനങ്ങളുടെ അഭിപ്രായങ്ങൾ, പരാതികൾ, നിർദ്ദേശങ്ങൾ എന്നിവ ക്രോഡീകരിച്ച് കേന്ദ്ര വനം, പരിസ്ഥിതി മന്ത്രാലയത്തിന് നൽകുക എന്ന നടപടി മാത്രമാണ് നടത്തുന്നതെന്നും യാതൊരുവിധ തീരുമാനങ്ങളും ഹിയറിംഗിൽ സ്വീകരിക്കുകയില്ലാത്തതിനാൽ ഇത് ബഹു. ഇലക്ഷൻ കമ്മീഷണറുടെ പെരുമാറ്റചട്ടങ്ങൾക്ക് വിരുദ്ധമാകില്ലെന്നും ബഹു.ജില്ലാ വികസന കമ്മീഷണർ അറിയിച്ചു. കൊച്ചി മെട്രോ പ്രതിനിധിയോട് പദ്ധതിയെക്കുറിച്ചുള്ള രൂപരേഖ അവതരിപ്പിക്കാൻ ബഹു. ജില്ലാ വികസന കമ്മീഷണർ അറിയിച്ചു. കെ.എം.ആർ.എൽ എൻവയോൺമെന്റൽ എക്സ്പേർട്ട് ശ്രീ. നിഷാദ് നാരായൺ പദ്ധതിയെ കുറിച്ചുള്ള Power Point Presentation നടത്തി. PPT **അനുബന്ധം-2** ആയി ഉൾപ്പെടുത്തുന്നു. തുടർന്ന് പരിസ്ഥിതി ആഘാതപഠനം സംബന്ധിച്ച് കെ.എം.ആർ.എൽ നിയോഗിച്ച കൺസൾട്ടന്റ് നടത്തിയ പഠനത്തിന്റെ വിശദവിവരങ്ങൾ വാപ്കോസ് ലിമിറ്റഡിന്റെ പ്രതിനിധി ശ്രീ. സ്റ്റീഫൻ ലിയോ അവതരിപ്പിച്ചു.

കൊച്ചി കോർപ്പറേഷൻ, തൃക്കാക്കര, തൃപ്പൂണിത്തുറ, കളമശ്ശേരി എന്നീ മുനിസിപ്പാലിറ്റികളിലൂടെ കടന്നു പേകുന്ന 5 കനാലുകൾ ഉൾപ്പെടുത്തിയാണ് ഈ പദ്ധതി നടപ്പിലാക്കുന്നത്. ഇടപ്പള്ളി കനാൽ (11.23 കി.മീ), ചിലവന്നൂർ കനാൽ (11.15 കി.മീ), തേവര പേരണ്ടൂർ കനാൽ (9.88 കി.മീ), തേവര കനാൽ (1.41 കി.മീ) മാർക്കറ്റ് കനാൽ (0.66 കി.മീ) എന്നീ കനാലുകളുടെ നവീകരണമാണ് പദ്ധതിയിൽ ഉൾപ്പെടുന്നത്. ആയിരത്തി അഞ്ഞൂറ്റി ഇരുപത്തിയെട്ട് കോടി രൂപയാണ് പദ്ധതിയുടെ ആകെ മൂലധനം. കനാൽ പുനരുജ്ജീവനം, വെള്ളപ്പൊക്ക നിവാരണം, പദ്ധതി പ്രദേശത്തിന്റെ പ്രാദേശികമായ വികസനം എന്നിവയാണ് പദ്ധതിയുടെ ലക്ഷ്യം. കനാൽ കയ്യേറ്റം ഒഴിപ്പിക്കുക, കനാലിനോടനുബന്ധിച്ചുള്ള ചേരിപ്രദേശങ്ങൾ നീക്കം ചെയ്യുക, പ്രദേശവാസികളെ മാറ്റി പാർപ്പിക്കുക, കനാലുകളുടെ തീരപരിരക്ഷ, വില്ലേജ് രേഖകൾ അനുസരിച്ച് കനാൽ കയ്യേറ്റം ചെയ്തിട്ടുള്ളത് ഒഴിപ്പിക്കുക, കനാലിലേക്ക് മാലിന്യങ്ങൾ നിക്ഷേപിക്കുന്നത് തടയാൻ നടപടികൾ സ്വീകരിക്കുക, ഉയരംകുറഞ്ഞ രീതിയിൽ കനാലിലേക്ക് ഇറക്കി പണിതിട്ടുള്ള പാലങ്ങൾ (56 എണ്ണം) കനാലിന്റെ നീരൊഴുക്കിനെ ബാധിക്കുന്നതാകയാൽ

ഇവ പുനർനിർമ്മിക്കുക എന്നിവ പദ്ധതിയിൽ ഉൾപ്പെടുന്നു. കനാലുകളിൽ നിന്ന് നീക്കം ചെയ്യുന്ന മണ്ണ് അംഗീകൃത സ്ഥാപനമായ KEIL –ന് നൽകുന്നതാണ്. കനാലുകളിൽ ഷട്ടർ സംവിധാനം വീണ്ടും കൊണ്ടുവരും, എൻവയോൺമെന്റൽ മോണിറ്ററിംഗ് പ്ലാൻ നടപ്പിലാക്കും, വെള്ളപ്പൊക്ക നിയന്ത്രണം സാധ്യമാക്കും കൂടാതെ ടി പദ്ധതിയിൽ നാല് മലിനജല സംസ്കരണ പ്ലാന്റുകൾ വിവധ സ്ഥലങ്ങളിൽ സ്ഥാപിക്കുകയും കനാൽ വികസനത്തോടനുബന്ധമായി തീരദേശം മോടികൂട്ടുന്നതിലൂടെ വിനോദ സഞ്ചാരമേഖലയേയും പരിപോഷിപ്പിക്കും എന്നീ കാര്യങ്ങൾ കെ.എം.ആർ.എൽ പ്രതിനിധി അവതരിപ്പിച്ചു.

മുപ്പത്തിയാറുപേർ നേരിട്ടും പത്ത് പേർ വീഡിയോ കോൺഫറൻസ് മുഖേനയും തെളിവെടുപ്പിൽ പങ്കെടുത്തു.

പദ്ധതിയെക്കുറിച്ചുള്ള വിശദമായ അവതരണങ്ങൾക്ക് ശേഷം ജനപ്രതിനിധി കളോടും, പൊതുജനങ്ങളോടും തങ്ങളുടെ അഭിപ്രായങ്ങളും ആശങ്കങ്ങളും പങ്കുവെ യ്ക്കുവാൻ ബഹു.ജില്ലാ വികസന കമ്മീഷണർ ആവശ്യപ്പെട്ടു. പൊതുജനങ്ങൾ അഭിപ്രായങ്ങൾ അറിയിക്കുകയും പദ്ധതിയുടെ DPR തയ്യാറാക്കിയ M/s Antea Netherlands-ന്റെ team leader ആയ ശ്രീ. അനിൽകുമാർ ഗോപിനാഥ് പൊതുജനങ്ങളുടെ ചോദ്യങ്ങൾക്ക് മറുപടി പറയുകയും ചെയ്തു. പൊതുജനങ്ങളുടെ അഭിപ്രായങ്ങൾ ചുവടെ ചേർക്കുന്നു.

1. <u>ശ്രീ. ശങ്കർ ഇടപ്പള്ളി</u>

ചോദ്യം :- പദ്ധതി നടപ്പിലാക്കുന്നതിലേക്കായി തോട് വീതികൂട്ടുന്നതിന് എത്ര മീറ്റർ സ്ഥലമാണ് ഏറ്റെടുക്കുന്നതെന്ന് വിശദമാക്കാൻ ആവശ്യപ്പെട്ടു ?

ഉത്തരം :-

- തോടിന്റെ മധ്യഭാഗത്തുനിന്നും ഇരുവശങ്ങളിലേക്കം 8.25 മീറ്റർ എടുത്ത് പിന്നീട് 2 മീറ്റർ കൂടി അധികം എടുക്കുമെന്നും അറിയിച്ചു.

2. <u>ശ്രീ. ജെയിംസൺ തൈപ്പാടത്ത്</u>

ചോദ്യം :-

1. ഇടപ്പള്ളിയിൽ നിന്നും മുട്ടാറിലേയ്ക്ക് എത്ര ബോട്ട് ജെട്ടി നൽകിയിട്ടുണ്ട് ?
2. ഇടപ്പള്ളിയിൽ കനാലിലെ ആഴം എത്രയാണ് ?

3. 16.50 മീറ്റർ തോടിന്റെ വിസ്തൃതി എങ്ങനെ തീരുമാനിച്ചു എന്നും, സൈക്കിൾ പാത്ത്, ഗ്രീൻ ബെൽറ്റ് എന്നിവ ഉണ്ടാക്കുന്നതിന് ആകെ എത്ര സ്ഥലം ഏറ്റെടുക്കുമെന്നും ചോദ്യം ഉന്നയിച്ചു

4. പദ്ധതിയിൽ സൗന്ദര്യവത്കരണത്തിന്റെ ഭാഗമായി എത്രസ്ഥലമാണ് ഏറ്റെടുക്കുന്നതെന്ന് ചോദ്യമുന്നയിച്ചു.

ഉത്തരം :-

- ഇടപ്പള്ളിയ്ക്കും മുട്ടാറിനും ഇടയിൽ 9 ജട്ടികളാണ് ഉള്ളത്.
- കൊച്ചിൻ പോർട്ട് ട്രസ്റ്റിന്റെ ടൈഡൽ ചാർട്ടിന്റെ അടിസ്ഥാനത്തിൽ ആഴം −0.90 മീറ്ററായി നിജപ്പെടുത്തിയിട്ടുണ്ടെന്നും dredging നടത്തുമെന്നും അറിയിച്ചു. ഇങ്ങനെ ചെയ്യുന്നത് വേലിയേറ്റ സമയത്ത് ഉപ്പുവെള്ളം വീടുകളിലെ കിണറുകളിലെ ശുദ്ധജലവുമായി കലരാതിരിക്കാനാണെന്ന് പ്രതിനിധി അറിയിച്ചു.
- International guidelines അനുസരിച്ചാണ് കനാലിന്റെ നിർമ്മാണം എന്നും അറിയിച്ചു.
- കനാലിന്റെ വീതി 16.50 മീറ്റർ ആയിനിശ്ചയിച്ചത് വില്ലേജ് ഓഫീസുകളിൽ നിന്നും തോട് സംബന്ധമായി ലഭിച്ച രേഖകൾ പരിശോധിച്ച് കനാലിന്റെ ശരിയായ വിസ്തൃതി കണക്കാക്കിയതിന്റെ അടിസ്ഥാനത്തിലാണ്.
- സൗന്ദര്യവത്കരണത്തിന്റെ ഭാഗമായി പൈപ്പ്ലൈൻ ജംഗ്ഷൻ മുതൽ ഇടപ്പള്ളി തോട് ചിത്രപ്പുഴയിൽ ചേരുന്ന ഭാഗം വരെ 4 കീ.മീ ഗ്രീൻബെൽറ്റാണ് നൽകുന്നത്.
- പദ്ധതി പ്രദേശം CRZ പരിധിയിൽ വരുന്ന മേഖലയായതിനാൽ കോൺക്രീറ്റ് ഉപയോഗിച്ചുകൊണ്ടുള്ള നിർമ്മിതികൾ അനുവദിനീയമല്ല.
- Corrugated Steel Plate ഉപയോഗിച്ചുകൊണ്ടുള്ള നിർമ്മാണമാണ് നടത്തുന്നത്. ആയതിനാൽ നിർമ്മാണം വളരെ വേഗത്തിൽ പൂർത്തിയാക്കാമെന്നും 16.70 ഹെക്ടർ സ്ഥലമാണ് ഏറ്റെടുക്കുന്നതെന്നും KMRL പ്രതിനിധി അറിയിച്ചു.

3. <u>ശ്രീ. രാജു തോമസ്</u>

ചോദ്യം: – ഇടപ്പള്ളിയിൽ കനാലിന്റെ വലതു വശത്ത് വിവധ കെട്ടിടങ്ങൾ നിലവിലുള്ളതാണെന്നും ഇടതുവശത്ത് NH- 66 ന്റെ വികസന പദ്ധതികൾ നിലവിലുള്ളതുമായതിനാൽ ഈ പ്രദേശത്തിന്റെ കനാലിന്റെ വിസ്തൃതി കൂട്ടുന്നതിന് ഏത് രീതിയിലാണ് സ്ഥലം ഏറ്റെടുക്കുന്നത് ?

ഉത്തരം :– നിലവിൽ ഇടപ്പള്ളിയിൽ NH 66 ഭാഗത്ത് കനാലിന്റെ ശരാശരി വീതി 10 മീറ്റർ മാത്രമാണ് ഉള്ളത്. ആകെ 16.50 മീറ്റർ ആണ് വേണ്ടത്. ഏറ്റെടുക്കേണ്ട കൂടുതൽ സ്ഥലവും സർക്കാർ പുറമ്പോക്ക് ഭൂമിയിലാണ്. കൂടുതൽ സ്വകാര്യ സ്ഥലം ഏറ്റെടുക്കാത്ത രീതിയിലായിരിക്കും പദ്ധതി നടപ്പിലാക്കുന്നത്. ഇതിനെക്കുറിച്ചുള്ള വിവരങ്ങൾ ഓഫീസിൽ ലഭ്യമാണെന്നും, എപ്പോൾ വേണമെങ്കിലും പൊതുജനങ്ങൾക്ക് ആയത് പരിശോധനയ്ക്ക് ലഭ്യമാകുമെന്നും കെ.എം.ആർ.എൽ പ്രതിനിധി അറിയിച്ചു.

4. <u>ശ്രീ. സെബാസ്റ്റ്യൻ. എം.എ ഓൺലൈൻ മുഖാന്തിരം ചോദ്യം ഉന്നയിച്ചു.</u>

ചോദ്യം:– ഇടപ്പള്ളി കനാൽ പരിസരത്ത് STP യുടെ കപ്പാസിറ്റി എത്രയാണെന്നും എത്ര വീടുകളിൽ നിന്നും ഇതിലേക്ക് മലിനജലം ശേഖരിക്കുമെന്നും, വീടുകളിൽ നിന്നുമുള്ള മലിനജലം ഏത് രീതിയിൽ ശേഖരിക്കുമെന്നും ചോദ്യം ഉന്നയിച്ചു.

ഉത്തരം :–

- 2051 വരെയുള്ള ജനസംഖ്യാ കണക്കെടുപ്പ് നടത്തി CPHEEO manual പ്രകാരമാണ് മലിനജലത്തിന്റെ അളവ് (load) കണക്കാക്കിയിട്ടുള്ളത്. 10 MLD capacity യുള്ള STP ആണ് വെണ്ണലയിൽ സ്ഥാപിക്കുന്നത്.
- വീടുകളിൽ നിന്നും നേരിട്ട് കണക്ഷൻ നൽകിക്കൊണ്ടാണ് മലിനജലം ശേഖരിക്കുന്നത്. പദ്ധതിയ്ക്കായി വിശദ സർവ്വേ നടത്തി വസതികളിൽ സെപ്റ്റിക് ടാങ്ക് ഇല്ലാത്തവരേയും ഈ പദ്ധതിയിൽ ഉൾപ്പെടുത്തുന്നതാണെന്നും അവർക്ക് പ്രത്യേകം ചാർജ്ജ് ഈടാക്കുന്നതാണെന്നും അറിയിച്ചു.
- ഗ്രാവിറ്റി വഴിയും പമ്പിംഗ് വഴിയുമാണ് മലിനജലം വീടുകളിൽ നിന്നും ശേഖരിക്കുന്നത്.

പബ്ലിക്ക് ഹിയറിംഗുമായി ബന്ധപ്പെട്ട് pcbdo1publichearing@gmail.com ഇ-മെയിൽ വഴി ലഭിച്ച ഏഴ് ചോദ്യങ്ങൾക്കും KMRL പ്രതിനിധി ശ്രീ. നിഷാദ് നാരായണൻ മറുപടി അറിയിച്ചു. ഇ-മെയിൽ വഴി ലഭിച്ച ചോദ്യങ്ങളും അവയുടെ ഉത്തരങ്ങളും **അനുബന്ധം- 3, 4** ആയി ഇതോടൊപ്പം ഉള്ളടക്കം ചെയ്യുന്നു.

പൊതുജനങ്ങൾ അറിയിച്ച അഭിപ്രായങ്ങളും പരാതികളും ഉൾകൊള്ളിച്ച് കൊണ്ട് തെളിവെടുപ്പിന്റെ മിനിറ്റ്സ് മറ്റ് അനുബന്ധങ്ങൾ ഉള്ളടക്കം ചെയ്തുകൊണ്ട് കേന്ദ്ര വനം, പരിസ്ഥിതി മന്ത്രാലയത്തിന് സമർപ്പിക്കുന്നതാണ് എന്ന് ബഹു.ഡിസ്ട്രിക്റ്റ് ഡവലപ്പ്മെന്റ് കമ്മീഷണർ സദസ്സിനെ അറിയിച്ചു. കേരള സംസ്ഥാന മലിനീകരണ നിയന്ത്രണ ബോർഡ്, എൻവയോൺമെന്റൽ എൻജിനീയർ ശ്രീമതി. പി.ബി. ശ്രീലക്ഷ്മി കരട് മിനിറ്റ്സ് അവതരിപ്പിച്ചു. കോൺഫറൻസ് ഹാളിൽ നടന്നുകൊണ്ടിരുന്ന നേരിട്ടുള്ള പൊതുതെളിവെടുപ്പ് 1 മണിക്ക് അവസാനിച്ചു. ഓൺലൈൻ മുഖാന്തിരം പൊതുജനങ്ങൾക്ക് അഭിപ്രായങ്ങൾ 3 മണിവരെ രേഖപ്പെടുത്താവുന്നതാണെന്ന് ബഹു.ഡിസ്ട്രിക്റ്റ് ഡവലപ്പ്മെന്റ് കമ്മീഷണർ അറിയിച്ചു.

ചടങ്ങിൽ പങ്കെടുത്ത എല്ലാവർക്കും കെ.എം.ആർ.എൽ പ്രതിനിധി കൃതജ്ഞത രേഖപ്പെടുത്തി.

18/3/24

ശ്രീമതി. അഫ്സാന പർവീൺ ഐ.എ.എസ്
ജില്ലാ ഡെവലപ്പ്മെന്റ് കമ്മീഷണർ
എറണാകുളം
DISTRICT DEVELOPMENT COMMISSIONER
ERNAKULAM

OFFICE OF THE DISTRICT DEVELOPMENT COMMISSIONER
COLLECTRATE
KAKKANAD 682030

Minutes of the public hearing conducted on 16.03.2021 at Collectorate conference hall, Ernakulam in connection with KMRL project on Integrated Urban Regeneration and Water Transport System (IURWTS) in Kochi

The project involves rejuvenation of 5 canals running through the heart of the urban fabric of Kochi Corporation and occupies nearly one-third of the corporation area. The overall objective of the project is to mitigate floods in the IURWTS catchment area and to restore Inland Water Transport in the canal systems, and thereby have an inter-modal connectivity and integration with the Rail Metro and Water Metro. The restoration of canals and urban regeneration is aimed at restructuring the urban fabric as well as renewal of the urban economy which will lead to the overall improvement of the Image of the city. As per the EIA Notification, the project is included in Schedule- 7E under "A" category which needs public hearing for obtaining environmental clearance from the Ministry of Environment, Forest and Climatic change (MoEF)

The matter was discussed with Hon'ble District Collector and it was decided to conduct the public hearing at 11 AM on 16.03.2021 at Collectorate conference hall. The notices were published on 13.02.2021 i.e., one month prior to the hearing in both regional and national dailies to inform the public regarding the project and the hearing (venue, date, time etc) to invite their suggestions, views, comments and objections.

The hearing started at 11.AM presided by the Hon'ble District Development Commissioner (DDC), Smt.Afsana Perween IAS on behalf of the District Collector. Public participation was ensured in the meeting through both physical and online arrangement. Sri. M.A Baiju, the Chief Environmental Engineer, Kerala State Pollution Control Board, welcomed all the participants to the hearing and invited the Hon'ble DDC for the presidential speech. The DDC explained about the project and procedure to be adhered in the public hearing process. District Development Commissioner also informed the gathering that the notice for the hearing was already published in the newspaper one month before and as per the EIA notification the procedure for public hearing has to be completed within 45 days from the date of request submitted by the project proponent. The DDC pointed out that hearing being conducted is not in violation of model code of conduct of Hon'ble Election Commission owing to the fact that hearing is only to gather public views, suggestions and comments which will be sent to ministry of Environment and Forest &Climate Change (MoEF&CC) for further decision regarding the clearance for the project and no decision at District level shall be taken in alignment with model code of conduct. The list of participants is enclosed as Annexure-1.

DDC directed the project proponent Kochi Metro Rail Limited M/s KMRL to give presentation detailing the various components of the project. The Environment Expert, Sri. Nishad Narayanan, assisting KMRL explained about the project in detail. In continuation to the KMRL presentation, Sri. Stephen Leo, the representative of WAPCOS Limited; the KMRL consultant who conducted EIA study explained about the EIA study report. The presentation slides are enclosed as Annexure-2. The details of the presentations are as follows

The project includes rejuvenation of five canals namelyEdappally Canal (11.23 km), Chilavanoor Canal (11.15km), Thevara-Perandoor canal (9.88km), Thevara canal (1.41km) and Market canal (0.66km). The total capital investment of the project is 1528 Cr. The project focuses on the rejuvenation of the canals, flood mitigation, Canal Oriented development in the projectarea. The project also includes the rehabilitation of the people residing at the banks of the canals, to rehabilitate people residing in slums, protection of canal banks etc. The existing bridges which affect the environment flow of the canals will be reconstructed in this project. The desilted earth obtained during the construction phase will be disposed in common facility, KEIL, Ambalamughal. The project also includes construction of four STPs to treat the sewage generated from houses and flats, beautification of the canal banks and water transport systems.

36 people participated directly from the hall and 10 people participated virtually for the hearing. After the project presentation, the Hon'ble DDC invited the public to express their views, concerns, suggestions or questions on the project. Three persons expressed their views directly and one person raised his query through online. Sri.Anil Kumar Gopinath, Team Leader, (General consultant) assisting KMRL, replied to all the queries raised by the public.

1. Sri SankarEdappally

Q. Raised query on the land requirement and acquisition of land for the canal widening.

Ans. Replied that a minimum of 8.25 meters on either side from the center line of the canal based on the village records will be acquired and an additional 2m on either side will also be acquired for laying primary sewer lines along the canal.

2. Sri. Jameson Thaipadath

Q. Raised question regarding how KMRL have fixed 16.5m for the canal widening and also asked to clarify the total land required for the complete infra structure development such as jetty construction, green belt, cycle path etc in Edapally Canal and also asked about the no of jetties from Muttar to Chitrapuzha, and depth of canal.

Answer

- The width of 16.5m was fixedbased on the international guidelines for restoring 2 way navigation in the canals.
- Informed that total 16.71 hectares of land will be acquired for Edappally canal. Major part of the land for acquisition is Govt. land.
- About 4km of stretch in Edappally canal is to be used for beautification starting from pipeline junction up to the confluence point of Edapally thodu and Chitrapuzha.
- Since, the project area is included under CRZ Zone, no concrete structures will be constructed.
- The bridge construction will be done using corrugated steel plates to reduce construction time.
- The bottom level of the canal isfinal depth fixed at (-) 0.90mCD with respect to the reference levels fixed by Cochin Port Trust. Depth is fixed at(-) 0.9m CD without entering into the stiff clay layer to prevent the salt water intrusion during tidal effect.
- 9 jetties are proposed in Edappally canals between Muttar in the north and Chitrapuzha in the southern end.

3. Sri.Raju Thomas

Q. Raised query on the process of acquisition of land and properties in Edappally thodu since there are many buildings on the right side of canal and future expansion has already been proposed in the NH 66 which falls in the left side of the canal

Answer

- Already avg 10m width existing in the area. As per the village records 16.5m land to be acquired for widening comes under *Purambokke* (Govt land) very limited area in acquisition part. Maximum acquisition of flats will be avoided. informed that the public can visit the KMRL office at any time and all the records and details related to the project will be made available to the public in this regard

4. Sri.Sebastian M.A- joined through online

Q. Question was to clarify on the capacity of STP at proposed at Vennala in Edappally canal on the southern end. He enquired about the method of calculating the sewage load and the no of residences served by the STP. He also enquired on how sewage will be collected from flats which do not have STP.

Answer

- The STPs designed was taking into account the anticipated population of 2051 and following the guidelines of CPHEEO manual. Sewage will be collected through laying sewer lines and collected directly from the houses.
- Sewage will be collected through a combination of gravity and pumping system.
- Survey will be conducted to identify the flats who have no STPs. Their sewage will be collected for treatment and suitable charges will be levied for the treatment.
- The treated sewage effluent will be collected from the flats who have already installed STPs.

Seven people have rasied their queries on the project through email pcbdo1publichearing@gmail.com. After answering all the queries raised by the public in the hearing, KMRL Environment Expert Sri. Nishad Narayanan answered all the queries received from the public through email. The queries received from the public and the reply is enclosed as Annexure-3 and Annexure-4.The draft minutes of the meeting was read by the Environmental Engineer, Kerala State Pollution Control Board.

The Hon'ble DDC concluded the hearing informing that the minutes of the hearing including issues raised by the public will be sent to the MoEF for further regulatory decision on the project. The Hon'ble DDC informed that the online link will be open and the public can submit their views and comments till 3PM through online platform.

Vote of thanks was proposed by AGM (Civil) KMRL and the meeting ended at 1 P.M.

OFFICE OF THE DISTRICT DEVELOPMENT COMMISSIONER ERNAKULAM
COLLECTRATE
KAKKANAD - 682030

Afsana

Smt. Afsana Perween I A S
District Development Commissioner,
Ernakulam

DISTRICT DEVELOPMENT COMMISSIONER
ERNAKULAM

അനുബന്ധം - 1

Public Hearing in connection with the Environmental Clearance for the project "Integrated Urban Rejuvenation and Water Transport System (IURWT)

Attendance Sheet

Venue: Collectorate Conference Hall, Ernakulam.	Date: 16.03.2021

Sl. No	Name and Address	Signature
1.	Smt. Afsana Perveen I.A.S District Development Commissioner	
2.	Sri. M .A Baiju The Chief Environmental Engineer Kerala State Pollution Control Board Regional Office, Ernakulam	
3.	Smt. P.B.Sreelakshmy Environmental Engineer Kerala State Pollution Control Board District Office, Ernakulam	
4.	Sri. A.M.Harees Assistant Environmental Engineer Kerala State Pollution Control Board District Office, Ernakulam	
5.	Smt. Shahana. M.A Assistant Environmental Engineer Kerala State Pollution Control Board Regional Office, Ernakulam	

Public Hearing in connection with the Environmental Clearance for the project "Integrated Urban Rejuvenation and Water Transport System (IURWT)

Attendance Sheet.

Venue: Collectorate Conference Hall, Ernakulam. Date: 16.03.2021

Sl. No	Name and Address	Signature
1.	AJITH - A AGM- KMRL	[signature]
2.	Eldho Thomas Manager - KMRL	[signature]
3	K. Gangadharan Sr. LA Consultant KMRL	[signature]
4	Felix Melvin Frank Consultant (LA- WT) KMRL	[signature]
5.	Jacmon .T.A Chartered Engr Rtd. Ex. Engr. 9447237372	[signature]
6	S. Subramonia Iyer Consult (Pass LA)	[signature]

Public Hearing in connection with the Environmental Clearance for the project "Integrated Urban Rejuvenation and Water Transport System (IURWT)

Attendance Sheet

Venue: Collectorate Conference Hall, Ernakulam. Date: 16.03.2021

Sl. No	Name and Address	Signature
7.	TONY JAMES A.M - KMRL 7356602848	
8	SREEKESH. S. K MANAGER - IT (KMRL) 7356602836	
9.	MS. MEETU ASOKAN KEY EXPERT ARCHITECT (ANTEAGROUP) 9746212212	
10	Dr. Jaxy George Expert Public Health Engg. Antea	
11	Haneesh . K.R WAPCOS LTD KOCHI	
12.	Dhaneesh. V.V WAPCOS ltd, Kochi	

Public Hearing in connection with the Environmental Clearance for the project "Integrated Urban Rejuvenation and Water Transport System (IURWT)

Attendance Sheet

Venue: Collectorate Conference Hall, Ernakulam. Date: 16.03.2021

Sl. No	Name and Address	Signature
13	A.STEPHEN LEE GM WAPCOS Ltd, Kol.	A. Stephen Lee
14.	Dr. BALAJI A. RAJU Structural Engg-II ANTEA	[illegible]
15	SASITH. SATHYAPRAKASH ELECTRICAL ENGINEER ANTEA GROUP 8129058654	[illegible]
16	Shankar.G.S, Villa No 1, Star Enclave V.P.Mavakkar Road. Edapally Toll Jn. Ph. 94463 11093	[illegible]
17	Raju Thomas. Villa No. 26. Star Enclave. Edapelly Toll Ph. 9744957080.	[illegible]
18	AJAS P KARIM Padagatha (h), mannopillynagar kalamassery 9496805797	Ajas

Public Hearing in connection with the Environmental Clearance for the project "Integrated Urban Rejuvenation and Water Transport System (IURWT)

Attendance Sheet

Venue: Collectorate Conference Hall, Ernakulam. Date: 16.03.2021

Sl. No	Name and Address	Signature
19	IBRAHIM PASSAR MANATH (H) THRIKKAKARA P.O 8606908525	[signature]
20	VISHNU V [illegible] Site co-ordinator Survey Antea Kochi (9746622[illegible])	[signature]
21	Susan Aby Landscape Architect Antea India (9995902707)	[signature]
22	Neethu Susan Abraham Junior Architect Antea India (9747747564)	[signature]
23	Divya Rose Mary Assistant Engineer Antea India (8281457464)	[signature]
24	Renuka Menon Anbas	[signature]

Public Hearing in connection with the Environmental Clearance for the project "Integrated Urban Rejuvenation and Water Transport System (IURWT)

Attendance Sheet

Venue: Collectorate Conference Hall, Ernakulam.

Date: 16.03.2021

Sl. No	Name and Address	Signature
25	Reshma Raman, Muthirapparambil House, Koovappady PO Koodalappad, Ernakulam Dist- Pin - 683544	Reshma
26	Kannan . M Aswathy House, Pallanamthitta - 689649.	Kannan
27	Nikhil.M. Revathy, Madavampat House, Mannur, P.O Calicut. 673328 97455 49025	Nikhil
28	Anil Kumar Gopinath Team leader, Antea Group General Consultant	16/3
29	Jayakrishnan K.S Office Assistant Anteaindia Pvt General consultant	Jaya
30	Bibin Mathew Jnr Architect, Anteagroup P.Ltd. (8281870957)	

Public Hearing in connection with the Environmental Clearance for the project "Integrated Urban Rejuvenation and Water Transport System (IURWT)

Attendance Sheet

Venue: Collectorate Conference Hall, Ernakulam. Date: 16.03.2021

Sl. No	Name and Address	Signature
31	Nishad Narayanan Environmental Expert Antea Group, Kochi	
32	ARAVIND BABU MANAGER, ANTEA GROUP, KOCHI	
33	Divya Damodaran·B AE1, RO EKM	
34	Bissy Varghese AE4, DO1-EKM	
35	Aneesa md UM AG - DO1 EKM	
36	FARIS-K-R GEA - DO1 EKM	

അനുബന്ധം - 2

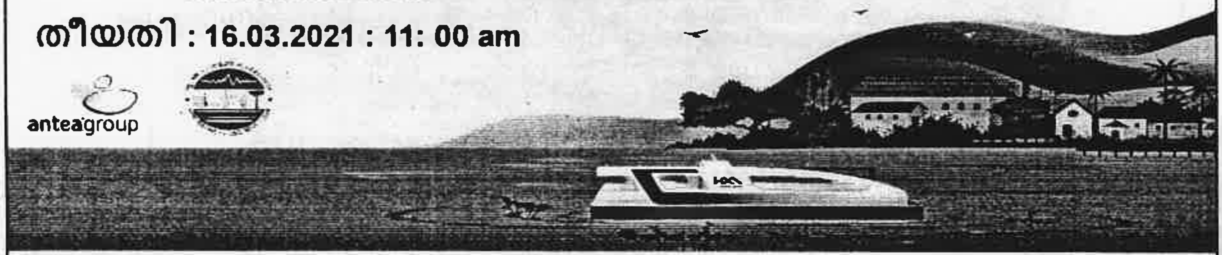
പൊതു തെളിവെടുപ്പ്

സംയോജിത നഗര പുനരുജ്ജീവന ജലഗതാഗത പദ്ധതി
(Integrated Urban Regeneration and Water Transport System)

സ്ഥലം : എറണാകുളം ജില്ലാ കളക്ടറേറ്റ് കോൺഫറൻസ് ഹാൾ, കാക്കനാട്

തീയതി : 16.03.2021 : 11: 00 am

anteagroup



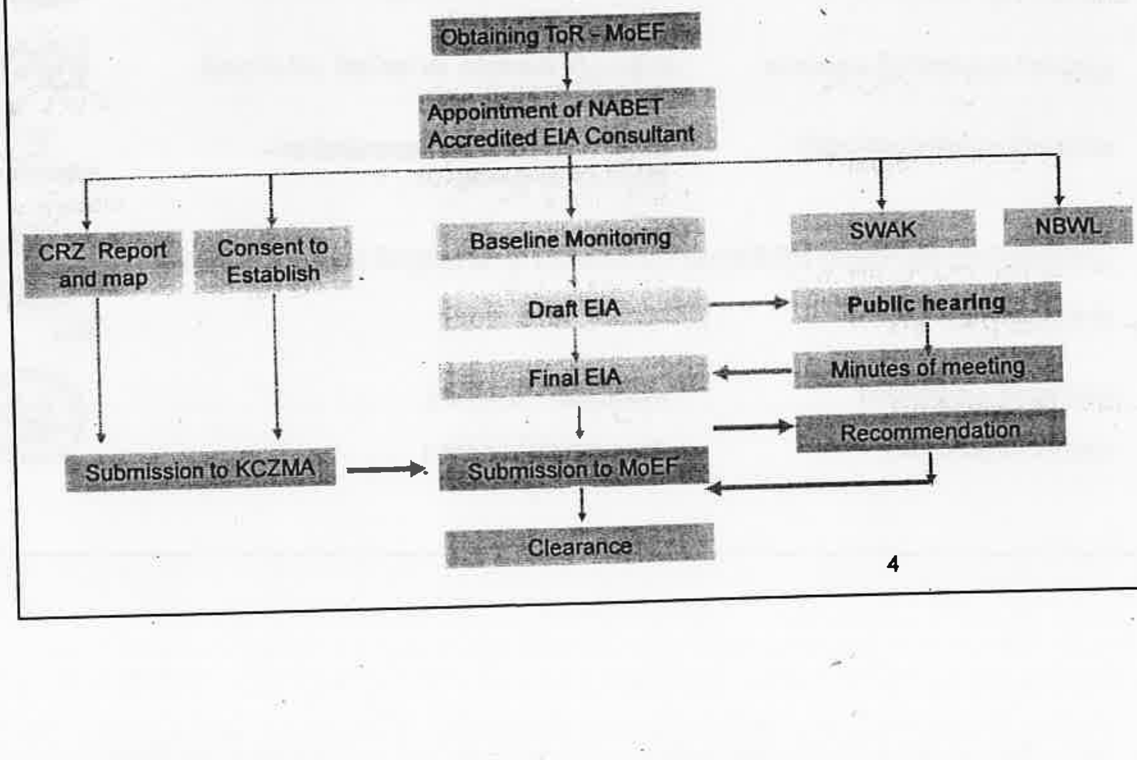
പദ്ധതി ഉപജ്ഞാതാവ്	: CSIN Department, കേരള സർക്കാർ
പദ്ധതി നടത്തിപ്പ് ചുമതല	: കൊച്ചി മെട്രോ റെയിൽ ലിമിറ്റഡ്
ജനറൽ കൺസൽട്ടൻറ്	: ആന്റിയ നെതെർലാൻഡ് BV– ആന്റിയ ഇന്ത്യ JV
പരിസ്ഥിതി ആഘാത നിർണയ കൺസൽട്ടൻറ് (EIA)	: വാപ്കോസ് ലിമിറ്റഡ് (WAPCOS Ltd. GOI)
ഫണ്ടിങ് ഏജൻസി	: കിഫ്ബി (KIIFB)
പദ്ധതി മൂലധനം	: 1528 കോടി (KIIFB)

anteagroup

പബ്ലിക് ഹിയറിംഗ്

- ഇഐഎ വിജ്ഞാപന പ്രകാരം കാറ്റഗറി എസ്. നമ്പർ 7 (ഇ), എ,
- പാരിസ്ഥിതിക ക്ലിയറൻസ് പ്രക്രിയയുടെ ഭാഗമാണ് പബ്ലിക് ഹിയറിംഗ്. (ഇന്ത്യാ ഗവൺമെന്റിന്റെ പരിസ്ഥിതി വനം മന്ത്രാലയത്തിന്റെ 14.09.2006 ലെ വിജ്ഞാപന നമ്പർ S.O. 1533 (പ്രകാരം)
- വരാനിരിക്കുന്ന പദ്ധതിയെക്കുറിച്ചുള്ള ആശങ്കകളെക്കുറിച്ച് സർക്കാർ ഉദ്യോഗസ്ഥരുമായും പ്രോജക്റ്റ് വക്താവുമായും ബന്ധപ്പെട്ടവർക്ക് നേരിട്ട് സംവദിക്കാൻ കഴിയും.
- പൊതുജനങ്ങൾ ഉന്നയിക്കുന്ന എല്ലാ അഭിപ്രായങ്ങളും അന്തിമ ഇഐഎ റിപ്പോർട്ടിൽ അപ്ഡേറ്റ് ചെയ്യുകയും ക്ലിയറൻസിനായി പരിസ്ഥിതി വനം മന്ത്രാലയത്തിന് MoEF& CC സമർപ്പിക്കുകയും ചെയ്യും.

EIA – STUDY

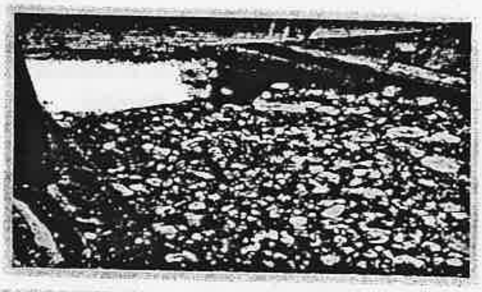


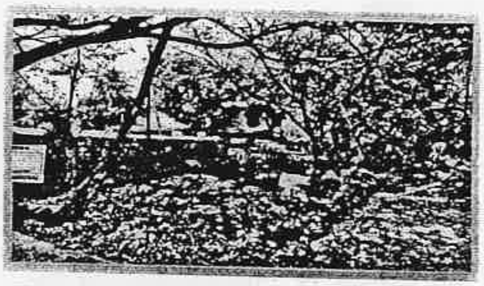
4

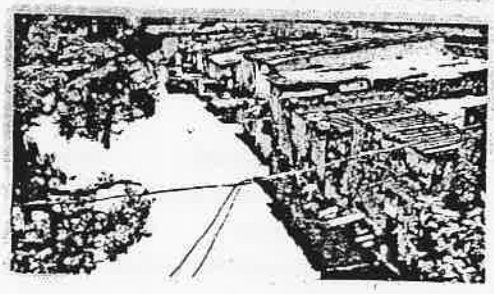
കൊച്ചി കനാൽ പുരാതന പ്രൗഢിയിൽ

Ernakulam Market

കൊച്ചിയുടെ നിലവിലെ ദുരവസ്ഥ

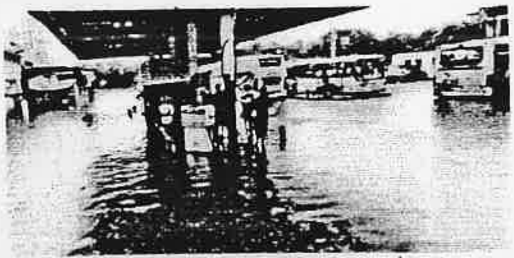




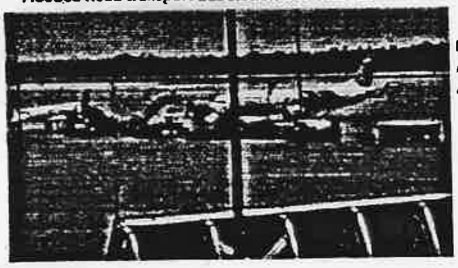


കൊച്ചിയുടെ നിലവിലെ ദുരവസ്ഥ

Main road in IURWTS catchment

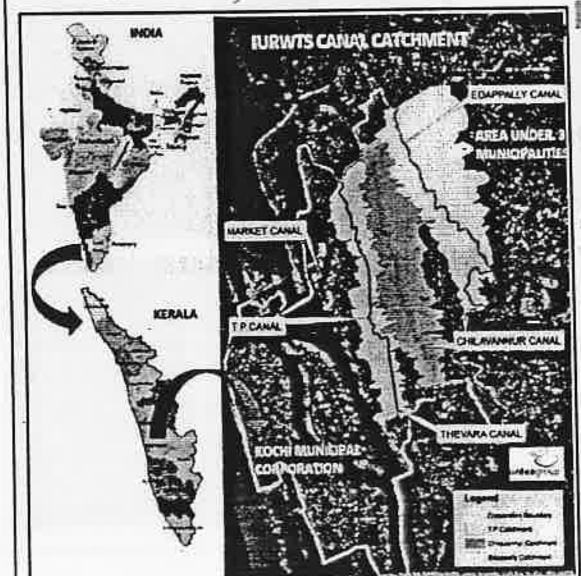


Flooded Road transport bus station in IURWTS catchment



Kochi International Airport flooded Aug 14th 2018

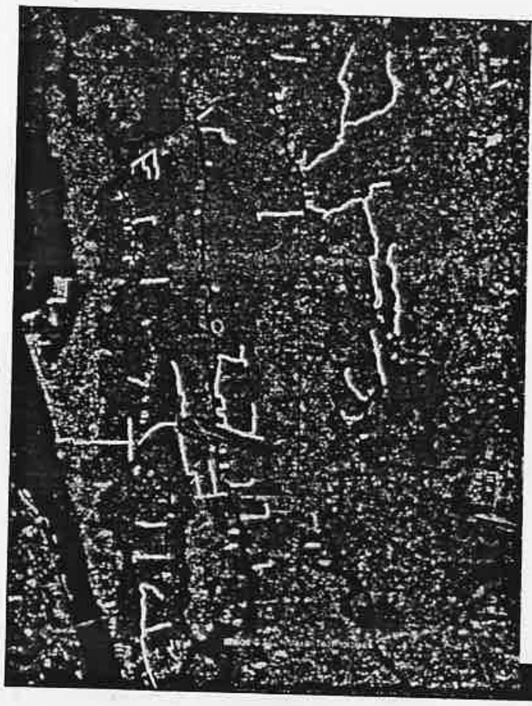
ആമുഖം



	വിസ്തീർണ്ണം (ച.കി.മീ.)		വാർഡ് വിശദാംശങ്ങൾ	
	Total	Benefited	Total	Benefited
കൊച്ചി കോർപറേഷൻ	94.88	31.07	74	43
കളമശ്ശേരി	27.4	5.06	42	20
തൃക്കാക്കര	28	5.66	43	21
തൃപ്പൂണിത്തുറ	29.17	0.65	49	3
Total benefited area		42.44		

❖ പദ്ധതി നടപ്പാക്കുന്ന കനാലുകൾ :

- ഇടപ്പള്ളി കനാൽ (11.23 കി.മീ.)
- ചിലവനൂർ കനാൽ (11.15 കി.മീ.)
- തേവര-പേരണ്ടൂർ കനാൽ (9.88 കി.മീ.)
- തേവര കനാൽ (1.41 കി.മീ.)
  - കോന്തുരുത്തി സബ് കനാൽ (0.67 കി.മീ.)
- മാർക്കറ്റ് കനാൽ (0.66 കി.മീ.)



കനാലുകളും ഉപകനാലുകളും

Sl. No	Name of the canal	Length of main canal (Km)	No. of Sub canals
1	Edappally canal	11.231	73
2	Chilavanoor Canal	11.152	69
3	Thevara_Perandoor canal + Thevara canal	(9.885+1.41)	135
4	Market Canal	0.664	6

IURWTS പദ്ധതി ലക്ഷ്യം

കനാൽ പുനരുജ്ജീവനം

വെള്ളപ്പൊക്ക നിവാരണം

പദ്ധതി പ്രദേശ വികസനം

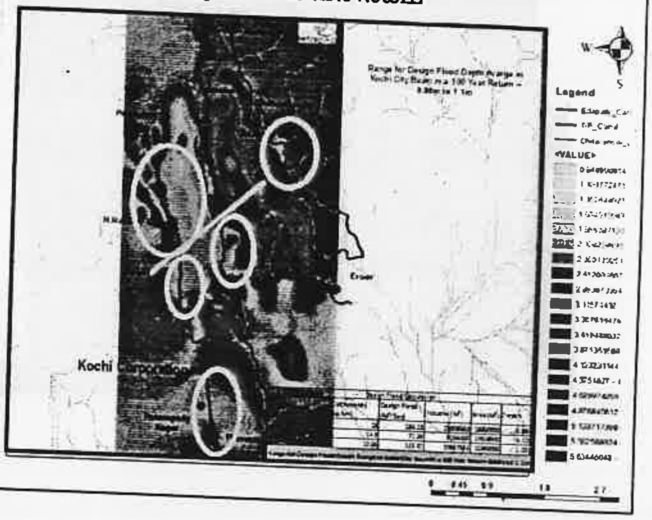
കനാൽ പുനരുജ്ജീവനം

- കയ്യേറ്റം ഒഴിപ്പിക്കലും ചേരിപ്രദേശങ്ങൾ നീക്കം ചെയ്തു പുനരധിവാസവും
- സാമൂഹിക ആഘാത പഠനം നടത്തിയതിന്റെ അടിസ്ഥാനത്തിൽ 280 ഓളം അനധികൃത താമസക്കാരെ പദ്ധതിയുടെ ഭാഗമായി പുനരധിവസിപ്പിക്കാനുള്ള നടപടികൾ സ്വീകരിച്ചു കഴിഞ്ഞു

P&T colony

Udaya colony

- കനാലുകളുടെ തീര പരിരക്ഷ



കനാൽ പുനരുജ്ജീവനം

- കനാലുകൾ ഖര / ദ്രവ മാലിന്യ മുക്തമാക്കുക

- കനാൽ കളിലേക്കുള്ള മാലിന്യ -മലിന ജല നിർഗമനം തടയുന്നതിനായി രണ്ടു സർക്കാർ ഉത്തരവുകൾ ഇറങ്ങി.

  G.O.(Rt)No.823/2020/LSGD dated 04/05/2020

  G.O(Rt) No. 2466/2019/LSGD dated 06.11.2019

- ജില്ലാ കളക്ടർ നടപടിക്രമ വ്യവഹാരം ഇറക്കി

- ജലമൊഴുക്കിനും കനാലുകളുടെ പരിരക്ഷയ്ക്കു വേണ്ടിയും 4 കനാലുകളിലുമായി 56 പാലങ്ങളുടെ പുനർനിർമാണം

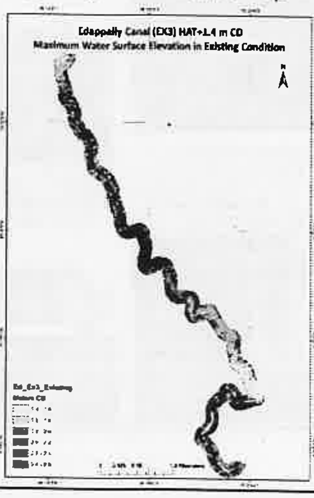
- കനാൽ ഗതാഗതത്തിന് യാത്രക്കാരുടെ സൗകര്യാർത്ഥം ജെട്ടികൾ നിർമ്മിക്കുന്നു
- കനാലുകൾ ജലഗതാഗത യോഗ്യമാക്കി മറ്റ് യാത്ര മാർഗങ്ങളുമായി ബന്ധിപ്പിക്കുക

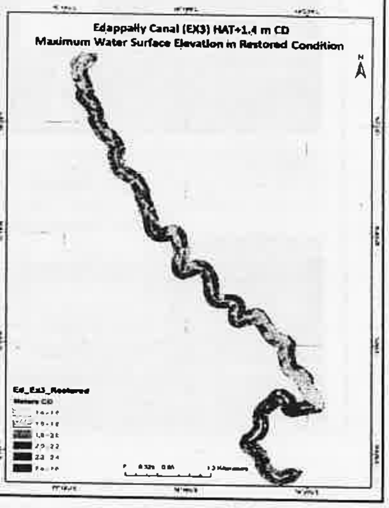
IURWTS

വെള്ളപ്പൊക്ക നിവാരണം

- വിശദമായ വെള്ളപ്പൊക്ക സാധ്യത പഠനം
- വെള്ളപ്പൊക്ക നിവാരണത്തിന് കനാലുകളിലും ഇടത്തോടുകളിലും കാനകളിലും ആവശ്യമായ വീതിയും ആഴവും നിജപ്പെടുത്തുക.

Flood 2018 – water level in catchment

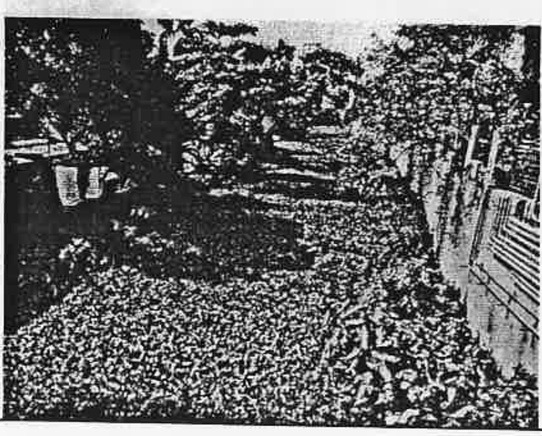




IURWTS

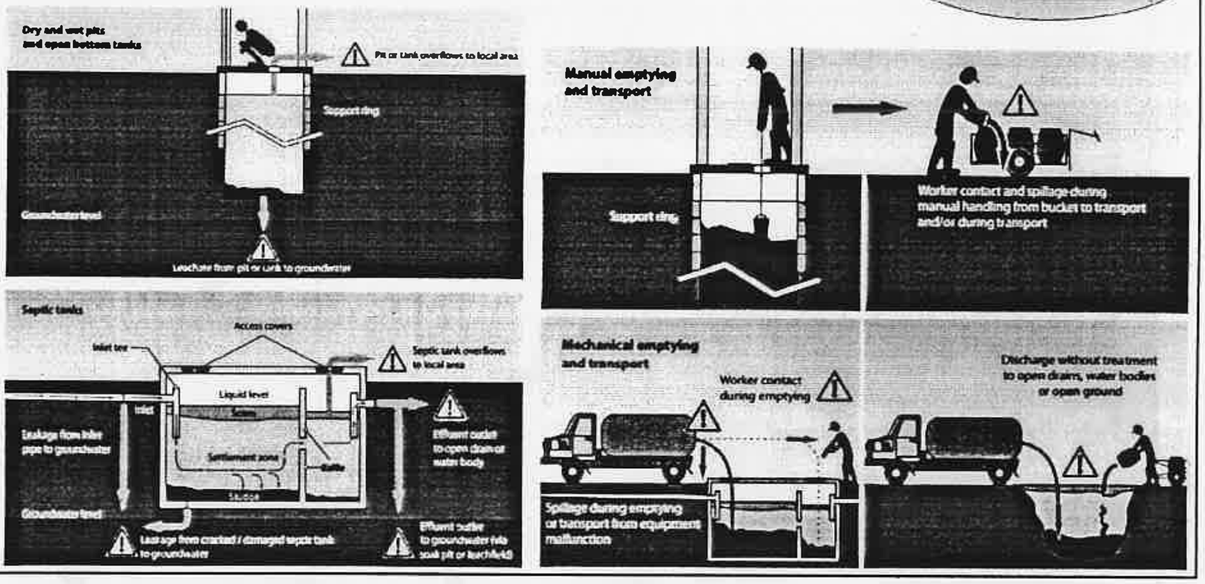
വെള്ളപ്പൊക്ക നിവാരണം

- കനാലുകളിൽ നിന്ന് നീക്കം ചെയ്യുന്ന മണ്ണ് സുരക്ഷിതമായി നിർമാർജനം ചെയ്യുന്നതിനുള്ള നടപടികൾ
- ജലനിരപ്പ് ക്രമീകരിക്കുന്നതിനും പായൽ നിർമാർജനത്തിനുമുള്ള സംവിധാനം



പദ്ധതി പ്രദേശത്തെ On site sanitation (soak pit septic tanks) മൂലമുള്ള പാരിസ്ഥിതിക പ്രശ്നങ്ങൾ

പദ്ധതി പ്രദേശ വികസനം



THE NEW INDIAN EXPRESS

NATION | WORLD | STATES | CITIES | BUSINESS | SPORT | GOOD NEWS | MOVIES | GALLERIES

STOCK MARKET BSE 50056.58 -735.50(-1.45%) NSE 14825.80

Home › Cities › Kochi

Indira Nagar residents demand action against septage waste dumping

A culvert over the two-metre-wide canal that connects a YMCA office with the mainland has sunk two feet causing further disruption in the flow of water.

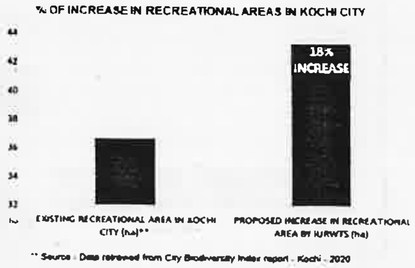
Published: 29th August 2020 05:12 AM | Last Updated: 29th August 2020 05:12 AM

പദ്ധതി പ്രദേശ വികസനം

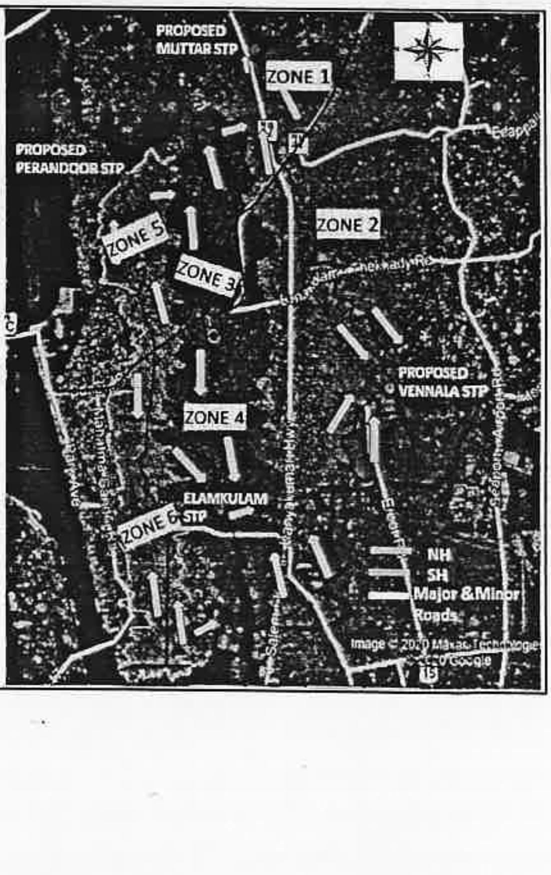
പദ്ധതി അധിഷ്ഠിത പരിഹാര മാർഗങ്ങൾ

പദ്ധതി പ്രദേശ വികസനം

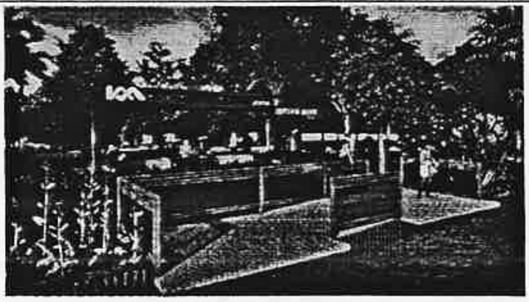
- 36 MLD മലിനജല ശുദ്ധീകരണ സംവിധാനം ആവശ്യമുള്ള IURWTS പദ്ധതി പ്രദേശത്തു നിലവിൽ ശുദ്ധീകരണ സംവിധാനം 5MLD-ക്ക് താഴെ മാത്രം - ഈ പദ്ധതിയിലൂടെ ഇത് 100% ഉറപ്പാക്കുന്നു
- പദ്ധതി പ്രാന്ത പ്രദേശത്തു ഉൽപാദിപ്പിക്കുന്ന മലിനജല ലോഡ് സംസ്ക്കരിക്കാൻ മൊത്തം 4 STPs
- ശുദ്ധീകരിച്ച മലിനജലത്തിന് NGT യുടെ മാർഗനിർദ്ദേശപ്രകാരമുള്ള ഗുണനിലവാരം ഉറപ്പു വരുത്തുക
- എല്ലാ STPകളും കനാലുകളുടെ വാൽ അറ്റത്ത് ജനവാസ മേഖലയ്ക്ക് പുറത്താണ് സ്ഥാപിക്കുന്നത്
- കനാൽ തീരങ്ങളിൽ ആവാസ വ്യവസ്ഥയെ പുനരുജ്ജീവിപ്പിക്കുക
- പദ്ധതിയുടെ ഭാഗമായി 36800m² ഹരിത മേഖല സൃഷ്ടിക്കുക
- Miyawaki വനം ഉൾപ്പെടെ ഒരു നഗര ഗ്രീൻ ബെൽറ്റ് സൃഷ്ടിക്കുന്നതിന് 1.08 കിലോമീറ്റർ നീളം നീക്കിവച്ചിട്ടുണ്ട്.



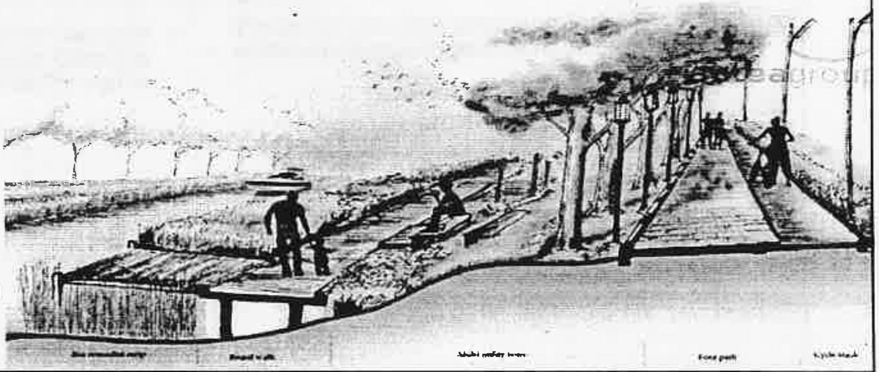
Sl. No	STP location	Proposed STP
1	Elamkulam STP Chilavanoor & TP south	10 MLD
2	Vennala STP - Edappally south	10 MLD
3	Muttar STP-Edappally north	7 MLD
4	Perandoor STP - TP north	4 MLD
	Total MLD	31 MLD



പദ്ധതി ഘടകങ്ങള്



നിർദ്ദിഷ്ട IURWTS ജെട്ടിയുടെ കൺസെപ്റ്റ് ഡിസൈൻ



ഇടപ്പള്ളി കനാലിന്റെ ഹരിത വികസന രൂപ രേഖ

പദ്ധതി ഘടകങ്ങള്

ഭൂമി ആവശ്യകത

- പദ്ധതിക്കായി മൊത്തം ഭൂമി ഏറ്റെടുക്കേണ്ടത് ഏകദേശം 45.60 ഹെക്ടർ ആണ്.

Canal	Area to be acquired (in Ha)
Edappally	16.72
Chilavanoor	17.43
Thevara Perandoor	9.79
Thevara	1.5
Market	0.163

- ഏകദേശം 1151 കെട്ടിടങ്ങളെ പദ്ധതിയെ ബാധിക്കുന്നു

- ഭൂമി ഏറ്റെടുക്കൽ, പുനരധിവാസം, പുനരധിവാസ നിയമം, 2013 ലെ ന്യായമായ നഷ്ടപരിഹാരത്തിനും സുതാര്യതയ്ക്കും ഉള്ള അവകാശം പ്രകാരം നഷ്ടപരിഹാരം നൽകും.(Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 201 and The Land Acquisition, Rehabilitation and Resettlement Act
- LARR ACT.)

പദ്ധതിയുടെ നിയമപരമായ അനുമതികളുടെ സ്ഥിതി

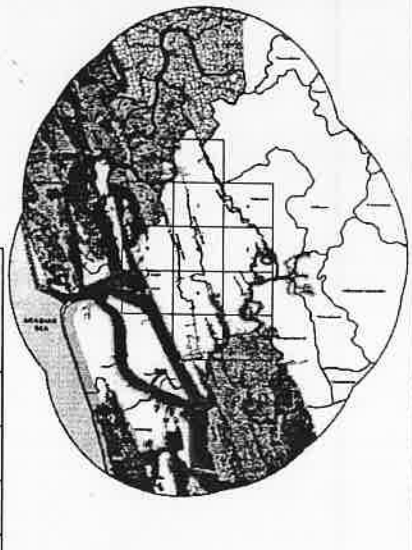
- മലിനീകരണ നിയന്ത്രണ ബോർഡിന്റെ CTE ലഭിച്ചു
- സ്വാക് (സംസ്ഥാന തണ്ണീർത്തട മാനേജ്മന്റ് അതോറിട്ടി) യുടെ NOC ലഭിച്ചു
- തീരദേശ പരിപാലന നിയമം (CRZ) അനുസരിച്ചുള്ള അപേക്ഷ സമർപ്പിച്ചു
- NBWL അനുമതി അപേക്ഷ സമർപ്പിച്ചു
- പാരിസ്ഥിതിക അനുമതിക്കായുള്ള പാരിസ്ഥിതിക ആഘാത പഠനത്തിനായുള്ള നിബന്ധന റഫറൻസ് MOEF&CC അംഗീകരിച്ചു
- ജൈവ വൈവിധ്യവും സമുദ്ര പരിസ്ഥിതി സർവേ CUSAT സമർപ്പിച്ചു

CRZ

തീരദേശ പരിപാലന മേഖല

- നിർദ്ദിഷ്ട പ്രോജക്റ്റിനായുള്ള CRZ മാപ്പിംഗ് ചെന്നൈയിലെ അണ്ണ സർവകലാശാലയിലെ ഇൻസ്റ്റിറ്റ്യൂട്ട് ഓഫ് റിമോട്ട് സെൻസിംഗ് (IRS) നടത്തി CRZ അനുമതിക്കായി അപേക്ഷ സമർപ്പിച്ചിട്ടുണ്ട്

CRZ-Classification	Edappally Area in sq.m	Chilavanoor Area in sq.m	Thevara-Perandoor Area in sq.m	Thevara Area in sq.m	Market Area In sq.m
CRZ - II	15461.87	47146.11	20327.98	12078.42	1658.59
CRZ - IB	1104.67	3998.86	18.12	586.739	948.40
CRZ - IVB	8404.61	12045.87	9243.78	3073.92	2687.87
Out of CRZ	24845.99	164635.74	53005.52	611.78	00



22

പദ്ധതിയുടെ പ്രയോജനം

- വൃത്തിയുള്ളതും ഹരിതവുമായ പരിസ്ഥിതി
- വൃഷ്ടി പ്രദേശത്തെ സബ് കനാലുകൾ പുനരുദ്ധരിച്ചു മികച്ച ഡ്രെയിനേജ് സംവിധാനം, മലിനജലസംസ്കരണം, മഴവെള്ള സംഭരണ സംവിധാനം
- വിവിധ സ്ഥലങ്ങളിൽ നിന്നുള്ള ഫലപ്രദവും മെച്ചപ്പെട്ടതുമായ കണക്റ്റിവിറ്റി
- ചുറ്റുമുള്ള മെച്ചപ്പെട്ട ലാൻഡ്സ്കേപ്പ്
- കനാലുകൾക്ക് സമീപം വെള്ളപ്പൊക്ക സാധ്യത ഇല്ലാതാക്കുന്നു
- കനാൽ അധിഷ്ഠിത വികസനം പൊതുജങ്ങൾക്കായി ഉറപ്പ് വരുത്തും
- കനലുകളിലേക്കു ഒഴുകിയിരുന്ന മലിനജലം സംസ്കരിച്ചു വൃത്തിയുള്ള പരിസ്ഥിതി ഉറപ്പാക്കുന്നു
- പുനരധിവാസത്തിനുശേഷം കോളനി നിവാസികൾക്ക് മെച്ചപ്പെട്ട ജീവിത നിലവാരം ഉറപ്പാക്കുന്നു

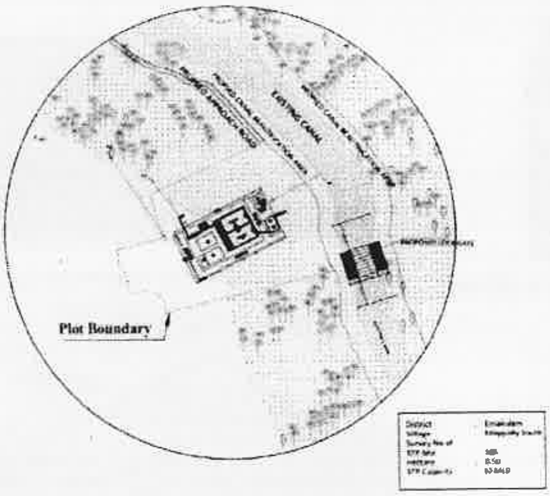
നന്ദി

24

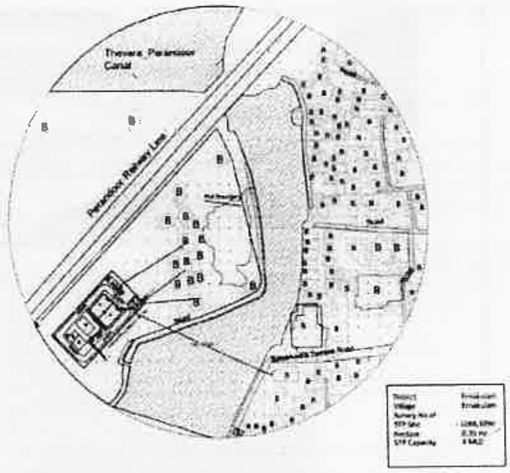
ചോദ്യോത്തരവേള

25

PROJECT COMPONENTS



Vennala STP

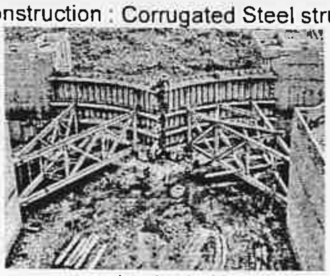


Perandoor STP

Proposed Structures

ROB reconstruction : Corrugated Steel structure (56 nos)

Jetty: Steel structure (30 Nos) Plinth area (70Sq.m)

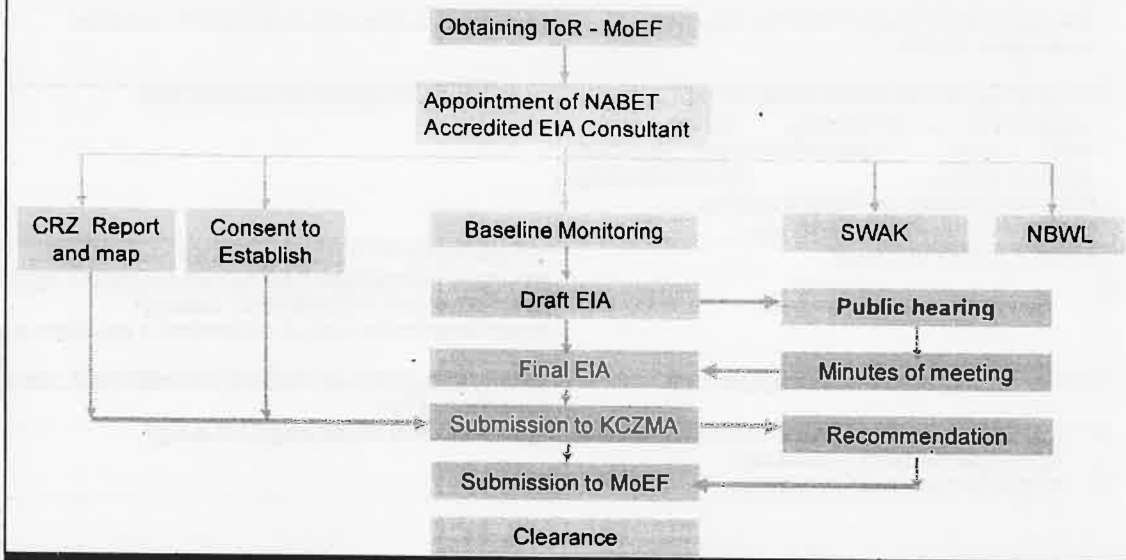


Locks (6 Nos)

FOB: Steel structure (35 nos)

IURWTS

പരിസ്ഥിതി ആഘാത പഠനം



IURWTS

ആമുഖം

പൊതു തെളിവെടുപ്പ്:

- ഇഐഎ വിജ്ഞാപന പ്രകാരം ഐആർഡബ്ല്യുടിഎസ് പ്രോജക്റ്റ് സീരിയൽ. നമ്പർ 7 (ഇ) കാറ്റഗറി എയിൽ ലിസ്റ്റു ചെയ്തിരിക്കുന്നു.
- പാരിസ്ഥിതിക ക്ലിയറൻസ് പ്രക്രിയയുടെ ഭാഗമാണ് പൊതു തെളിവെടുപ്പ്
- വരാനിരിക്കുന്ന പ്രോജക്റ്റിനെക്കുറിച്ചുള്ള ആശങ്കകളെക്കുറിച്ച് ബന്ധപ്പെട്ടവർക്ക് സർക്കാർ ഉദ്യോഗസ്ഥരുമായും പ്രോജക്റ്റ് വക്താവുമായും നേരിട്ട് സംവദിക്കാൻ കഴിയും.
- പൊതുജനങ്ങൾ ഉന്നയിച്ച എല്ലാ അഭിപ്രായങ്ങളും അന്തിമ ഇഐഎ റിപ്പോർട്ടിൽ ചേർത്തതിന് ശേഷം പാരിസ്ഥിതിക അനുമതിക്കായി സമർപ്പിക്കുന്നതായിരിക്കും

2

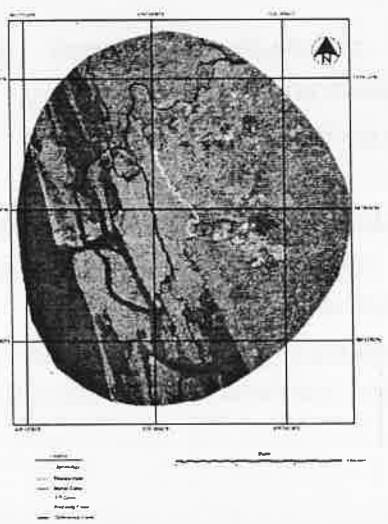
IURWTS

പരിസ്ഥിതി ആഘാത പഠനം

EIA പഠനത്തിനുള്ള നിബന്ധനകളുടെ പരാമർശം (TOR)	MoEF&CC .10-23/2020-IA-III തീയതി 13.05.2020
പ്രാഥമിക വിവര ശേഖരത്തിനായി ഫീൽഡ് പഠനങ്ങൾ. പ്രധാനമായും വായു , ജലം , മണ്ണ്, ശബ്ദം ഗുണനിലവാരം കൂടാതെ കരയിലെയും, ജലത്തിലെയും ജീവജാലങ്ങളെ പറ്റിയുള്ള പഠനം. (ശുദ്ധ ജലവും സമുദ്ര ജലവും)	സെപ്റ്റംബർ മുതൽ നവംബർ 2020
ജല ജീവി വൈവിധ്യം	ഡിപ്പാർട്ട്മെൻ്റ് ഓഫ് മറൈൻ ബയോളജി, മൈക്രോബയോളജി, ബയോകെമിസ്ട്രി, സ്കൂൾ ഓഫ് മറൈൻ സയൻസസ്, കൊച്ചി യൂണിവേഴ്സിറ്റി ഓഫ് സയൻസ് & ടെക്നോളജി (കുസാറ്റ്)
HTL/LTL അതിർത്തി രേഖപ്പെടുത്തൽ	ഇൻസ്റ്റിറ്റ്യൂട്ട് ഓഫ് റിമോട്ട് സെൻസിംഗ് , അണ്ണാ യൂണിവേഴ്സിറ്റി
• ചുറ്റുമുള്ള വായുവിന്റെ ഗുണനിലവാരം • ഭൂഗർഭജലംഗുണനിലവാരം • മണ്ണിന്റെ ഗുണനിലവാരം	സ്റ്റാൻഡേർഡ് ലബോറട്ടറി കൊച്ചി

IURWTS

അടിസ്ഥാന പരിസ്ഥിതി നിലവാരം

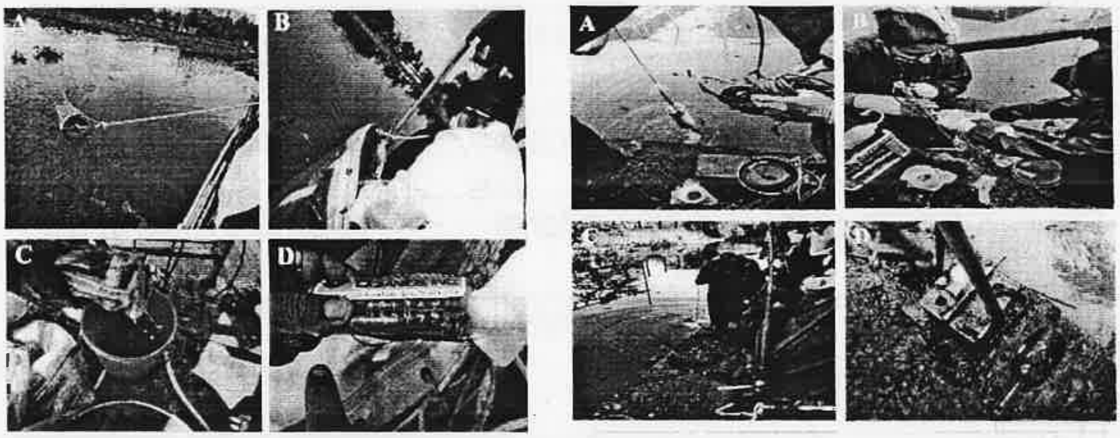


പദ്ധതി പ്രദേശത്തിന്റെ 10 കിലോ മീറ്റർ ആരത്തിലായിരിക്കും പഠന മേഖല

Aspect	Mode of Data Collection	Parameters Monitored
ഭൂമിയുടെ ഉപയോഗം	പ്രാഥമിക ഉറവിടം	ഭൂവിനിയോഗ മാതൃക
കാലാവസ്ഥാവ്യരണം	പ്രാഥമിക ദ്വിതീയ ഉറവിടം	താപനില, ഈർപ്പം, മഴ (സെപ്റ്റംബർ മുതൽ നവംബർ 2020)
ചുറ്റുമുള്ള വായുവിന്റെ ഗുണനിലവാരം	പ്രാഥമിക ഉറവിടം	PM10, PM2.5 ,SO2, NO2 (സെപ്റ്റംബർ മുതൽ നവംബർ 2020)
ശബ്ദം	പ്രാഥമിക ഉറവിടം	സമയാസമയങ്ങളായ പകലും രാത്രിയിലുമുള്ള ശബ്ദ നില.
ജല ജീവി വൈവിധ്യം	പ്രാഥമിക ഉറവിടം	ഭൗതിക- രസതന്ത്ര , ജീവശാസ്ത്രപരമായ ഘടകങ്ങൾ (സെപ്റ്റംബർ മുതൽ നവംബർ 2020)
ജല ജീവി വൈവിധ്യം	പ്രാഥമിക ദ്വിതീയ ഉറവിടം	Presence and abundance of various Planktons, Benthos (സെപ്റ്റംബർ മുതൽ നവംബർ 2020)
ഭൗമ പരിസ്ഥിതി	പ്രാഥമിക ദ്വിതീയ ഉറവിടം	സസ്യജാലങ്ങളും മൃഗങ്ങളും

IURWTS

അടിസ്ഥാന പരിസ്ഥിതി നിലവാരം



നിരീക്ഷണങ്ങളുടെ ചിത്രം

IURWTS

അടിസ്ഥാന പരിസ്ഥിതി നിലവാരം

ജല ജീവി വൈവിധ്യം

- **മിക്ക കനാലുകളിലും ജലത്തിന്റെയും അവശിഷ്ടത്തിന്റെയും ഗുണനിലവാരം മോശമായിരുന്നു.**
- **എല്ലാ കനാലുകളിലും കുറഞ്ഞ അളവിലുള്ള അലിഞ്ഞ ഓക്സിജൻ (ഡി ഒ) നില രേഖപ്പെടുത്തിയിട്ടുണ്ട്, അതേസമയം ബി ഒ ഡി നില കൂടുതലായിരുന്നു**
- **കനാലുകളിൽ നിന്നുള്ള മത്സ്യ സമ്പത്ത്, ജല മാക്രോഫൈറ്റുകൾ പൊതുവെ പഠനത്തിന് മോശമായിരുന്നു.**
- **ചിലവന്നൂർ, മാർക്കറ്റ്, ഇടപ്പള്ളി, തേവര- പെരണ്ടൂർ, തേവര കനാലുകളുടെ പാരിസ്ഥിതിക ഗുണനിലവാരവും ജൈവവൈവിധ്യവും വിവിധ പ്രവർത്തനങ്ങളിൽ നിന്നുള്ള മലിനീകരണവും ഗുരുതരമായി ബാധിക്കുന്നു.**

IURWTS

പാരിസ്ഥിതിക ആഘാതകളെ വിലയിരുത്തൽ

- ഉണ്ടാകാനിടയുള്ള പ്രതികൂല പ്രത്യാഘാതങ്ങൾ മൊത്തത്തിൽ ഇല്ലാതാക്കുകയോ, സാധ്യമായ പരിധി വരെ കുറയ്ക്കുകയോ ചെയ്യുന്നുവെന്ന് ഉറപ്പാക്കുന്നതിന് പരിസ്ഥിതി പരിപാലന പദ്ധതി (ഇഎംപി) നിർദ്ദേശിച്ചിട്ടുണ്ട്.

- നിർദ്ദിഷ്ട പദ്ധതിക്കായുള്ള പരിസ്ഥിതി പരിപാലന പദ്ധതി (ഇഎംപി) ഇനിപ്പറയുന്ന വിഭാഗങ്ങളായി തിരിച്ചിരിക്കുന്നു
  - ഭൂ പരിസ്ഥിതി
  - ജല പരിസ്ഥിതി
  - വായു പരിസ്ഥിതി
  - ശബ്ദത്തിൻറെ നിയന്ത്രണം
  - ഹരിത വലയ വികസനം
  - സാമൂഹിക സാമ്പത്തിക പരിസ്ഥിതി

IURWTS

പാരിസ്ഥിതിക ആഘാതകളെ വിലയിരുത്തൽ

ഭൗമ പരിസ്ഥിതി

നിർമ്മാണ

- പ്രദേശം വൃത്തിയാക്കൽ , നിലം നികത്തൽ , അടിത്തറ നിർമിക്കുന്നതിന് വേണ്ടിയുള്ള ഉത്ഖനനം, നിർമ്മാണ പ്രവർത്തനം എന്നിവ അവശിഷ്ടങ്ങളും, നിർമ്മാണ മാലിന്യങ്ങളും ഉണ്ടാകുവാൻ കാരണമാകുന്നു.
-
- നിർദിഷ്ട പദ്ധതിക്കായി ഏറ്റെടുത്ത പ്രദേശത്തു പ്രത്യേകതയുള്ള സസ്യങ്ങൾ ഇല്ലാത്തതിനാൽ, പ്രധാന ആഘാതങ്ങൾ ഉണ്ടാവുന്നില്ല.

IURWTS

പാരിസ്ഥിതിക ആഘാതകളെ വിലയിരുത്തൽ

ഭൗമ പരിസ്ഥിതി

പ്രവർത്തന ഘട്ടം

- നിർദിഷ്ട ബോട്ട് ജെട്ടിയുടെ പ്രവർത്തനം ഈ പ്രദേശത്തെ മറ്റു അനുബന്ധ പ്രവർത്തനങ്ങൾക്ക് ഊർജം പകരും. ടെർമിനലുകളിലും പരിസര പ്രദേശത്തും കടക്കാർ, ഭക്ഷണ ശാലകൾ തുടങ്ങിയവ അനേകം വികസന പ്രവർത്തനങ്ങളെ പ്രോത്സാഹിപ്പിക്കും
- ഖര മാലിന്യങ്ങളിൽ പ്രധാനമായും പ്ലാസ്റ്റിക്കുകൾ, പോളിത്തീൻ, പൊതിയാനുപയോഗിക്കുന്ന വസ്തുക്കൾ എന്നിവയാണ്.

IURWTS

പാരിസ്ഥിതിക ആഘാതകളെ വിലയിരുത്തൽ

ജല പരിസ്ഥിതി

നിർമ്മാണ ഘട്ടം

- നിർമ്മാണ ഘട്ടങ്ങളിൽ പ്രതി ദിനം ഉണ്ടായേക്കാവുന്ന മലിന ജലത്തിന്റെ അളവ് 132.2 ഘന മീറ്റർ ആയിരിക്കും.
- നിർമ്മാണ ഘട്ടങ്ങളിൽ ഉണ്ടാകുന്ന ഗാർഹിക മാലിന്യങ്ങളിൽ പ്രധാനമായും പച്ചക്കറിയുടെ അവശിഷ്ട്ടങ്ങൾ കൂടാതെ കടലാസ് കാർഡ് ബോർഡ് പോളിത്തീൻ , പൊതിയനുപയോഗിക്കുന്ന വസ്തുക്കൾ ,മരപ്പലകകൾ, കക്കൂസ് മാലിന്യം മറ്റു മലിന ജലം എന്നിവയാണ്.
- ഡ്രെഡ്ജിങ്ങും മറ്റു നിർമ്മാണ പ്രവർത്തനങ്ങളും സാധാരണ ഗതിയിൽ കലങ്ങിയ ജലോപരിതലത്തിന് കാരണമായേക്കാം ,എന്നാൽ ഡ്രെഡ്ജിങ് സമയത്തു ഉണ്ടായേക്കാവുന്ന ജലത്തിന്റെ കലങ്ങിയ അവസ്ഥ ഒരു ഹ്രസ്വകാല ആഘാതം മാത്രമാണ്.
- ചെറിയ അളവിൽ മാത്രമുള്ള ഇത്തരം ഡ്രെഡ്ജിങ് ചെയ്ത അവക്ഷിപ്പങ്ങൾ നിക്ഷേപിക്കുന്നത് ഭയാനകമായ പ്രത്യാഘാതങ്ങൾക്ക് കാരണമാകില്ല എന്ന് വിശദമായ പഠനങ്ങൾ വ്യക്തമാകുന്നത് .

IURWTS

പാരിസ്ഥിതിക ആഘാതകളെ വിലയിരുത്തൽ

ജല പരിസ്ഥിതി

പ്രവർത്തന ഘട്ടം

- പ്രവർത്തന ഘട്ടത്തിൽ ഈ പ്രദേശത്ത് ബോട്ട് നീക്കങ്ങൾ ഉണ്ടാകും. ബോട്ട് വിദ്യുദീകരിച്ചതും ടോയ്ലെറ്റ് ഇല്ലാത്തതും ആകുന്നു. ഈ പ്രവർത്തനങ്ങളെല്ലാം ജല ജീവികളിൽ ചെറിയ സ്വാധീനം ചെലുത്തിയേക്കാം.
- പദ്ധതിയുടെ ഭാഗമായി കനാലിലേക്ക് വരുന്ന എല്ലാ മലിനജലവും മലിനജല ശൃംഖലയിലൂടെ തിരിച്ചുവിടുകയും 4 വ്യത്യസ്ത മലിന ജല സംസ്കരണ പ്ലാൻറുകളിൽ സംസ്കരിക്കുകയും ചെയ്യുന്നു.
- ഗാർഹിക മലിനജലത്തിന്റെ ഘടനാപരമായ ശേഖരണവും സംസ്കരണവും വിവേചനരഹിതമായി പല ജലാശയങ്ങളിലും മലിനജലം കലരുന്നത് തടയുന്നു പദ്ധതിയുടെ ഭാഗമായി ഇത് ഇല്ലാതാവുകയും കനാലുകൾ വൃത്തിയകുകയും ചെയ്യുന്നു.

IURWTS

പാരിസ്ഥിതിക ആഘാതകളെ വിലയിരുത്തൽ

വായുവിലുണ്ടായേക്കാവുന്ന പ്രത്യാഘാതങ്ങൾ

നിർമ്മാണ ഘട്ടം

- നിർദിഷ്ട പദ്ധതിയുടെ നിർമ്മാണ സമയത്ത് പറന്നു പൊന്തുന്ന പൊടിപടലങ്ങളാണ് ആ പ്രദേശത്തെ വായുവിലെ ഗുണനിലവാരത്തിൽ വരുത്തുന്ന ഒരു പ്രധാന ആഘാതം
- വിവിധ നിർമ്മാണ ഉപകരണങ്ങളിൽ ഡീസൽ കത്തിക്കറിയുമ്പോൾ ബഹിർഗമിക്കുന്ന പുക , വായു മലിനീകരണത്തിന് കാരണമാകുന്നതാണ്.

പ്രവർത്തന ഘട്ടം

- പദ്ധതി പ്രവർത്തന ഘട്ടത്തിൽ, പ്രധാന പ്രവർത്തനം യാത്രക്കാരുടെ മാലിന്യങ്ങൾ സംസ്കരിക്കുന്നതിനുള്ള പ്ലാൻറുകളുടെ പ്രവർത്തനവുമാണ്.
- ബോട്ടുകളുടെ പ്രൊപ്പൽഷൻ വൈദ്യുതമായിരിക്കും
- മലിന ജല സംസ്കരണ പ്ലാൻറുകളുടെ പ്രവർത്തനം ചുറ്റുമുള്ള സ്ഥലത്ത് ചെറിയ രീതിയിൽ ദുർഗന്ധം സൃഷ്ടിക്കാൻ സാധ്യത ഉണ്ട്.

IURWTS പാരിസ്ഥിതിക ആഘാതകളെ വിലയിരുത്തൽ

ശബ്ദ പരിസ്ഥിതിയിൽ വരുന്ന ആഘാതം

നിർമ്മാണ ഘട്ടം

- നിർമ്മാണ ഘട്ടത്തിലെ ശബ്ദത്തിന്റെ ഉറവിടം നിർമ്മാണ ഉപകരണങ്ങളുടെ പ്രവർത്തനം മൂലമാണ് ഉണ്ടാകുന്നത്.
- നിർമ്മാണ സാമഗ്രികൾ തുടർച്ചയായി വാഹനങ്ങളിൽ കൊണ്ടുപോകുന്നത് വഴി വാഹന ഗതാഗതത്തിന്റെ അളവിൽ നേരിയ വർധനവുണ്ടാവാൻ സാധ്യതയുണ്ട്

പ്രവർത്തന ഘട്ടം

- പാസഞ്ചർ ബോട്ട് ഗതാഗതം മാത്രം ഉൾപ്പെട്ടിരിക്കുന്നതിനാൽ നിർദ്ദിഷ്ട പദ്ധതിയുടെ പ്രവർത്തന ഘട്ടത്തിൽ ശബ്ദ പരിതസ്ഥിതിയിൽ പ്രതികൂല പ്രത്യാഘാതങ്ങളൊന്നും പ്രതീക്ഷിക്കുന്നില്ല.

IURWTS സാമൂഹിക സാമ്പത്തിക പരിസ്ഥിതി - ആഘാതങ്ങളും ഗുണങ്ങളും

സാമൂഹിക സാമ്പത്തിക പരിസ്ഥിതിയിൽ ഉണ്ടായേക്കാവുന്ന ആഘാതങ്ങളും ഗുണങ്ങളും

നിർമ്മാണ ഘട്ടം

- താൽക്കാലിക തൊഴിലവസരങ്ങൾ സൃഷ്ടിക്കപ്പെടുന്നതുമൂലം തദ്ദേശവാസികളുടെ വരുമാന നിലവാരത്തെ താൽക്കാലികമായി ഉയർത്തും
- നിർമ്മാണ സാമഗ്രികൾ എത്തിച്ചുകൊടുക്കുന്നതിനായി പ്രാദേശിക വ്യവസായികൾക്ക് അവസരം ലഭിക്കും.
- സൈറ്റിൽ നിന്ന് ജോലി ചെയ്യുന്ന തൊഴിലാളികളുടെ നിത്യോപയോഗ സാധനങ്ങൾക്കായുള്ള ആവശ്യം വർധിക്കുന്നതിനാൽ പ്രാദേശിക വ്യവസായം മെച്ചപ്പെടും.
- താൽക്കാലികമായോ സ്ഥിരമായോ ഉണ്ടായേക്കാവുന്ന ഇത്തരത്തിലുള്ള ഏതൊരു വികസനവും പ്രദേശവാസികളെയും കുടുംബത്തെയും സഹായിക്കുന്ന രീതിയിലായിരിക്കും.

IURWTS സാമൂഹിക സാമ്പത്തിക പരിസ്ഥിതി - ആഘാതങ്ങളും ഗുണങ്ങളും

സാമൂഹിക സാമ്പത്തിക പരിസ്ഥിതിയിൽ ഉണ്ടായേക്കാവുന്ന ആഘാതങ്ങളും ഗുണങ്ങളും
പ്രവർത്തന ഘട്ടം

- സർക്കാരിന്റെ ദീർഘകാല വികസന സംരംഭങ്ങളിലൊന്നാണ് നിർദ്ദിഷ്ട പദ്ധതി. കഴിഞ്ഞ രണ്ട് വർഷത്തിനിടയിൽ (2018, 2019) വെള്ളക്കെട്ട് സംഭവിച്ചത് കനാൽ വികസനവുമായി ബന്ധപ്പെട്ട് ആളുകളുടെ മനസ്സിൽ ഒരു മനോഭാവം വരുത്തി.
- പതിവ് ആശയവിനിമയത്തിനായി ഒരു സംവിധാനം വികസിപ്പിക്കുകയും പരാതികൾ പരിഹരിക്കുകയും ചെയ്യുന്നത് കമ്മ്യൂണിറ്റി പങ്കാളിത്തം ഉറപ്പാക്കികൊണ്ട് പ്രത്യാഘാതത്തെ ലഘൂകരിക്കാവുന്നതാണ്.

IURWTS പരിസ്ഥിതി പരിപാലന പരിപാടി

ഭൂമി
നിർമ്മാണ ഘട്ടം

- ചരിഞ്ഞ പ്രദേശങ്ങൾ നിരപ്പാക്കുമ്പോഴുണ്ടാകുന്ന മണ്ണ് കല്ല് എന്നിവ താണ മേഖലകൾ നിരപ്പാക്കുന്നതിനും ഉറപ്പുവരുത്തുന്നതിനും വേണ്ടി ഉപയോഗിക്കുന്നതാണ്
- നിർമ്മാണ പ്രവർത്തനങ്ങൾ കഴിഞ്ഞാലുടൻ തന്നെ, അധികം വരുന്ന സാമഗ്രികൾ, നിർമ്മാണ മാലിന്യങ്ങൾ, പെട്ടികൾ, സംഭരണികൾ, ഡ്രമ്മുകൾ എന്നിവ സൈറ്റിൽ നിന്നും ഒഴിവാക്കുകയും മുൻകൂട്ടി നിശ്ചയിച്ചിട്ടുള്ള സ്ഥലങ്ങളിലേക്ക് എത്തിക്കുന്നതുമായിരിക്കും.
- നിർമാണ സമയത്ത് ഖരമാലിന്യ നിർമാർജ്ജനം, ഖരമാലിന്യങ്ങൾ കുറക്കുക, പുനരുപയോഗിക്കുക, പുനചക്രമണം ചെയ്യുക എന്നീ തത്വത്തെ അടിസ്ഥാനമാക്കിയായിരിക്കും പ്രാവർത്തികമാക്കുന്നത്.

പ്രവർത്തന ഘട്ടം

- ഖരമാലിന്യ ശേഖരണം, വിതരണം, എന്നിവയ്ക്കായി വേണ്ട സൗകര്യങ്ങൾ വികസിപ്പിക്കും. ജൈവമായതും അല്ലാത്തതുമായ ഖരമാലിന്യങ്ങൾ സൂക്ഷിക്കാൻ വെവ്വേറെ ബിന്നുകൾ തയ്യാറാക്കുകയും ചെയ്യും

IURWTS

പരിസ്ഥിതി പരിപാലന പരിപാടി

ജലം

നിർമ്മാണ ഘട്ടം

- നിർമ്മാണ തൊഴിലാളികൾക്കായി വേണ്ടത്ര ശുചീകരണ സൗകര്യങ്ങളും സഞ്ചരിക്കുന്ന ശൗച്യാലയങ്ങളും നൽകുന്നതായിരിക്കും .
- നിർമ്മാണ തൊഴിലാളികൾക്കായി കുടിവെള്ള സൗകര്യം ഉറപ്പുവരുത്തുന്നതായിരിക്കും
- പ്രാദേശിക ഭരണ നിർവഹണ വിഭാഗവുമായി ബന്ധപ്പെട്ടുകൊണ്ട് തൊഴിലിടങ്ങളിലെ ഖരമാലിന്യ നിർമാർജ്ജനം ഉറപ്പുവരുത്തുന്നതാണ്
- ചളി നീക്കം ചെയ്യുമ്പോൾ വളരെ നേരിയ കലക്കൽ മാത്രം ഉണ്ടാകുന്ന തരത്തിലുള്ള നൂതന ഡ്രഡ്ജറുകൾ ഉപയോഗിക്കുന്നതായിരിക്കും

IURWTS

പരിസ്ഥിതി പരിപാലന പരിപാടി

ജലം

നിർമ്മാണ ഘട്ടം

- എല്ലാ ഡ്രെഡ്ജിങ് ഉപകരണങ്ങളും ബാർജുകളും നന്നായി ഉപയോഗിക്കാവുന്ന രീതിയിൽ നിലനിർത്തേണ്ടതാണ്.
- ഗതാഗത സമയത്ത് കുറഞ്ഞ തോതിലുള്ള നഷ്ടം ഉറപ്പാക്കാൻ ഹോപ്പർ ഡോർ സീൽ ശരിയായ രീതിയിൽ പരിപാലിക്കുന്നതാണ് .
- കാലാവസ്ഥക്ക് അനുകൂലമായി മാത്രമേ ഡ്രെഡ്ജിങ് പ്രവർത്തങ്ങൾ നടത്തുകയുള്ളൂ. പരിസ്ഥിതി ലോല മേഖലകളിലേക്ക് അവക്ഷിപ്തങ്ങൾ ഒലിച്ചുപോകാത്ത രീതിയിലായിരിക്കും ഡ്രെഡ്ജിങ് സമയം നിശ്ചയിക്കുന്നത്.
- മത്സ്യങ്ങളുടെ പ്രജനനം നടക്കുന്ന സമയങ്ങൾ ഒഴിവാക്കികൊണ്ടായിരിക്കും ഡ്രെഡ്ജിങ് ചെയ്യുന്നത്.
- ജലാശയത്തിന്റെ അടിത്തട്ടിലുണ്ടായേക്കാവുന്ന കലക്കം ഒഴിവാക്കുന്നതിന് വേണ്ടി ഡ്രെഡ്ജിങ് ചെയ്യാത്ത സമയങ്ങളിൽ സെക്ഷൻ ഹെഡ് ഉയർത്തിവക്കുന്നതായിരിക്കും

IURWTS

പരിസ്ഥിതി പരിപാലന പരിപാടി

വായു

നിർമാണ ഘട്ടം

- നിർമ്മാണ പ്രവർത്തന മേഖലയിലുള്ള എല്ലാ വാഹനങ്ങൾക്കും പൊലൂഷൻ അണ്ടർ കണ്ട്രോൾ സർട്ടിഫിക്കറ്റ് നിർബന്ധമാക്കും. നിർമ്മാണ പ്രവർത്തന മേഖലയിൽ നിന്നുള്ള പൊടിയുടെ ഉദ്വമനം തടയുന്നതിന് വേണ്ടി വെള്ളം തളിക്കുന്നതായിരിക്കും

- നിർമ്മാണ പ്രവർത്തന മേഖലയിൽ ഉപയോഗിക്കുന്ന എല്ലാ ഡീസൽ ജനറേറ്ററുകൾക്കും കേരള സ്റ്റേറ്റ് പൊലൂഷൻ കണ്ട്രോൾ ബോർഡിൻറെ കൺസെന്റ് ഉണ്ടായിരിക്കുന്നതാണ്. എല്ലാ ഡീസൽ ജനറേറ്ററുകൾക്കും പുകക്കുഴൽ നിർബന്ധമായും ഉണ്ടായിരിക്കുന്നതാണ്.

- വായു മലിനീകരണം കുറേക്കുന്നതിനാവശ്യമായ ബാരിയറുകൾ സ്ഥാപിക്കുന്നതാണ്

IURWTS

പരിസ്ഥിതി പരിപാലന പരിപാടി

ശബ്ദം

നിർമാണ ഘട്ടം

- വാഹന നിർമ്മാതാക്കൾ ശുപാർശ ചെയ്യുന്നതരം മഫ്ളറുകൾ വാഹനങ്ങളിൽ ഉപയോഗിക്കുന്നതായിരിക്കും
- നോയ്സ് സെൻസിറ്റീവ് സ്ഥലങ്ങളിൽ നിർമ്മാണ ഉപകരണങ്ങൾ സ്ഥാപിക്കുന്നതും വാഹനങ്ങൾ വെറുതെ നിർത്തിയിടുന്നതും ഒഴിവാക്കും
- നിർമാണ സമയങ്ങളിൽ ശബ്ദമലിനീകരണത്തിന്റെ തോത് അളന്നു രേഖ പെടുത്തുന്നതായിരിക്കും ഏതെങ്കിലും കാരണത്താൽ നിർമാണത്തിനു ഉപയോഗിക്കുന്ന യന്ത്രങ്ങളിൽ നിന്ന് മുൻ നിശ്ചയിച്ചിട്ടുള്ള ശബ്ദത്തിന്റെ തോതിനെക്കാൾ ശബ്ദം വരികയാണെകിൽ അവയുടെ പ്രവർത്തനം നിർത്തി വക്കുകയും അറ്റകുറ്റ പണികൾക്ക് ശേഷം മാത്രം പ്രവർത്തിക്കുകയും ചെയ്യുന്നതാണ്.
- നിർമ്മാണ പ്രവർത്തനങ്ങൾ പകൽ സമയം മാത്രമായി നിജപ്പെടുത്തും. നിർമ്മാണ മേഖലകൾക്ക് ചുറ്റും ബാരികേടുകൾ സ്ഥാപിക്കും

IURWTS

പരിസ്ഥിതി പരിപാലന പരിപാടി

മരങ്ങളും ചെടികളും നട്ടുപിടിപ്പിക്കൽ

- നിർദിഷ്ട പദ്ധതി പ്രദേശത്തു ചുറ്റുമായി മരങ്ങളും ചെടികളും നട്ടുപിടിപ്പിക്കുന്നതായിരിക്കും

IURWTS

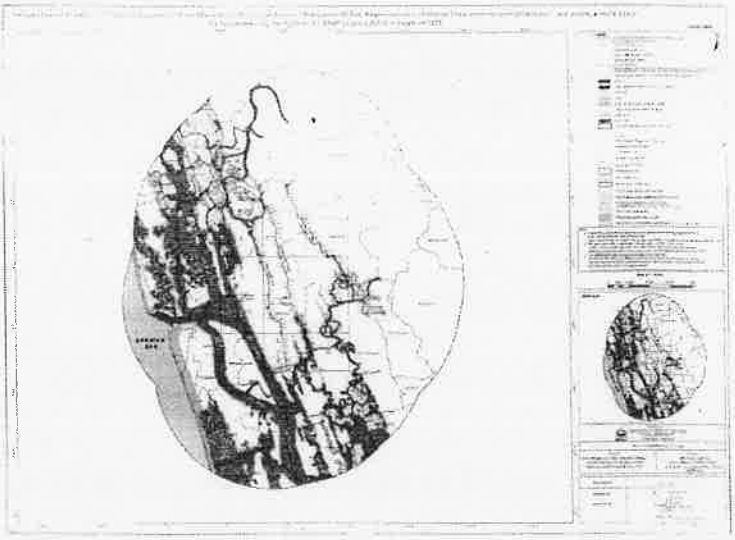
പുനരധിവാസവും പുനഃസ്ഥാപനവും (R&R)

- പുനരധിവാസവും പുനഃസ്ഥാപനവും LARRA പോളിസി പ്രകാരം നടപ്പാക്കുന്നതായിരിക്കും
- Right to Fair Compensation & Transparency in Land Acquisition, Rehabilitation & Resettlement Act, 2013 (RTFCTLARRA, 2013) , Rehabilitation and Resettlement, (Kerala), Rules, 2015 (LARR Rules)and the World bank guidelines എന്നിവയെ ആസ്പദമാക്കി പോളിസി തയ്യാറാക്കിയിട്ടുണ്ട്
- പുനരധിവാസം പുനഃസ്ഥാപനം പദ്ധതി നടപ്പാക്കുന്നതിന് വേണ്ടി ആവശ്യമായ തുക കണക്കാക്കിയിട്ടുണ്ട്

IURWTS

വേലിയേറ്റ രേഖ/വേലിയിറക്ക രേഖ എന്നിവയുടെ അതിർത്തി നിർണ്ണയം

- പ്രസ്തുത പദ്ധതിയുടെ സി ആർ ഇസെഡ് മാപ്പിംഗ്, പരിസ്ഥിതി, വനം, കാലാവസ്ഥ വ്യതിയാന മന്ത്രാലയത്തിന്റെ അംഗീകാരമുള്ള ചെന്നൈ ആസ്ഥാനമായ അണ്ണാ യൂണിവേഴ്സിറ്റിയുടെ കീഴിലുള്ള ഇന്സ്റ്റിട്യൂറ്റ് ഓഫ് റിമോട്ട് സെൻസിംഗ് എന്ന ഏജൻസിയാണ് ചെയ്തിരിക്കുന്നത്.



IURWTS

പരിസ്ഥിതി ഗുണ നിലവാര അവലോകന പദ്ധതി

നിർമ്മാണ ഘട്ടവും പ്രവർത്തന ഘട്ടവും

ക്രമ നമ്പർ	സ്വഭാവം	അവലോകനം ചെയ്യേണ്ട ഘടകങ്ങൾ	അവലോകനം ചെയ്യേണ്ട ഇടവേള	അവലോകനം ചെയ്യേണ്ട സ്ഥലങ്ങൾ
1.	കായൽ വെള്ളം			
	ഭൗതിക - രാസ ഘടകങ്ങൾ	പിഎച്, സലായ്നിറ്റി, വൈദ്യുത ചാലകത, കലക്കൽ, ഫോസ്ഫൈറ്റ്, നൈട്രൈറ്റ്, സൾഫേറ്റ്, ക്ളോറൈഡ്	മൂന്നു മാസത്തിൽ ഒരിക്കൽ	6-8 സ്ഥലങ്ങൾ
	ജൈവ ഘടകങ്ങൾ	സുതാര്യത, ക്ലോറോഫിൽ, പ്രാഥമിക ഉൽപ്പാദനശേഷി, ഫ്യൂറ്റോപ്ലാങ്ക്ടൺ, സൂപ്ലാങ്ക്ടൺ.	മൂന്നു മാസത്തിൽ ഒരിക്കൽ	6-8 സ്ഥലങ്ങൾ
2.	അവക്ഷിപ്തങ്ങൾ			
	ഭൗതിക - രാസ ഘടകങ്ങൾ	ഇഴകളുടെ വിന്യാസം, പി എച്, സോഡിയം, പൊട്ടാസിയം, ഫോസ്ഫേറ്റ്, ക്ളോറൈഡ്, സൾഫേറ്റ്	മൂന്നു മാസത്തിൽ ഒരിക്കൽ	6-8 സ്ഥലങ്ങൾ
	ജൈവ ഘടകങ്ങൾ	ജലാശയത്തിന്റെ അടിത്തട്ടിലുള്ള ഉരഗങ്ങൾ, ജലാശയത്തിന്റെ അടിത്തട്ടിലുള്ള ജീവജാലങ്ങൾ	മൂന്നു മാസത്തിൽ ഒരിക്കൽ	6-8 സ്ഥലങ്ങൾ
3.	വായുവിന്റെ നിലവാരം	പിഎം$_{2.5}$, പിഎം$_{10}$, സൾഫർ ഡൈ ഓക്സൈഡ്, നൈട്രസ് ഓക്സൈഡ്	മൂന്നു വെത്യസ്ഥ കാലാവസ്ഥകളിൽ ഒരു ആഴ്ചയിൽ രണ്ടു ദിവസം വീതം തൊട്ടടുത്ത നാല് ആഴ്ചകളിൽ	നിർമ്മാണ മേഖലക്ക് അടുത്തുകിടക്കുന്ന സ്ഥലങ്ങളിൽ
4.	ശബ്ദം	സമതുല്യമായ ശബ്ദത്തിന്റെ തോത്	ത്വരിത ഗതിയിൽ നിർമ്മാണ പ്രവർത്തനങ്ങൾ നടന്നുകൊണ്ടിരിക്കുന്ന സമയത്ത്	നിർമ്മാണ മേഖലയിൽ

IURWTS

പരിസ്ഥിതി പരിപാലന പദ്ധതിക്കുള്ള ചെലവ് കണക്കുകൾ

പരിസ്ഥിതി പരിപാലന പദ്ധതിക്കുള്ള ചെലവ് കണക്കുകൾ

ക്രമ നമ്പർ	ഇനം	ബജറ്റ് (ലക്ഷം രൂപ)
1	ലേബർ ക്യാമ്പുകളിലെ ശുചിത്വ സൗകര്യങ്ങൾ	125.00
2	വായു മലിനീകരണ നിയന്ത്രണ നടപടികൾ	30.00
3	സൗജന്യ ഇന്ധനം വിതരണം	49.0
4	ഖരമാലിന്യ പരിപാലനം	94.64
5	അഗ്നിശമന പരിശീലനവും അവബോധവും	30.0
6	പൊതു സൗകര്യങ്ങൾ	30.0
7	ഗ്രീൻ ബെൽറ്റ് വികസനം	30.0
8	ജല ജൈവവൈവിധ്യ പരിപാലന പദ്ധതി	60.0
	മൊത്തം	448.64

IURWTS

പദ്ധതിയുടെ പ്രയോജനങ്ങൾ

- കനാലുകൾ പുനസ്ഥാപിക്കുന്നതിലൂടെ റെയിൽ മെട്രോ, വാട്ടർ മെട്രോ എന്നിവയുമായി ഇന്റർമോഡൽ കണക്റ്റിവിറ്റി മെച്ചപ്പെടുത്തുക.
- വെള്ളപ്പൊക്ക ലഘൂകരണവും വെള്ളപ്പൊക്ക സമതല പരിപാലനവും.
- കനാൽ വികസനം വിനോദത്തിനും വിനോദസഞ്ചാരത്തിനുമായി മനോഹരമായി പുൽത്തകിടി വച്ചുപിടിപ്പിച്ച കനാൽ പരിസരങ്ങൾ, മനോഹരമായ കടകൾ, ഭക്ഷണശാലകൾ എന്നിവ കനാൽ തീരങ്ങളിൽ നഗരചൈതന്യം സൃഷ്ടിക്കുന്നതിനും ഉപജീവന അവസരങ്ങൾ വർദ്ധിപ്പിക്കുന്നതിനും സഹായിക്കും. ഇത് നഗരത്തിന്റെ ഛായ കൂടുതൽ മെച്ചപ്പെടുത്തും
- ശുചിത്വ സൗകര്യങ്ങളും മലിനജല നിർമാർജന സംവിധാനവും പ്രോജക്ട് കമാൻഡിലെ നിവാസികൾക്ക് സേവനം നൽകുന്നു.
- മാലിന്യം തള്ളുന്നത് നിയന്ത്രിക്കുക, കയ്യേറ്റങ്ങൾ നിയന്ത്രിക്കുക, മലിനജല മിശ്രണം നിർത്തുക തുടങ്ങിയവ.
- കനാൽ വാട്ടർഫ്രണ്ടിന്റെ മെച്ചപ്പെട്ട ഉപയോഗം പ്രദേശവാസികൾക്ക് സാമൂഹികവും സാമ്പത്തികവുമായ പ്രവർത്തനങ്ങളുടെ സ്വാഭാവിക ആകർഷണമാകും

IURWTS

നന്ദി....
എല്ലാവർക്കും....

അനുബന്ധം - 3

Gmail

KSPCB DO1 <pcbdo1publichearing@gmail.com>

Question and concern regarding "Integrated Urban Regeneration and Water Transport System (IURWTS)"

2 messages

suni mole <sunimolenk@gmail.com> Sun, Mar 14, 2021 at 1:19 PM
To: pcbdo1publichearing@gmail.com

To
Sri. Baiju M.A,
Cheif Environmental Engineer,
Regional Office,
Kerala State Pollution Control Board,
Gandhi Nagar, Ernakulam-682020

Sir,

Ref: Advertisement in Mathrubhumi daily dated 13th February, 2021.
Enclosed are my question regarding the project mentioned in the subject line:

1. നിയമസഭാ തിരഞ്ഞെടുപ്പുമായി ബന്ധപ്പെട്ട്ട പെരുമാറ്റച്ചട്ടം നിലവിലുള്ളപ്പോൾ മാർച്ച് 16 നു നടത്തുന്ന പബ്ലിക് ഹിയർങിന് നിയമപരമായ സാധുത ഉണ്ടോ ? ഇതിനു തിരഞ്ഞെടുപ്പ് കംമീഷന്റെ അനുമതി ലഭിച്ചിട്ടുണ്ടോ ?
2. പദ്ധതി ക്കു വേണ്ടി കുടിയിറക്കേണ്ടി വരുന്നവരെ പുനരധി വസിപ്പിക്കുന്നതിന് ഏതെങ്കിലും സ്ഥലം കണ്ടെത്തിയിട്ടുണ്ടോ ? അവിടെ പുതിയ വീട് നിർമിച്ചു നൽകുമോ ? അവിടെ എന്തെല്ലാം അടിസ്ഥാന സൗകര്യങ്ങൾ ആണ് ഉണ്ടാവുക?

3. കൊച്ചി കോർപറേഷൻ പരിധിക്കുള്ളിൽ ധാരാളം ഒഴിഞ്ഞ ഭൂമി ഉള്ളപ്പോൾ എന്തുകൊണ്ടാണ് അത് പരിഗണിക്കാതെ പുനരധിവാസത്തിനായി കോര്പ്പറേഷന് സ്ഥലം ഏറ്റെടുത്ത് ?
4. പുനഃരധിവസിക്കപെടുന്നവർ തങ്ങൾക്കു ലഭിക്കുന്ന സ്ഥലം നിരസിക്കാൻ സാധിക്കുമോ ? അതിനു നിയമപരമായ സാധുത ഉണ്ടോ ? അങ്ങനെ വന്നാൽ പകരം സ്ഥലം കൊടുക്കുമോ ? അത് എവിടെയാവും?

I request you to kindly address these concerns during the public hearing proposed on 16th March

Thanks and regards
Sunimole N.K.

KSPCB DO1 <pcbdo1publichearing@gmail.com> Mon, Mar 15, 2021 at 11:17 AM
To: Nishad.Narayanan@anteagroup.com, ajith.nair@kmrl.co.in
Cc: ernakulamdc@gmail.com, m2dcekm@gmail.com, pcbroekm@gmail.com, ms.kspcb@gov.in

Sir,
Kindly see the questions received from the public related to the public hearing on 16.03.2021.
Please reply to the queries raised on the project during the hearing.
[Quoted text hidden]

Gmail

KSPCB DO1 <pcbdo1publichearing@gmail.com>

Question and concern regarding "Integrated Urban Regeneration and Water Transport System".

2 messages

Deva Dathan <devadathan96@gmail.com> — Sun, Mar 14, 2021 at 1:05 PM
To: pcbdo1publichearing@gmail.com

To
Sri. Baiju M.A,
Cheif Environmental Engineer,
Regional Office,
Kerala State Pollution Control Board,
Gandhi Nagar, Ernakulam-682020
email: pcbdo1publichearing@gmail.com

Sir,
Sub: Question and concern regarding "Integrated Urban Regeneration and Water Transport System (IURWTS)"
Ref: Advertisement in Mathrubhumi daily dated 13th February, 2021.
Enclosed are my question regarding the project mentioned in the subject line:

1. നിയമസഭാ തിരഞ്ഞെടുപ്പുമായി ബന്ധപ്പെട്ട്ട പെരുമാറ്റച്ചട്ടം നിലവിലുള്ളപ്പോൾ മാർച്ച് 16 നു നടത്തുന്ന പബ്ലിക് ഹിയർങിന് നിയമപരമായ സാധുത ഉണ്ടോ ?
2. Resettlement and Rehabilitation എന്നത് പലപ്പോഴും ബന്ധപ്പെട്ട അധികാരികൾ ഒന്നായി കണക്കാക്കുന്നു. രണ്ടും വ്യത്യസ്തമാണെന്ന് മനസ്സിലാക്കാൻ അധികാരികൾ പരാജയപ്പെടുന്നു. Resettlement എന്നത് ഭൗതികമായ പ്രക്രിയയാണ് . എന്നാൽ Rehabilitation (പുനരധിവാസം) , ആളുകളുടെ ഭൗതികവും സാമ്പത്തിക വുമായ ഉപജീവന മാർഗം, അവരുടെ സ്വത്തുക്കൾ, സാംസ്കാരികവും സാമൂഹികവുമായ ബന്ധങ്ങൾ എന്നിവ പുനഃസ്ഥാപിക്കൽ, പുനരധിവാസ സമയത്ത് മന ശാസ്ത്രപര മായി മാറിയ സാഹചര്യത്തിന്റെ സ്വീകാര്യത ഉറപ്പാക്കൽ ഇതെല്ലം ഉൾക്കൊള്ളുന്നു ....കേവലം resettlement എന്നതിലുപരി rehabiltation എന്ന വിശാലമായ തലത്തിൽ ഈ പ്രൊജക്റ്റ് നടപടികൾ സ്വീകരിക്കുന്നുണ്ടോ ?
3. പുനഃരധിവസിക്കപെടുന്ന പുതിയ സ്ഥലത്തു ഉടമസ്ഥാവകാശം ഉണ്ടായിരിക്കുമോ ?
4. പുനഃരധിവസിക്കപെടുന്ന പുതിയ സ്ഥല ത്തിന്റെ ഉടമസ്ഥാവകാശം കൈമാറ്റം ചെയ്യാൻ സാധിക്കുമോ? സ്ഥലം വിൽക്കാൻ എന്തെകിലും നിയമ തടസം ഉണ്ടോ?

I request you to kindly address these concerns during the public hearing proposed on 16th March.
Thanks and regards
Devadathan S

KSPCB DO1 <pcbdo1publichearing@gmail.com> — Mon, Mar 15, 2021 at 11:16 AM
To: Nishad.Narayanan@anteagroup.com, ajith.nair@kmrl.co.in
Cc: ernakulamdc@gmail.com, m2dcekm@gmail.com, pcbroekm@gmail.com, ms.kspcb@gov.in

Sir,
Kindly see the questions received from public related to the public hearing on 16.03.2021.
Please give reply to the queries raised on the project during the hearing.
[Quoted text hidden]

Gmail KSPCB DO1 <pcbdo1publichearing@gmail.com>

Question and concenrn regarding “Integrated Urban Regeneration and Water Transport System (IURWTS)’

2 messages

Santhosh A K <aksanthu@gmail.com> Sun, Mar 14, 2021 at 10:28 AM
To: pcbdo1publichearing@gmail.com

To

Sri. Baiju M.A,

Cheif Environmental Engineer,

Regional Office,

Kerala State Pollution Control Board,

Gandhi Nagar, Ernakulam-682020

email: pcbdo1publichearing@gmail.com

Sir,

Sub: Question and concenrn regarding “Integrated Urban Regeneration and Water Transport System (IURWTS)’

Ref: Advertisement in Malayala Manorama dated 13th February, 2021.

I have the following question regarding the project mentioned in the subject line:

Questions:

1. കാലാവസ്ഥാ പ്രതിരോധശേഷിയുള്ള അടിസ്ഥാന സൗകര്യങ്ങൾ (Climate-Resilient Infrastructure: Adaptive Design and Risk Management)എന്നത് ഇപ്പോൾ ആഗോളതലത്തിൽ പ്രാവർത്തിക മാക്കി വരുന്ന വികസന മാർഗമാണ്. ഈ പദ്ധതിയിൽ ഡിസൈൻ ഈ തലത്തിൽ ആണോ നടത്തിയിട്ടുള്ളത് ?

2. വെള്ളപ്പൊക്ക നിവാരണം ഈ പ്രോജക്ടിന്റെ ഒരു പ്രധാന ലക്ഷ്യം ആണെന്ന് മനസ്സിലാക്കുന്നു . കൊച്ചി നഗര സഭയുടെ കീഴിൽ വരുന്ന പ്രധാന വെള്ളപ്പൊക്ക മേഖലകൾ പദ്ധതിയുടെ ഭാഗമായി പഠന വിധേയമാക്കിയിട്ടുണ്ടോ ? കനാലിനു സമീപത്തല്ലാത്ത വെള്ളപ്പൊക്ക മേഖലകൾ ഉണ്ടോ ? ഉണ്ടെങ്കിൽ അവിടം എങ്ങനെയാണ് വെള്ളപ്പൊക്ക വിമുക്ത മേഖല ആക്കുന്നത് ?

Thanks and regards

Santhosh A K

9447475859

KSPCB DO1 <pcbdo1publichearing@gmail.com> Mon, Mar 15, 2021 at 11:14 AM
To: Nishad.Narayanan@anteagroup.com, ajith.nair@kmrl.co.in
Cc: ernakulamdc@gmail.com, m2dcekm@gmail.com, pcbroekm@gmail.com, ms.kspcb@gov.in

Sir,
Kindly see the questions received from public related to the public hearing on 16.03.2021.

Gmail

KSPCB DO1 <pcbdo1publichearing@gmail.com>

Question and concern regarding "Integrated Urban Regeneration and Water Transport System (IURWTS)"

2 messages

Nirmala V U <vunirmala@gmail.com> Mon, Mar 15, 2021 at 2:16 PM

To: pcbdo1publichearing@gmail.com

To

Sri. Baiju M.A,

Cheif Environmental Engineer,

Regional Office,

Kerala State Pollution Control Board,

Gandhi Nagar, Ernakulam-682020

Sir,

Please see my question regarding the project mentioned in the subject line:

1. ഈ പ്രൊജക്റ്റ് നടപ്പിലായാൽ കൊച്ചി കോർപ്പറേഷൻ പരിധിയിൽ ഇപ്പോൾ സ്ഥിരം വെള്ളപ്പൊക്കം ഉണ്ടാകുന്ന മേഖലകളിൽ തുടർന്ന് വെള്ളപ്പൊക്കം ഉണ്ടാകില്ല എന്ന് ഉറപ്പു പറയാനാകുമോ ?

2. ആഗോള കാലാവസ്ഥാ വ്യതിയാനവും സമുദ്ര നിരപ്പിൽ (MSL) ഉണ്ടാകുന്ന വർധനവും ഈ പ്രോജെക്ടിൽ പരിഗണിച്ചിട്ടുണ്ടോ ?

3. നിലവിൽ കൊച്ചിയിലെ മിക്ക അപ്പാർട്മെന്റുകൾക്കും സ്വന്തമായി STP സംവിധാനം ഇല്ല. ഉള്ള അപ്പാർട്മെന്റുകൾ പോലും പലപ്പോഴും ഉയർന്ന പ്രവർത്തന ചെലവ് മൂലം അവ പ്രവൃത്തിപ്പിക്കാറില്ല. അങ്ങനെയുള്ള മലിനജലം മുഴുവൻ കനാലുകളിലേക്കു ഒഴുകുകയാണ് പതിവ്. ഇത്തരം പ്രവർത്തികൾക്ക് അറുതി വരുത്തുവാൻ ഈ പദ്ധതിയുടെ ഭാഗമായി എന്ത് നടപടികൾ ആണ് സ്വീകരിക്കാനാവുക ?

4. പദ്ധതിയുടെ ഭാഗമായി കനാലുകളിലെ ജലത്തിന്റെ ഗുണനിലവാരം തുടർച്ചയായി ഓൺലൈൻ സംവിധാനത്തിലൂടെ നിരീക്ഷിക്കുന്നതിനുള്ള സംവിധാനം ഉണ്ടാക്കുമോ ? മലിനജല ശുദ്ധീകരണ പ്ലാന്റുകളിലെ നിരീക്ഷണ സംവിധാനം മാത്രം ഇതിനായി മതിയാവുകയില്ല. പദ്ധതിയിൽ ഇതിനായി എന്തെങ്കിലും സംവിധാനം ഒരുക്കിയിട്ടുണ്ടോ ?

....

Thanks and regards

Nirmala V.U.,

Nelliparambil House
Nenmanikara
Pudukad P.O
Thrissur,Kerala,India
Pincode-680301

Mob:+91 9446350891

Please consider your environmental responsibility before printing this e-mail - Save paper Save Environment******

KSPCB DO1 <pcbdo1publichearing@gmail.com> Mon, Mar 15, 2021 at 3:48 PM
To: Nishad.Narayanan@anteagroup.com, ajith.nair@kmrl.co.in
Cc: RO ERNAKULAM <pcbroekm@gmail.com>, ms.kspcb@gov.in, ernakulamdc@gmail.com, collectorate ernakulam <m2dcekm@gmail.com>

Sir,

Kindly see the question related to public hearing
[Quoted text hidden]

Gmail

KSPCB DO1 <pcbdo1publichearing@gmail.com>

Question and concenrn regarding “Integrated Urban Regeneration and Water Transport System (IURWTS

2 messages

---

reena sebastian <reenaslovedale@gmail.com> Mon, Mar 15, 2021 at 9:23 AM
To: pcbdo1publichearing@gmail.com

Sir,
Ref: Advertisement in Malayala Manorama dated 13th February, 2021.
I have the following question regarding the project mentioned in the subject line:
Questions:
1. നിലവിൽ പ്രൊജക്റ്റ് നടപ്പാക്കുന്ന കനാലുകൾ അഞ്ചു എണ്ണം മാത്രമാണ്. മുല്ലശ്ശേരി , കോന്തുരുത്തി പോലുള്ള കനാലുകളെ എന്ത് കൊണ്ടാണ് ഈ പ്രോജെക്ടിൽ ഉൾപ്പെടുത്താത്തതു ?
2. പ്രൊജക്റ്റ് പരിധിയിൽ ഉൾപ്പെടുന്ന കനാലുകളിൽ ധാരാളം കയ്യേറ്റം ഉള്ളതായി പറയപ്പെടുന്നു. കയ്യേറ്റം എങ്ങനെയാണ് പ്രൊജക്റ്റിന്റെ ഭാഗമായി കണ്ടെത്തുന്നത്? കൈയേറ്റം ഒഴിപ്പിക്കാൻ സമഗ്രമായ നടപടികൾ ആവശ്യമാണ്. എങ്ങനെ നടപ്പിലാകും
Thanks and regards

KSPCB DO1 <pcbdo1publichearing@gmail.com> Mon, Mar 15, 2021 at 11:18 AM
To: Nishad.Narayanan@anteagroup.com, ajith.nair@kmrl.co.in
Cc: ernakulamdc@gmail.com, m2dcekm@gmail.com, pcbroekm@gmail.com, ms.kspcb@gov.in

Sir,
Kindly see the questions received from the public related to the public hearing on 16.03.2021.
Please reply to the queries raised on the project during the hearing.
[Quoted text hidden]

KSPCB DO1 <pcbdo1publichearing@gmail.com>

Question and concern regarding "Integrated Urban Regeneration and Water Transport System (IURWTS)'

2 messages

sudhish kumar <sudhishchennam@gmail.com> Sun, Mar 14, 2021 at 2:22 PM
To: pcbdo1publichearing@gmail.com

To

Sri. Baiju M.A,

Chief Environmental Engineer,

Regional Office,

Kerala State Pollution Control Board,

Gandhi Nagar, Ernakulam-682020

Sir,

Sub: Question and concern regarding "Integrated Urban Regeneration and Water Transport System (IURWTS)'

Ref: Advertisement in Malayala Manorama dated 13th February, 2021.

I have the following question regarding the project mentioned in the subject line:

Questions:

1. പദ്ധതിക്കു വേണ്ടി കുടിയിറക്കേണ്ടി വരുന്നവരെ പുനരധിവസിപ്പിക്കുന്നതിന് ഏതെങ്കിലും സ്ഥലം കണ്ടെത്തിയിട്ടുണ്ടോ ? അവിടെ പുതിയ വീട് നിർമിച്ചു നൽകുമോ ? അവിടെ എന്തെല്ലാം അടിസ്ഥാന സൗകര്യങ്ങൾ ആണ് ഉണ്ടാവുക?

2. പദ്ധതിയുടെ ഭാഗമായി ഏറ്റെടുക്കുന്ന ഭൂമി മറ്റുള്ള ആവശ്യങ്ങൾക്ക് ഉപയോഗിക്കുമോ ?

3. ഏറ്റെടുക്കുന്നതിൽ മിച്ച ഭൂമി ഉണ്ടായാൽ അത് എങ്ങനെ വിനിയോഗിക്കും ?

Thanks and regards

Sudhish Kumar .S

KSPCB DO1 <pcbdo1publichearing@gmail.com> Mon, Mar 15, 2021 at 11:18 AM
To: Nishad.Narayanan@anteagroup.com, ajith.nair@kmrl.co.in
Cc: ernakulamdc@gmail.com, m2dcekm@gmail.com, pcbroekm@gmail.com, ms.kspcb@gov.in

Kindly see the questions received from public related to the public hearing on 16.03.2021.
Please give reply to the queries raised on the project during the hearing
[Quoted text hidden]

Elite Residents Association
Soonoro Church Road, **Elamkulam,** Kochi – 682 020.
E-mail: elite.elamkulam@gmail.com, Phone: 70120 87206
President: *Sri. L.Kuriakose* Ph. 98462 30658, Secretary: *Smt. MS Jaya* Ph 99465 52311,
Vice-President: Sri. Joseph C Varghese, Treasurer: *Sri. Shaji Varghese*

DATE 16-3-2021

To
Addl. General Manager (Civil),
KMRL, JLN Metro Station, 4 th Floor,
Kaloor, Ernakulam – 682 017.

Respected Sir,
Subject: Cleaning of Chilavannur Lake – Reg.
Ref. : Notice on Public Hearing dated 16/03/2021

Ours is a Residents' association with houses on the banks of Chilavannur lake. This Residentrs association is very near to the Elamkulam Metro Station. The lake which was once full of water is now filled with silt and mud and there is no flow of water. Whenever there are high tide water flows into the houses in our colony and the residents are forced to lift the houses incurring heavy costs.

- As you are aware, the Chilavannur Lake is a God given water mass amidst the densely populated area of our city and between the most environmentally polluted spots as per available data.
- No cleaning work has been done on this lake which is quite visible. This lake is now filled with wastes & mud. Very soon this location will become uninhabitable, if the mud and silt are not dredged and removed. Thus, dredging and removing the wastes & mud should be done on priority basis..
- ELAMKULAM Metro Station's eastern boundary is this lake and can be easily connected with Water Metro. The only hindrance is a bridge and the blockage made under the bridge at Bund Road. Earlier boats used to come though this lake. Now boats cannot come near the station. A boat jetty near the Elamkulam Metro Station which can be connected to the main Water Metro will attract not only passengers but also tourists.
- A cycle Track cum Walkway with shade trees planted along the shores of this lake can protect further erosion and dumping of wastes. Besides, such a project will be a point of attraction in our city which can reduce environmental pollution. The maintenance & protection of this trees planted can be entrusted with the near residents Groups. Further there is no park or walkway in this area, though this is thickly populated.

Extending the walk way and cycle track through the shores of this lake will make this area beautiful.

- Earlier you would recall that there was a project for making this lake a water sports stadium. This is an ideal place for a water sports stadium with gallery on the banks of either side of the lake.

We request you to consider the above suggestions of our Association sincerely and we assure our full cooperation and support in this project.

Yours sincerely

Sd/- Sd/-

PRESIDENT SECRETARY

സെക്രട്ടറി

പദ്ധതിയെക്കുറിച്ച് ഇ-മെയിൽ മുഖാന്തിരം ലഭിച്ച ചോദ്യങ്ങളും ഉത്തരങ്ങളും

അനുബന്ധം (4)

Sl. No	Question	Answer
1	നിയമസഭ തെരെഞ്ഞെടുപ്പുമായി ബന്ധപ്പെട്ട പെരുമാറ്റച്ചട്ടം നിലവിലുള്ളപ്പോൾ മാർച്ച് 16 ന് നടത്തുന്ന പബ്ലിക് ഹിയറിംഗിന് നിയമപരമായ സാധുത ഉണ്ടോ ?	ഉണ്ട്
2	കാലാവസ്ഥാ പ്രതിരോധ ശേഷിയുള്ള അടിസ്ഥാന സൗകര്യങ്ങൾ (Climate-Resilient Infrastructure : Adaptive Design and Risk Management) എന്നത് ഇപ്പോൾ ആഗോളതലത്തിൽ പ്രാവർത്തികമാക്കി വരുന്ന വികസന മാർഗമാണ്. ഈ പദ്ധതിയിൽ ഡിസൈൻ ഈ തലത്തിൽ ആണോ നടത്തിയിട്ടുള്ളത്?	അതെ, 25 വർഷത്തെ മഴ, എന്നിവ പരിഗണിച്ചാണ് ഡിസൈൻ നടത്തിയിരിക്കുന്നത്.
3	വെള്ളപ്പൊക്ക നിവാരണം ഈ പ്രോജക്ടിന്റെ ഒരു പ്രധാന ലക്ഷ്യം ആണെന്ന് മനസിലാക്കുന്നു. കൊച്ചി നഗരസഭയുടെ കീഴിൽ വരുന്ന പ്രധാന വെള്ളപ്പൊക്ക മേഖലകൾ പദ്ധതിയുടെ ഭാഗമായി പഠന വിധേയമാക്കിയിട്ടുണ്ടോ ? കനാലിനു സമീപത്തല്ലാത്ത വെള്ളപ്പൊക്ക മേഖലകൾ ഉണ്ടോ? ഉണ്ടെങ്കിൽ അവിടം എങ്ങനെയാണ് വെള്ളപൊക്ക വിമുക്ത മേഖലയാകുന്നത്	ഉണ്ട്, കനാലിന് സമീപത്തല്ലാത്ത വെള്ളപ്പൊക്ക മേഖലകൾ ഉണ്ട്. അവിടെ നിന്നും കൃത്യമായ ഡ്രൈനേജ് സംവിധാനം ഒരുക്കി വെള്ളക്കെട്ട ഒഴിവാക്കും.

4	Resettlement and Rehabilitation എന്നത് പലപ്പോഴും ബന്ധപ്പെട്ട അധികാരികൾ ഒന്നായി കണക്കാക്കുന്നു. രണ്ടും വ്യത്യസ്തമാണെന്ന് മനസിലാക്കാൻ അധികാരികൾ പരാജയപ്പെടുന്നു. Resettlement എന്നത് ഭൗതികമായ പ്രക്രീയയാണ് എന്നാൽ. Rehabilitation (പുനരധിവാസം) ആളുകളുടെ ഭൗതികവും സാമ്പത്തികവുമായ ഉപജീവനമാർഗ്ഗം അവരുടെ സ്വത്തുക്കൾ സാംസ്കാരികവും സാമൂഹികവുമായ ബന്ധങ്ങൾ എന്നിവ പുനസ്ഥാപിക്കൽ, പുനരധിവാസ സമയത്ത് മനശാസ്ത്രപരമായി മാറിയ സാഹചര്യത്തിന്റെ സ്വീകര്യത ഉറപ്പാക്കൽ ഇതെല്ലാം ഉൾക്കൊള്ളുന്നു. കേവലം resettlement എന്നതിലുപരി rehabilitation എന്ന വിശാലമായ തലത്തിൽ ഈ പ്രൊജക്റ്റ് നടപടികൾ സ്വീകരിക്കുന്നുണ്ടോ ?	ഉണ്ട്, നിലവിൽ അടിസ്ഥാന സൗകര്യങ്ങളുടെ അഭാവത്തിൽ വെള്ളക്കെട്ട് സാധ്യതയുള്ള മേഖലയിൽ ഏറെ പരിതാപകരമായ അവസ്ഥയിൽ കഴിയുന്നവരെ ഉയർന്ന ജീവിത നിലവാരത്തിലേക്ക് ഉയർത്തുക എന്നത് Rehabilitation ആണ്.

5	പുനഃരധിവസിക്കപ്പെടുന്ന പുതിയ സ്ഥലത്തു ഉടമസ്ഥാവകാശം ഉണ്ടായിരിക്കുമോ ?	ഉണ്ട്.
6	പുനഃരധിവസിക്കപെടുന്ന പുതിയ സ്ഥലത്തിന്റെ ഉടമസ്ഥാവകാശം കൈമാറ്റം ചെയ്യാൻ സാധിക്കുമോ ? സ്ഥലം വിൽക്കാൻ എന്തെങ്കിലും നിയമ തടസ്സം ഉണ്ടോ ?	കൈമാറ്റം ചെയ്യാൻ സാധിക്കില്ല. വിൽക്കാനും സാധിക്കില്ല.
7	പദ്ധതിക്കുവേണ്ടി കുടിയിറക്കേണ്ടി വരുന്നവരെ പുനരധിവസിപ്പിക്കുന്നതിന് ഏതെങ്കിലും സ്ഥലം കണ്ടെത്തിയിട്ടുണ്ടോ ? അവിടെ പുതിയ വീട് നിർമ്മിച്ചു നൽകുമോ ?അവിടെ എന്തെല്ലാം അടിസ്ഥാന സൗകര്യങ്ങൾ ആണ് ഉണ്ടാവുക ?	ഉണ്ട്. Kakkanad apartment,G+10, 7 blocks, 670 sq.ft

8	കൊച്ചി കോർപ്പറേഷൻ പരിധിക്കുള്ളിൽ ധാരാളം ഒഴിഞ്ഞ ഭൂമി ഉള്ളപ്പോൾ എന്തുകൊണ്ടാണ് അത് പരിഗിക്കാതെ പുനരധിവാസത്തിനായി കോർപ്പറേഷന് പുറത്തു സ്ഥലം ഏറ്റെടുത്തത്?	സ്ഥലത്തിന്റെ വില. നിലവിലേ സാമൂഹിക ബന്ധങ്ങൾ സമതുലിതാവസ്ഥ ഉറപ്പുവരുത്തി എല്ലാവരെയും ഒന്നിച്ചു ഒരു സ്ഥലത്തേക്ക് മാറ്റാനുള്ള സൗകര്യം, ഇവയെല്ലാം പരിഗണിച്ചാണ് സർക്കാരാണ് ടെൻഡർ നടപടികളിലൂടെ തീരുമാനം എടുത്തത്.
9	പുനഃരധിവസിക്കപ്പെടുന്നവർ തങ്ങൾക്കു ലഭിക്കുന്ന സ്ഥലം നിരസിക്കാൻ സാധിക്കുമോ ? അതിനു നിയമപരമായ സാധുത ഉണ്ടോ ? അങ്ങനെ വന്നാൽ പകരം സ്ഥലം കൊടുക്കുമോ ? അത് എവിടെയാവും?	സാധിക്കചഷ്ട. നിരസിച്ചാല നിയമപരമായ സാധുത ഇല്ല. നിരസിച്ചാൽ പകരം സ്ഥലം കൊടുക്കില്ല.
10	പദ്ധതിയുടെ ഭാഗമായി ഏറ്റെടുക്കുന്ന ഭൂമി മറ്റുള്ള ആവശ്യങ്ങൾക്ക് ഉപയോഗിക്കുമോ ?	ഇല്ല

11	ഏറ്റെടുക്കുന്നതിൽ മിച്ച ഭൂമി ഉണ്ടായാൽ അത് എങ്ങനെ വിനിയോഗിക്കും ?	മിച്ച ഭൂമി ഉണ്ടാവില്ല.
12	ഈ പ്രാജക്റ്റ് നടപ്പിലായാൽ കൊച്ചി കോർപ്പറേഷൻ പരിധിയിൽ ഇപ്പോൾ സ്ഥിരം വെള്ളപ്പൊക്കം ഉണ്ടാകുന്ന മേഖലകളിൽ തുടർന്ന് വെള്ളപ്പെക്കം ഉണ്ടാകില്ല എന്ന് ഉറപ്പു പറയാനുകുമോ ?	പദ്ധതിക്കായി 25 വർഷത്തെ മഴയുടെ തോത് പരിഗണിച്ചിട്ടുണ്ട്. കൂടാതെ കൂടുതൽ വെള്ളപ്പൊക്ക വെള്ളം ഉൾക്ക് ഉന്നതിനായി കനാലിന്റെ വീതി, ആഴം എന്നിവ പഠനത്തെ അടിസ്ഥാനമാക്കി കൂട്ടുകയും ചെയ്യും. താഴ്ന്ന പ്രദേശങ്ങൾ ഗ്രേഡിംഗ് നടത്തുകയും ചെയ്യും . ഇതിന്റെ എല്ലാം അടിസ്ഥാനത്തിൽ വെള്ളപ്പൊക്ക സാധ്യത കുറയും
13	ആഗോള കാലാവസ്ഥാ വ്യതിയാനവും സമുദ്ര നിരപ്പിൽ (MSL) ഉണ്ടാകുന്ന വർധനവും ഈ പ്രൊജക്ടിൽ പരിഗണിച്ചിട്ടുണ്ടോ ?	ഉണ്ട്. കൊച്ചിയിൽ അടിക്കടിയുണ്ടാകുന്ന കനത്ത മഴ, ആഗോള കാലാവസ്ഥാ വ്യതിയാനത്തിന്റെ ഒരു ഫലം ആണ്. ശാസ്ത്രീയമായ flood പ്ലെയിൻ പഠനം എന്നിവ നടത്തിയാണ് പദ്ധതി വെള്ളപ്പെക്ക സാധ്യയതാ മേഖലകൾ കണ്ടെത്തിയിരിക്കുന്നത്.
14	നിലവിൽ കൊച്ചിയിലെ മിക്കഅപ്പാർട്ട്മെന്റ്കൾക്കും സ്വന്തമായി STP സംവിധാനം എല്ല. ഉള്ള അപ്പാർട്മെന്റ്കൾ പോലും പലപ്പോഴും ഉയർന്ന പ്രവർത്തന ചെലവ് മൂലം അവ പ്രവ്യത്തിപ്പിക്കാറില്ല. അങ്ങനെയുള്ള മലിനജലം മുഴുവൻ കനാലുകളിലേക്കു ഒഴുകുകയാണ് പതിവ്. ഇത്തരം പ്രവർത്തികൾക്ക്	മലിനീകരണ നിയന്ത്രണ ബോർഡ് ചീഫ് എൻവയോൺമെന്റൽ എൻജിനീയറിന്റെ മറുപടി എല്ലാകെട്ടിടങ്ങളിലും ഫ്‌ളാറ്റുകളിലും കൃത്യമായ മലിനീകരണ സംവിധാനം ഏർപ്പെടുത്തേണ്ടതാണ്. അങ്ങനെ ചെയ്യാത്തവർക്കെതിരെ നടപടികൾ ഉണ്ടാകുന്നതാണ്.

	അറുതി വരുത്തുവാൻ ഈ പദ്ധതിയുടെ ഭാഗമായി എന്ത് നടപടികൾ ആണ് സ്വീകരിക്കാനാവുക ?	
15	പദ്ധതിയുടെ ഭാഗമായി കനാലുകളിലെ ജലത്തിന്റെ ഗുണനിലവാരം തുടർച്ചയായി ഓൺലൈൻ സംവിധാനത്തിലൂടെ നിരീക്ഷിക്കുന്നതിനുള്ള സംവിധാനം ഉണ്ടാകുമോ ? മലിനജല ശുദ്ധീകരണ പ്ലാന്റുകളിലെ നിരീക്ഷണ സംവിധാനം മാത്രം ഇതിനായി മതിയാവകയില്ല. പദ്ധതിയിൽ ഇതിനായി എന്തെങ്കിലും സംവിധാനം ഒരുക്കിയിട്ടുണ്ടോ ?	ഉണ്ട്. കനാലിലെ വെള്ളവും STP കാലിലെ ശുദ്ധീകരണം നടത്തിലെ വെള്ളവും തുടർച്ച്യായി നിരീക്ഷിക്കുന്നതിനുള്ള സംവിധാനം പദ്ധതിയുടെ ഭാഗമായി ഉണ്ടാവും
16	നിലവിൽ പ്രൊജക്റ്റ് നടപ്പാക്കുന്ന കനാലുകൾ അഞ്ചു എണ്ണം മാത്രമാണ്. മുല്ലശ്ശേരി, കോന്തുരുത്തി പോലുള്ള കനാലുകളെ എന്ത് കൊണ്ടാണ് ഈ പ്രൊജക്റ്റിൽ ഉൾപ്പെടുത്താത്തത് ?	കൊച്ചിയിലെ ഏറ്റവും വെള്ളപ്പൊക്ക ബാധിത മേഖലകളിൽ ഉൾപ്പെടുന്ന അഞ്ചു കനാലുകൾ ആണ് ഈ പദ്ധതിയിൽ ഉൾപ്പെടുത്തിയിരിക്കുന്നത്. മുല്ലശ്ശേരി കനാല് കൊച്ചി കോർപ്പറേഷന് നേരിട്ട് നവീകരിക്കുന്നുണ്ട്. കോന്തുരുത്തി കനാല് ഈ പദ്ധതിയുടെ ഭാഗം തന്നെ ആണ്.
17	പൊജക്റ്റ് പരിധിയിൽ ഉൾപ്പെടുന്ന കനാലുകളിൽ ധാരാളം കയ്യേറ്റം ഉള്ളതായി പറയപ്പെടുന്നു. കയ്യേറ്റം എങ്ങനെയാണ് പ്രെജക്റ്റിന്റെ ഭാഗമായി കണ്ടെത്തുന്നത് ? കൈയ്യേറ്റം ഒഴിപ്പാക്കാൻ സമഗ്രമായ നടപടികൾ ആവശ്യമാണ്. എങ്ങനെ നടപ്പിലാകും ?	വില്ലേജ് രേഖകൾ (FMB) പരിശോധിച്ചാണ് കയ്യേറ്റം കണ്ടെത്തുക. കൂടാതെ വിശദമായ LIDAR സർവ്വേ പദ്ധതി പ്രദേശത്തു നടത്തിയിട്ടുണ്ട്.

Annexure-4

English translation of Reply on queries raised by the public through E-Mail

Sl No	Question	Answer
1.	Is the public hearing proposed on March 16 legally valid when the Code of Conduct for Assembly Elections is in force?	Yes
2.	Climate-Resilient Infrastructure (Adaptive Design and Risk Management) is a global development tool. Has the design been done at this level in this project?	Yes. The design is based on 25 years of rainfall and HAT
3.	It is understood that flood mitigation is one of the main objectives of this project. Have the major flood prone areas under Kochi Municipal Council been studied as part of the project? Are there floodplains near the canal? If so, how can it be made a flood free zone?	Yes. There are floodplains that are not close to the canal. From there, proper drainage system will be set up to prevent flooding
4.	Resettlement and Rehabilitation are often considered as one by the concerned authorities. Authorities fail to understand that the two are different. Resettlement is a physical process. But it includes rehabilitation, the restoration of people's physical and financial livelihoods, the restoration of their property, cultural and social ties, and the assurance of acceptance of the situation that has changed psychologically during rehabilitation ....Is this project taking steps on a broader level of rehabilitation than just resettlement?	Yes. Rehabilitation in this project is about raising the living standards of those living in the worst-prone areas in the current flood-prone area to a higher standard of living.
5.	Will there be ownership of the new land to be rehabilitated?	yes
6.	Is it possible to transfer ownership of the new land to be rehabilitated? Is there any legal impediment to selling the land?	Unable to transfer. Can't sell also.
7.	Has any site been found to rehabilitate those who have to relocate for the project? Will a new house be built there? What infrastructure will be	Yes. Land is identified at kakkanad. 7 apartment blocks ofG+10, in which each unit with

	provided there?	an area of 670 sq. ft. will be constructed there. CCTV, fire exit, solar heating system, waste management facilities, STP, and parking areas are also part of the infractructure proposed there.
8.	When there is a lot of vacant land within the limits of Kochi Corporation, why did it take over the land outside the Corporation for rehabilitation without considering it?	The government has decided to purchase the land at Kakkanad based on the tender process after considering the price of the land, the social relations of the rehabilitated people and the facility to move everyone together to one place by ensuring social and communal balance..
9.	Can resettlers refuse the land they receive? Does it have legal validity? If so, will you replace it? Where is it?	Not possible. Rejection has no legal validity. If rejected, no replacement will be given.
10.	Will the land acquired as part of the project be used for other purposes?	no
11.	If there is surplus land in the acquisition, how will it be utilized?	There will not be surplus land in the acquisition
12.	If this project is implemented, will it be possible to ensure that there will be no further floods in the areas of Kochi Corporation which are currently experiencing regular floods?	The project has considered 25 years of rainfall. In addition, the width and depth of the canal will be increased based on the hydraulic and flood plain modelling study to accommodate more flood water. The lower prongs will be graded. Based on all this, the risk and vulnerability of flooding will decrease.
13.	Has global climate change and sea level rise (MSL) been considered in this project?	Yes. Frequent heavy rains in Kochi are a result of global climate change. The project has identified flood prone areas through scientific flood plain study and hydraulic modeling study.
14.	At present most of the apartments in Kochi do	

	not have their own STP facility. Even existing STPs of many apartments are often not operational due to high operating costs. It is common for such sewage to flow all over the canals. What steps can be taken as part of this plan to put an end to such activities?	These apartments can avail sewerage network to dispose the sewage in to it. KSPCB will take strict action to stop illegal discharge of sewage in to the canals
15.	Will there be a system for continuous online monitoring of water quality in canals as part of the project? Surveillance systems at wastewater treatment plants alone will not suffice. Is there any provision in the plan for this?	Yes. As part of the project, there will be a system for continuous monitoring of canal water and treated water from the STP.
16.	Currently there are only five canals under which the project is being implemented. Why are canals like Mullassery and Konthuruthy not included in this project?	The project covers five canals in the worst affected areas of Kochi. The Mullassery canal is being upgraded directly by the Kochi Corporation. The Konthuruthycanals being a subcanal of ThevaraCanal is already part of this project.
17.	It is said that there is a lot of encroachment on the canals included in the project scope. How is encroachment detected as part of the project? Comprehensive measures are needed to evacuate the encroachment. How to implement?	The encroachment is detected by checking the Village Records (FMB). In addition a detailed LIDAR survey has been conducted in the project area.

Concerns received from Shaji Varghese, Secretary, Elite Residents association

Sl #	Concern	Reply
1.	No cleaning work has been done on Chilavannur lake which is quite visible. This lake is now filled with wastes & mud. Very soon this location will become uninhabitable, if the mud and silt are not dredged and removed. Thus, dredging and removing the wastes & mud should be done on priority basis..	Proper cleaning that includes deepening and removal of silt and mud will be done in all canals to contain flood water.
2.	ELAMKULAM Metro Station's eastern boundary is this lake and can be easily connected with Water Metro. The only hindrance is a bridge and the blockage made under the bridge at Bund Road. Earlier boats used to come though this lake. Now boats cannot come near the station. A boat jetty near the Elamkulam Metro Station which can be connected to the main Water Metro will attract not only passengers but also tourists.	Two boat jetties are already proposed near Elamkulam Metro station and bund road to ensure connectivity with water metro.
3.	A cycle Track cum Walkway with shade trees planted along the shores of this lake can protect further erosion and dumping of wastes. Besides, such a project will be a point of attraction in our city which can reduce environmental pollution. The maintenance & protection of this trees planted can be entrusted with the near residents Groups. Further there is no park or walkway in this area, though this is thickly populated. Extending the walk way and cycle track through the shores of this lake will make this area beautiful.	2m additional acquisition along the canal bank is proposed. This can be converted into walkway and the possibility of Cycle track can be explored . However, a green belt that cover both sides of the canal is considered in the proposal. As part of this project, parks and recreational areas will be increased. Support of local association and resident groups will be utilised for the surveillance and maintenance.
4.	Earlier you would recall that there was a project for making this lake a water sports stadium. This is an ideal place for a water sports stadium with gallery on the banks of either side of the lake.	Due to budget constraints, in this project water sports complex is not considered. when sufficient funding available, this suggestion will be considered.

National Accreditation Board for Testing and Calibration Laboratories
(A Constituent Board of Quality Council of India)

CERTIFICATE OF ACCREDITATION

STANDARDS ENVIRONMENTAL & ANALYTICAL LABORATORIES

has been assessed and accredited in accordance with the standard

ISO/IEC 17025:2017

"General Requirements for the Competence of Testing & Calibration Laboratories"

for its facilities at

K. J. TOWER, PATHALAM, UDYOGAMANDAL P.O., ERNAKULAM, KERALA, INDIA

in the field of

TESTING

Certificate Number:	**TC-5402**		
Issue Date:	**21/11/2019**	**Valid Until:**	**20/11/2021**

This certificate remains valid for the Scope of Accreditation as specified in the annexure subject to continued satisfactory compliance to the above standard & the relevant requirements of NABL.
(To see the scope of accreditation of this laboratory, you may also visit NABL website www.nabl-india.org)

Signed for and on behalf of NABL

N. Venkateswaran
Chief Executive Officer

FILE NO. :PCB/HO/EKM-1/ICE/04/2018
Date of issue :27/08/2020

KERALA

KERALA STATE POLLUTION CONTROL BOARD

CONSENT TO ESTABLISH

ISSUED UNDER

Section 25 of Water (Prevention & Control of Pollution) Act, 1974
Section 21 of the Air (Prevention & Control of Pollution) Act, 1981

and

Environment (Protection) Act, 1986

As per Application No. :12919394
Dated:18-03-2020

TO

M/s KOCHI METRO RAIL LIMITED
Corporate Office,
JLN Metro Station,
4th Floor, Kaloor,
Ernakulam
Kochi - 682017.

Consent No. :PCB/HO/EKM-1/ICE/ 08 /2020

Valid Upto :26/08/2025

1. GENERAL

1.1. This integrated consent is granted subject to the power of the Board to withdraw consent, review and make variation in or revoke all or any of the conditions as the Board deems fit.

1	**VALIDITY**	26/08/2025
2	Name and Address of the establishment	KOCHI METRO RAIL LIMITED CORPORATE OFFICE, JLN METRO STATION, 4TH FLOOR, KALOOR, ERNAKULAM KOCHI. 682017
3	Communication	Telephone :0484-2826700 Fax :- E-mail:ajith.nair@kmrl.co.in
4	Occupier Details	Ajith A Nair, Additional General Manager, Kochi Metro Rail Ltd, Corporate Office, JLN Metro Station, 4th Floor, Kaloor, Ernakulam
5	Local Body	Kochi
6	Survey Number	As per annexure attached.
7	Village	Kochi
8	Taluk	KOCHI
9	District	Ernakulam i
10	Capital Investment(Rs in Lakhs)	16800.00 Rs in Lakhs
11	Scale	Large
12	Category	RED
13	Annual fee(Rs) Total Fee remitted(Rs)	Rs. 3, 77, 000/- Rs. 18, 85, 000/-
14	Activity	Rejuvenation of 5 major canals running through the heart and suburbs of the city ie 1)Edappally canal (11.23 kms), 2) Perandoor -Thevara Canal (11.15km), 3)Chilavannoor Canal(9.88 kms), 4) Thevara Canal (1.405 km), 5) Market Canal(0.006 kms) Installation of the STP 1)10MLD Capacity STP at the existing site of STP at Elamkulam 2) 10MLD STP at Vennala 3)7MLD Capacity STP at Muttar 4)4 MLD Capacity STP at Perandoor.

2. CONDITIONS AS PER

The Water(Prevention and Control of Pollution)Act, 1974

2.1 Sewage Treatment Plant (STP) consisting of treatment units having adequate capacity shall be made functional/ arrangement for sewage treatment shall be provided, as per the proposal submitted along with the application, before commissioning of the establishment. Additional facilities required, if any, to achieve the standards laid down by the Board u/s 17(1)(g) of the Water Act shall also be made along with.

2.2 Water Consumption : 515 kLD

2.3 Effluent Generation : 34.45 MLD

2.4 The characteristics of effluent after treatment shall confirm to the following tolerance limits:

SI.NO.	Characteristics	Unit	Tolerance Limit	
			Sewage	Trade Effluent
1	pH	-	6.5-9.0	-
2	BOD	mg/l	10	-
3	COD	mg/l	50	-
4	TSS	mg/l	10	-
5	NH4-N	mg/l	5	-
6	N-TOTAL	mg/l	10	-
7	FECAL COLIFORM	MPN/100 ml	<230	-

2.5 Mode of disposal of treated effluent :
Drain after treatment

3. CONDITIONS AS PER
The Air(Prevention and Control of Pollution)Act, 1981

3.1 Adequate air pollution control measures shall be provided before commissioning of the industry. Additional facilities required, if any, to achieve the standards laid down by the Board shall also be made along with.

Stack No.	Sources of Emission	Emission Rate(Nm3/Hr)	Stack Height above		Control Equipment
			Ground Level	Roof Level	

3.2 Emission characteristics shall not exceed the following:

SI.No.	Parameter	Limiting Standards (mg/Nm3)

4. CONDITIONS AS PER
The Environment (Protection) Act, 1986.

4.1 The construction activities shall be carried out strictly in compliance with the provisions of the Noise Pollution (Regulation and Control) Rules 2000.

4.2 Used lead acid batteries shall be disposed of as per the Batteries (Management and Handling) Rules, 2001

4.3 e-waste shall be disposed off safely as per E-Waste (Management) Rules, 2016.

5. ADDITIONAL CONDITIONS

CONDITIONS DURING CONSTRUCTION PHASE

5.1. All operations likely to produce dust or noise shall be carried out with appropriate enclosure.

5.2. Water sprinklers shall be provided to suppress spreading of dust outside the premises during the construction phase.

5.3. Ambient air quality shall not exceed the National Ambient Air quality Standards.

5.4. Proper precautionary measures shall be provided during construction phase to minimize disturbance to neighbours and neighbouring properties due to excavation, piling, transportation of materials etc.

5.5. The construction debris and mud discharges etc from the construction site shall be disposed safely as per Construction and Demolition Waste Management Rules, 2016.

5.6. Sanitary facilities shall be provided to the construction workers.

5.7. A minimum set back as per Municipality Building Rule shall be provided between the boundary and the building and the set back can be utilised for the development of green belt.

5.8. Adequate sanitary facility shall be provided in all proposed jetties.

5.9. STP's shall be constructed above flood mark with reference to the nearby water body/river.

5.10. STP shall be housed with suitable material/acoustic enclosure to control noise pollution.

5.11. Adequate odour control measures shall be provided with STP's

6. GENERAL CONDITIONS

6.1. At the end of the validity period if the construction is in progress, the same shall be got renewed. If the construction is not started in the consent period, the applicant shall apply afresh for consent to establish.

6.2. The applicant shall comply with the instructions that the Board may issue from time to time regarding prevention and control of air, water, land and sound pollution.

6.3. The date of commissioning of the project shall be intimated at least one month in advance to the District Office of the Board.

6.4. Consent to Operate under the Water (Prevention and Control of Pollution) Act, 1974 and the Air (Prevention and Control of Pollution) Act, 1981 shall be obtained by the builder before commissioning the project.

6.5. Water & energy conservation measures shall be adopted. Renewable source of energy namely solar energy shall be utilized.

6.6. Adequate safety measures shall be provided in accordance with fire safety regulation.

6.7. No excavation of soil shall be carried out without adequate dust mitigation measures in place.

6.8. No loose soil or sand or Construction & Demolition Waste or any other construction material that causes dust shall be left uncovered.

6.9. Dust mitigation measures shall be displayed prominently at the construction site for easy public viewing.

6.10. Grinding and cutting of building materials in open area shall be prohibited.

6.11. Construction material and waste should be stored only within earmarked area and road side storage of construction material and waste shall be prohibited.

6.12. No uncovered vehicles carrying construction material and waste shall be permitted.

6.13. Construction and Demolition Waste processing and disposal site shall be identified and required dust mitigation measures be notified at the site.

6.14. Environment clearance and necessary clearances as per Coastal Zone Regulations shall be obtained.

6.15. The construction camp shall have a well maintained waste management system and sewage and effluent shall be treated to meet the standards. The solid waste and debris from the construction shall be disposed without causing environmental problems. The dredging shall be carried out without causing significant disturbance to the back water system.

6.16. Measures to counter the escape of oil spilled from the oil storage tank, if any, at the time of an accident shall be provided.

6.17. Arrangement shall be provided for preventing oil pollution in water due to the transportation.

6.18. Treatment facility shall be provided at the boat yard fro treating waste water generated due to the washing of boats.

6.19. Arrangements shall be provided for the disposal of used lead acid batteries as per Batteries (Management and Handling) Rules, 2001.

6.20. Arrangement shall be provided for the disposal of e-waste generated as per E-waste Management Rules, 2016.

DATE :27/08/2020

SIGNATURE & SEAL OF ISSUING AUTHORITY
CHAIRMAN

KERALA STATE POLLUTION CONTROL BOARD

To

M/s. Kochi Metro Rail Limited,
Corporate Office,
JLN Metro Station,
4th Floor, Kaloor,
Ernakulam
Kochi - 682017.

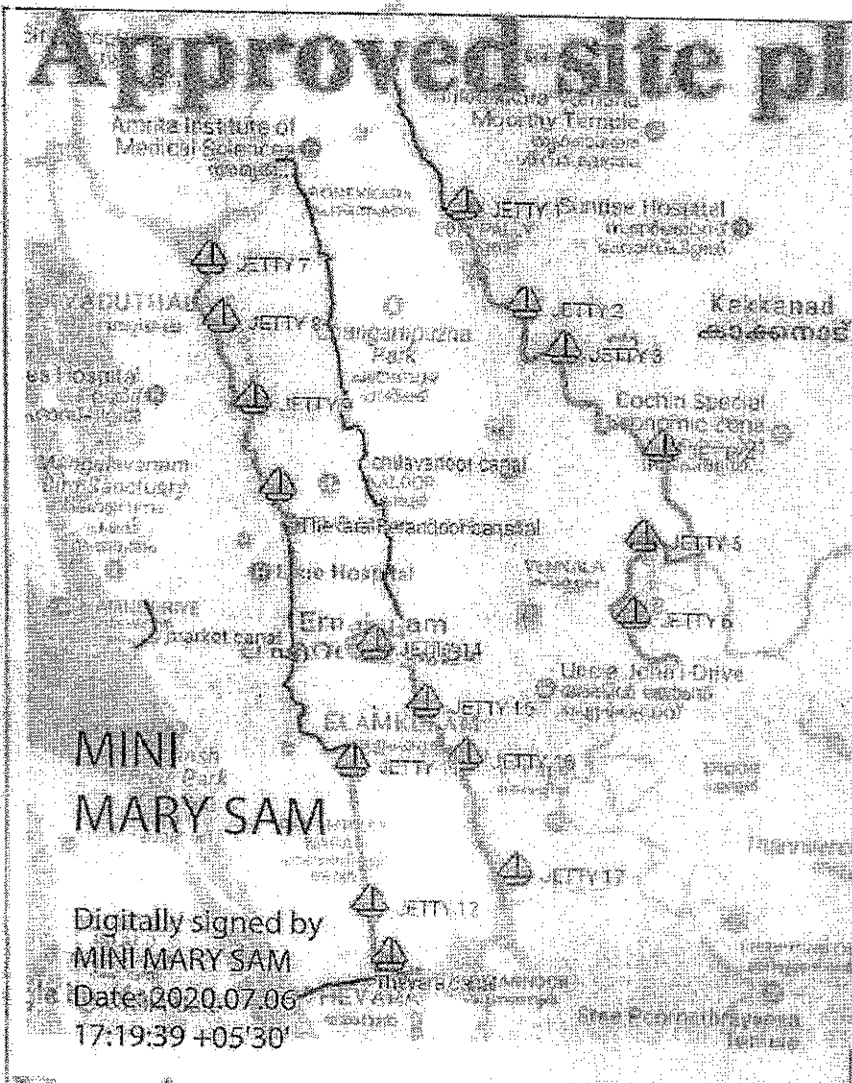
1. This digitally signed document is legally valid as per the Information Technology Act 2000

2. For verifying this document please go to krocmms.nic.in and search using date of issue/name of the unit/Application Number in "Consent Granted Applications" link in the home page of the Board's Online Consent Management and Monitoring System.

Survey Numbers of Area Allotted to STP

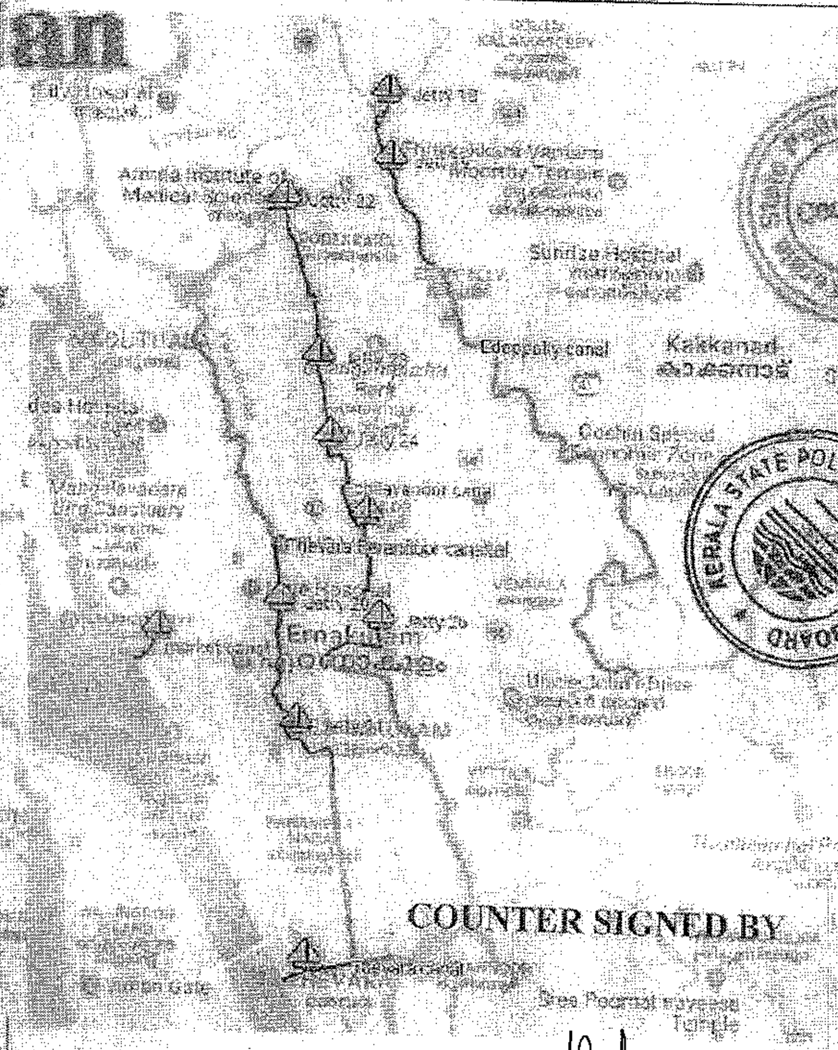
Sl. No	STP location	Proposed STP (MLD)	Block survey #	Village
1	Vennala STP - Edappally south	10	23,106	Edappally South
2	Elamkulam STP - Chilavanoor & TP south	10	514, 515	Elamkulam
3	Muttar STP-Edappally north and Chilavannur North	7	53,55	Edappally North
4	Perandoor STP - TP north	4	1088, 1090	Ernakulam

Approved site plan



MINI
MARY SAM

Digitally signed by
MINI MARY SAM
Date: 2020.07.06
17:19:39 +05'30'



COUNTER SIGNED BY

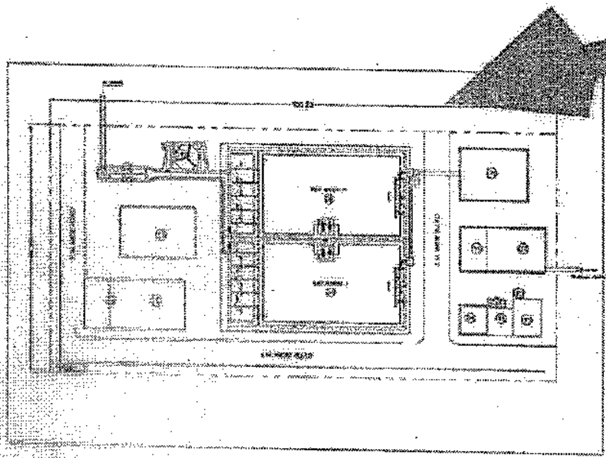
CHAIRMAN

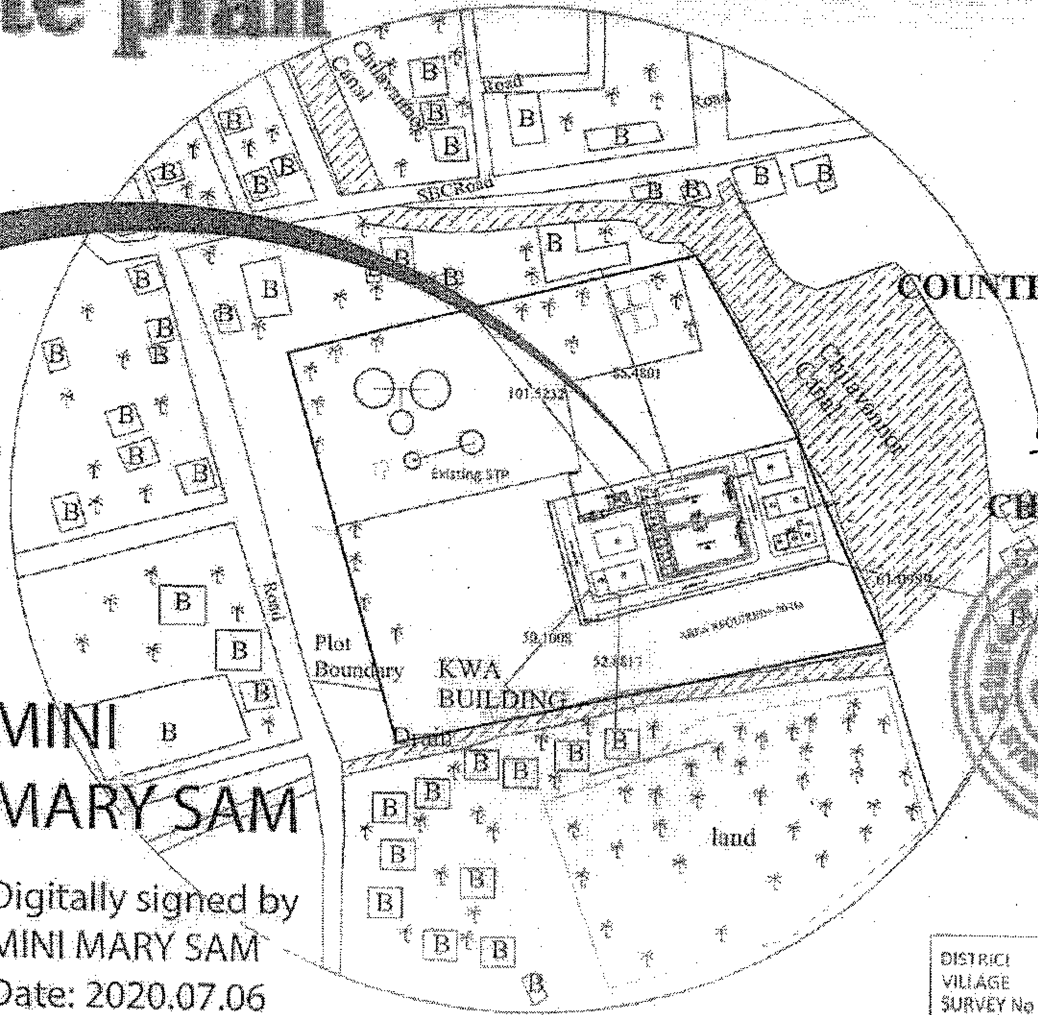
Environmental Engineer

Location of Jetties in Phase I	Location of Jetties in Phase II

Figure-2: Location of Jetties

Approved site plan





COUNTER SIGNED BY

CHAIRMAN

KERALA STATE POLLUTION CONTROL BOARD

Kerala State Pollution Control Board Cochin-20

PROCESS UNITS

SL.NO.	PROCESS UNITS	SIZE/CAPACITY	QTY.	REMARK
01	INLET CHAMBER	2000 x 2000 x 2000 SWD.	01	
02	FINE SCREEN CHANNEL-MANUAL	2000 x 650 x 800 SWD.	01	
03	FINE SCREEN CHANNEL-MECHANICAL	7500 x 650 x 800 SWD.	01	
04	GRIT CHAMBER-MECHANICAL	5500 x 5050 x 900 SWD.	01	
05	SBR BASINS	34200 x 17200 x 5500 SWD.	02	
06	CLOTH DISC FILTER	15500 x 10000 x 5100 SWD.	01	
07	CHLORINATION TANK	15500 x 5600 x 3000 SWD.	01	
08	SLUDGE SUMP	5000 x 5000 x 2000 SWD.	01	
09	POLYELECTROLYTE DOSING TANKS	1300 x 1300 x 1500 SWD.	02	
10	CENTRATE SUMP	2000 x 2000 x 2000 SWD.	01	

BUILDING LIST

11	HT SUBSTATION	15000 x 10000 x 4500 HT.	01	
12	DG SET HOUSE	10000 x 5050 x 4500 HT.	01	
13	SBR AIR BLOWER / MCC & CONTROL BLD.	15000 x 10500 x 10000 HT.		G+1
14	CHLORINATION CUM CHLORINE TONNER HOUSE (ABOVE CHLORINATION TANK)	5500 x 5050 x 4500 HT.	01	
15	CENTRIFUGE FEED PUMP HOUSE	5500 x 5000 x 4500 HT.	01	
16	CENTRIFUGE HOUSE	7500 x 5500 x 5500 HT.	01	G(STILT)+1

MINI
MARY SAM

Digitally signed by
MINI MARY SAM
Date: 2020.07.06
17:21:48 +05'30'

Environmental Engineer

DISTRICT	:	Ernakulam
VILLAGE	:	Elamkulam
SURVEY No of STP Site	:	514,515
Hectare	:	0.50
STP Capacity	:	10 MLD

CLIENT: KOCHI METRO RAIL LIMITED

GENERAL CONSULTANT: Antea Nederland B.V and Antea India(JV)

PROJECT: GENERAL CONSULTANCY SERVICES INTEGRATED URBAN REGENERATION AND WATER TRANSPORT SYSTEM, KOCHI

Antea Nederland B.V and Antea India(JV)

	NAME	SIGN	DATE
DRAWN			
CHECKED			
CHECKED			
APPROVED			

KEY PLAN:

NO OBJECTION BY KMRL

CIVIL

MEP

REVISIONS

TENDER DRAWING

DESCRIPTION

DATE

BY

PROJECT INTEGRATED URBAN REGENERATION & WATER TRANSPORT SYSTEM

LOCATION: ELAMKULAM

TITLE: SITE PLAN

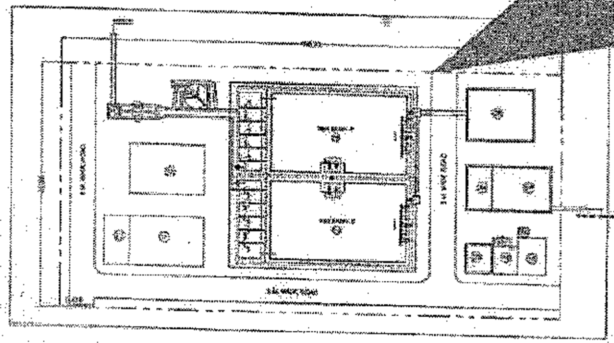
DRG NO:

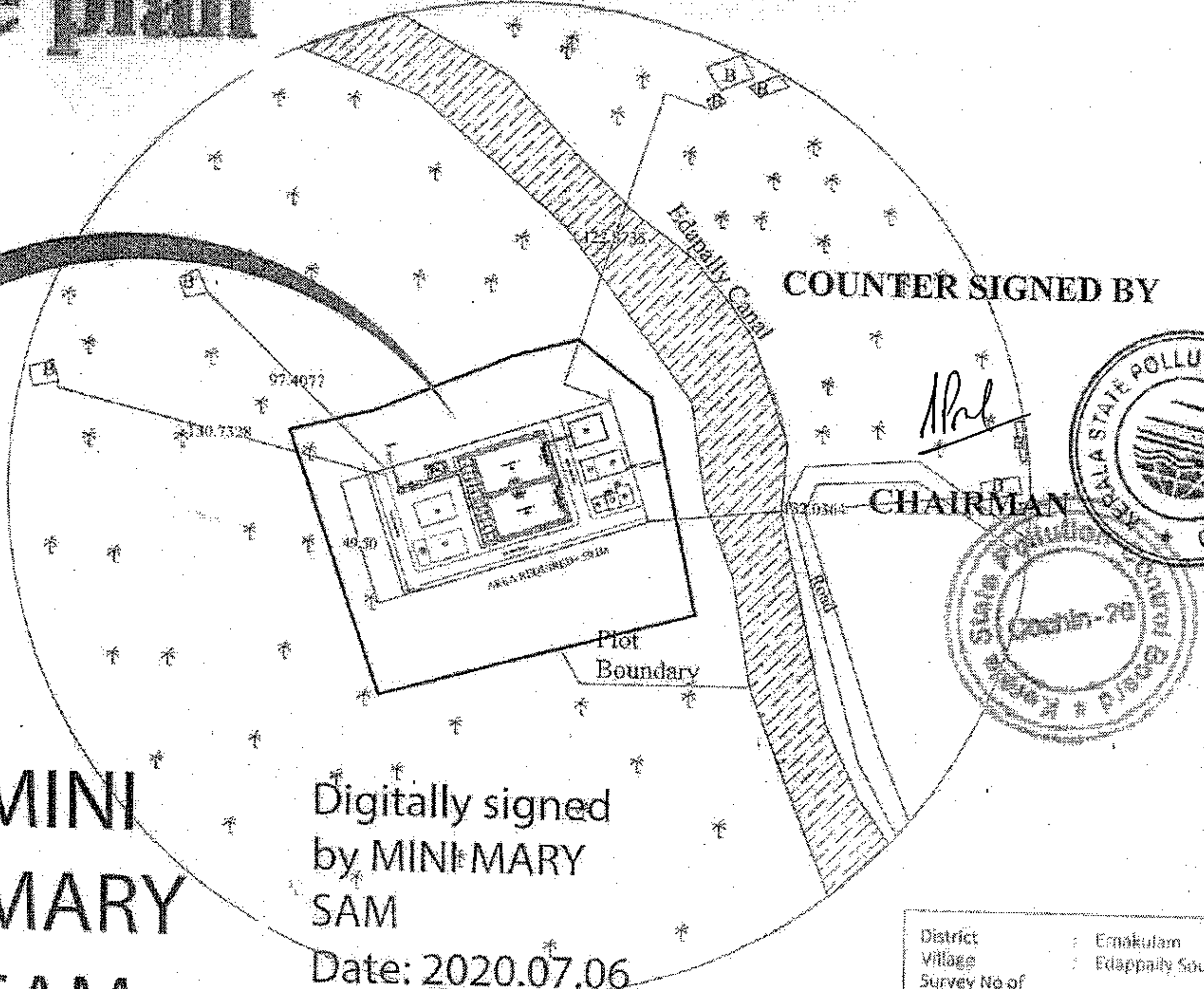
DATE

REV.

SHEET

Approved site plan





COUNTER SIGNED BY

CHAIRMAN

PROCESS UNITS				
SL.NO.	PROCESS UNITS	SIZE/CAPACITY	QTY.	REMARK
01	INLET CHAMBER	2000 x 2000 x 2000 SWD.	01	
02	FINE SCREEN CHANNEL-MANUAL	7000 x 850 x 800 SWD.	01	
03	FINE SCREEN CHANNEL-MECHANICAL	7000 x 550 x 000 SWD.	01	
04	GRIT CHAMBER-MECHANICAL	6000 x 5000 x 900 SWD.	01	
05	SBR BASINS	34200 x 17200 x 5500 SWD.	02	
06	FIBER DISC FILTER	14050 x 10000 x 5100 SWD.	01	
07	CHLORINATION TANK	16500 x 6800 x 3000 SWD.	01	
08	SLUDGE SUMP	5500 x 5000 x 2500 SWD.	01	
09	POLYELECTROLYTE DOSING TANKS	1300 x 1300 x 1300 SWD.	02	
10	CENTRATE SUMP	2000 x 2000 x 2000 SWD.	01	

BUILDING LIST				
11	HT SUBSTATION	25000 x 10000 x 4500 HT.	01	
12	DG SET HOUSE	10000 x 5000 x 4500 HT.	01	
13	SBR AIR BLOWER / MCC & CONTROL BLD.	10050 x 10000 x 10000 HT.		G+1
14	CHLORINATION CUM CHLORINE TONNER HOUSE (ABOVE CHLORINATION TANK)	8500 x 8000 x 4500 HT.	01	
15	CENTRIFUGE FEED PUMP HOUSE	7500 x 5000 x 4500 HT.	01	
16	CENTRIFUGE HOUSE	7500 x 5500 x 9500 HT.	01	G(STILT)+1

MINI MARY SAM

Digitally signed by MINI MARY SAM
Date: 2020.07.06 17:21:20 +05'30'

Environmental Engineer

District	:	Ernakulam
Village	:	Edappally South
Survey No of STP Site	:	23,106
Hectare	:	.50
STP Capacity	:	10 MLD

CLIENT:

GENERAL CONSULTANT:

Antea Nederland B.V. and Antea India(IV)

PROJECT: GENERAL CONSULTANCY SERVICES INTEGRATED URBAN REGENERATION AND WATER TRANSPORT SYSTEM, KOCHI

	NAME	SIGN	DATE
DRAWN			
DESIGNED			
CHECKED			
APPROVED			

KEY PLAN:

NO OBJECTION BY

CIVIL | MEP

TENDER DRAWING

DESCRIPTION

PROJECT: INTEGRATED URBAN REGENARATION & WATER TRANSPORT SYSTEM

LOCATION: VENNALA

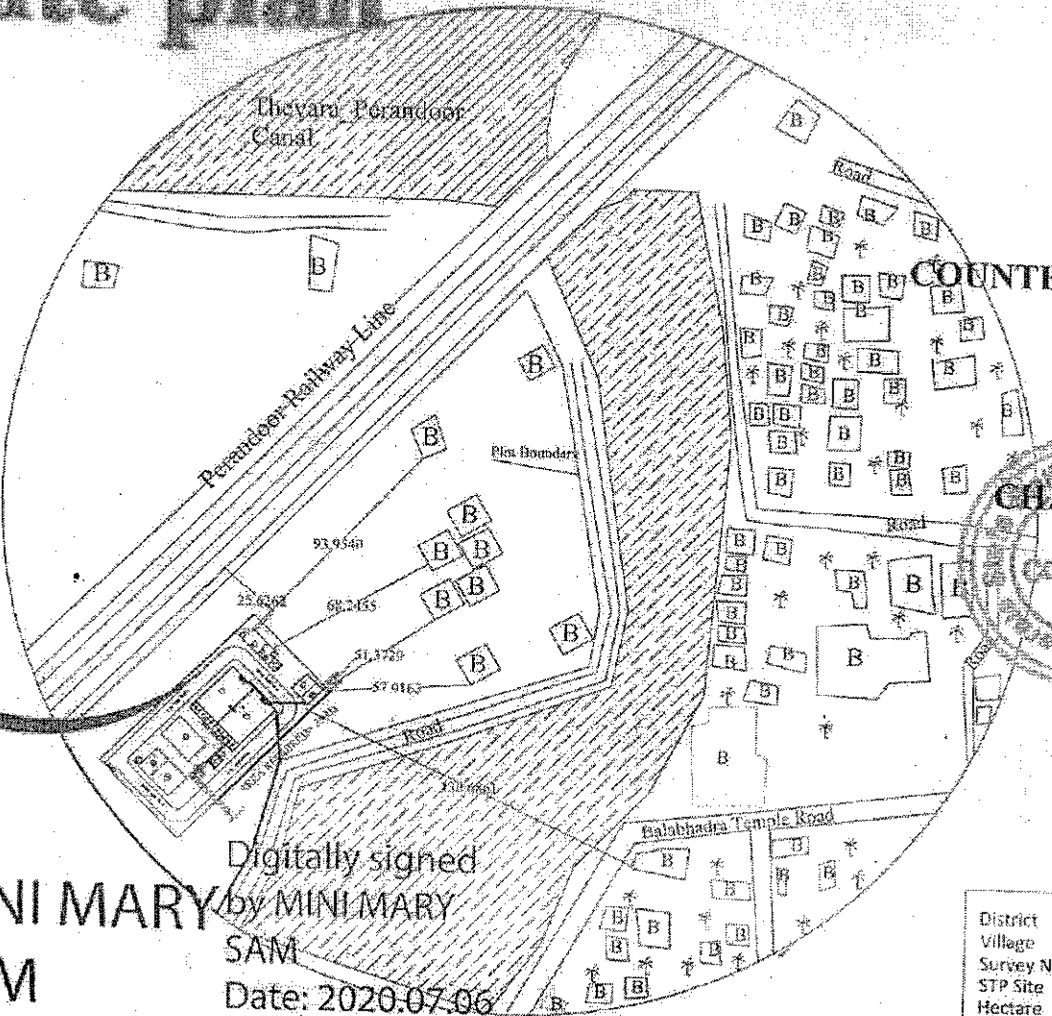
TITLE: SITE PLAN

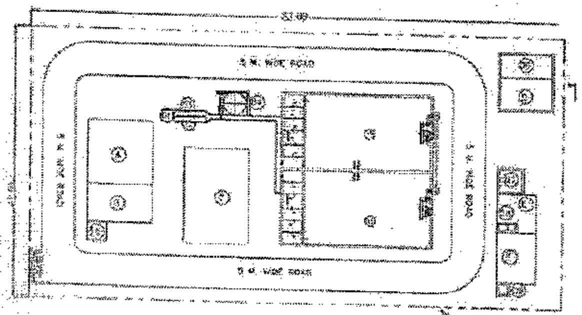
DATE: 17/06/2020

REV. R1

SHEET

Approved site plan





UNIT LIST				
UNIT NO	DESCRIPTION	SIZE/CAPACITY	QTY	REMARKS
01	STILLING CHAMBER	1500 x 1500 x 1500 SWD	01	
02	MANUAL BAR SCREEN (CHE)	5000 x 800 x 700 SWD	01	
03	MECHANICAL BAR SCREEN (MHE)	5000 x 500 x 700 SWD	01	
04	GRIT CHAMBERS	2500 x 2500 x 900 SWD	02	
05	SBR BASINS	23000 x 11500 x 5400 SWD	02	
06	CHLORINATION CONTACT TANK	2500 x 8000 x 2500 SWD	01	
07	SLUDGE SUMP	3500 x 3500 x 2500 SWD	01	
08	SAFE DOSING TANKS	1000 x 1000 x 900 SWD	02	
09	CENTRATE SUMP	1500 x 1500 x 1500 SWD	01	
BUILDING LIST				
a	HT SUBSTATION	15000 x 15000 x 4500 HT	01	
b	DG SET HOUSE	10000 x 5500 x 4500 HT	01	
c	SBR AIR BLOWER/MCC/ CONTROL ROOM	15000 x 10000 x 10000 HT	01	G+1
d	CHLORINATOR CUM CHLORINE TONNER STORAGE HOUSE	8000 x 5000 x 4500 HT	01	
e	CENTRIFUGE FEED PUMP HOUSE	6000 x 6000 x 4500 HT	01	
f	CENTRIFUGE HOUSE	8000 x 6000 x 9500 HT	01	[illegible]
g	SECURITY CABIN	2000 x 3000 x 3000 HT	01	

COUNTER SIGNED BY

CHAIRMAN

KERALA STATE POLLUTION CONTROL BOARD

Kerala State Pollution Control Board Cochin-20

District	: Ernakulam
Village	: Ernakulam
Survey No.of STP Site	: 1088,1090,
Hectare	: 0.35 Ha
STP Capacity	: 4 MLD

MINI MARY SAM

Digitally signed by MINI MARY SAM
Date: 2020.07.06 17:22:57 +05'30'

Environmental Engineer

CLIENT:

PROJECT: GENERAL CONSULTANCY SERVICES INTEGRATED URBAN REGENERATION AND WATER TRANSPORT SYSTEM, KOCHI

GENERAL CONSULTANT: Antea Nederland B.V and Antea India(JV)

Antea Nederland B.V and Antea India(JV)

	NAME	SIGN	DATE
DRAWN			
DESIGNED			
CHECKED			
APPROVED			

KEY PLAN

TENDER DRAWING

PROJECT: INTEGRATED URBAN REGENARATION & WATER TRANSPORT SYSTEM

LOCATION: PERANDOOR

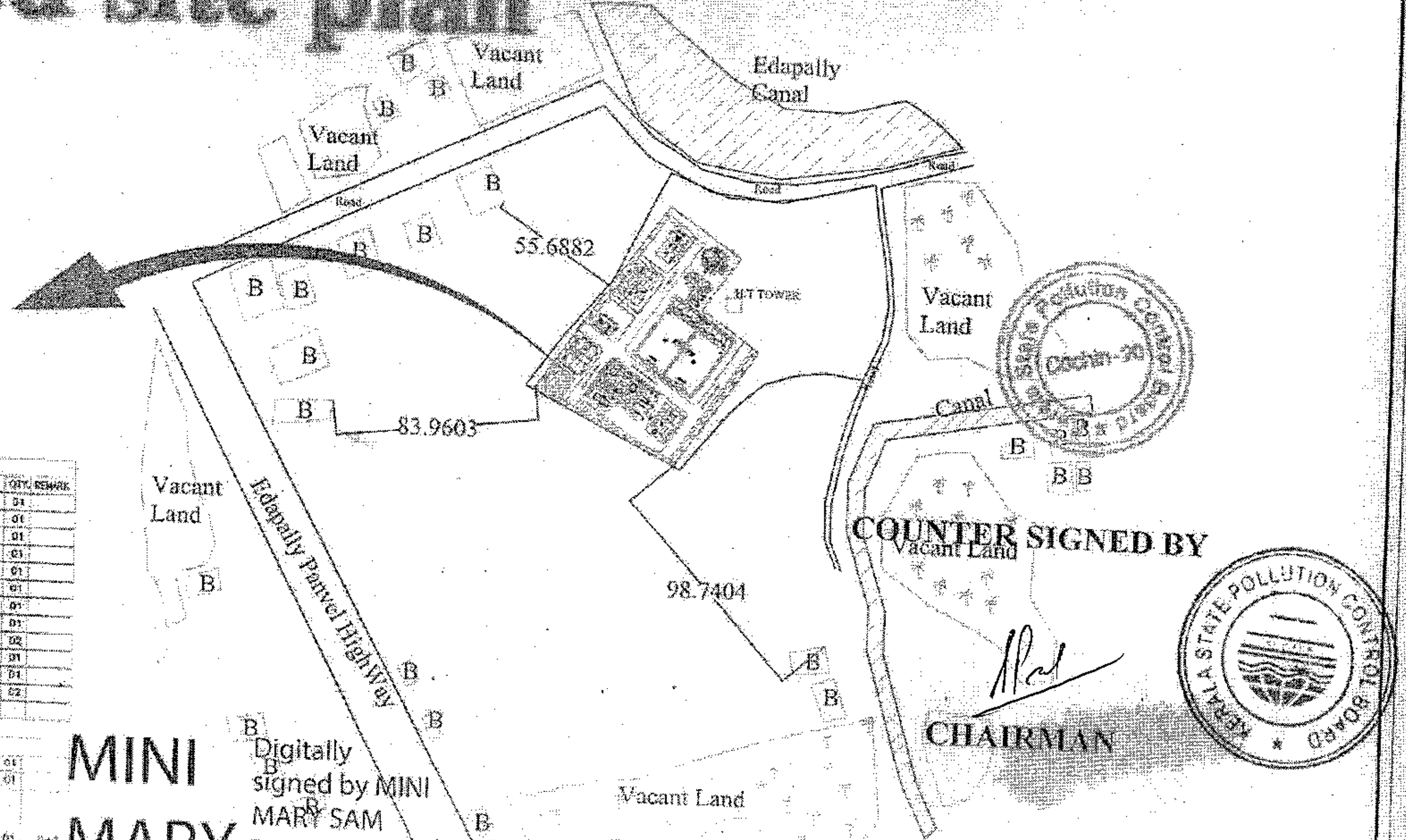
TITLE: SITE PLAN

SCALE: 1:1

DATE: 11/06/2020

REV. R1

Approved site plan



PROPOSED LAYOUT FOR 7MLD STP AT MUTTAR

SL.NO.	PROCESS UNITS	SIZE/CAPACITY	QTY.	REMARK
01	RECEIVING CHAMBER	3 m2. x 2000 SWD.	01	
02	COARSE SCREEN CHANNEL–MANUAL	5500 x 900 x 900 SWD.	01	
03	COARSE SCREEN CHANNEL–MECHANICAL	5000 x 900 x 600 SWD.	01	
04	RAW SEWAGE SUMP	9000 DIA x 1200 SWD.	01	
05	INLET CHAMBER	2500 x 2500 x 2000 SWD.	01	
06	FINE SCREEN CHANNEL–MANUAL	6500 x 900 x 500 SWD.	01	
07	FINE SCREEN CHANNEL–MECHANICAL	6500 x 900 x 500 SWD.	01	
08	GRIT CHAMBERS	4500 x 4500 x 900 SWD.	01	
09	SBR BASINS	28400 x 14500 x 6500 SWD.	02	
10	CHLORINATION TANK	12500 x 6500 x 3000 SWD.	01	
11	SLUDGE SUMP	6500 x 3000 x 3000 SWD.	01	
12	POLYELECTROLYTE DOSING TANKS	1200 x 1200 x 1200 SWD.	02	

A	HT SUBSTATION & PMCC ROOM	15000 x 12500 x 5000 HT.	01	
B	BLOWER ROOM	18500 x 7700 x 5000 HT.	01	
C	ADMIN. CUM PLC ROOM BUILDING–GROUND FLOOR: WORK SHOP, TOOL ROOM, OFFICE & TOILET BLOCK ADMIN. CUM PLC ROOM BUILDING–1ST FLOOR: LABORATORY, SCADA, TOILET BLOCK OPERATOR ROOM, CONFERENCE	14000 x 10000 x 9500 HT.	01	G+1
D	CHLORINATION CUM CHLORINE TONNER HOUSE (ABOVE CHLORINATION TANK)	5000 x 5000 x 3500 HT.	01	
E	CENTRIFUGE FEED PUMP HOUSE	6500 x 5000 x 4500 HT.	01	
F	CENTRIFUGE HOUSE	5500 x 5500 x 9500 HT.	01	(STILT)+1
G	DG ROOM	10000 x 5000 x 5000 HT.	01	
H	METERING ROOM	4500 x 4500 x 3000 HT.	01	
I	SECURITY CABIN	4500 x 3700 x 3000 HT.	01	
J	STAFF QUARTERS	12500 x 8000 x 3500 HT.	01	

MINI MARY SAM

Digitally signed by MINI MARY SAM
Date: 2020.07.06 17:20:37 +05'30'

Environmental Engineer

District	: Ernakulam
Village	: Edappally North
Survey No.of STP Site	: 53,55
Hectare	: 0.52
STP Caopacity	: 7 MLD

CLIENT:

GENERAL CONSULTANT:

PROJECT: GENERAL CONSULTANCY SERVICES INTEGRATED URBAN REGENERATION AND WATER TRANSPORT SYSTEM, KOCHI

	NAME	SIGN	DATE
DRAWN			
DESIGNED			
CHECKED			
APPROVED			

KEY PLAN

REVISIONS

NO.	DESCRIPTION	DATE	BY
R0	TENDER DRAWING		

PROJECT: INTEGRATED URBAN REGENARATION & WATER TRANSPORT SYSTEM

LOCATION: MUTTAR

TITLE: SITE PLAN

SCALE

DATE: 17/06/2020

REV: R0

DWG. NO.

SHEET

वाप्कोस लिमिटेड
WAPCOS LIMITED
(भारत सरकार का उपक्रम)
जल शक्ति मंत्रालय
(A Government of India Undertaking)
Ministry of Jal Shakti
ISO 9001: 2015

WAPCOS Limited

(A Government of India Undertaking)

76 C, Sector 18, Gurgaon – 122015, Haryana.

Tel. +91-124-2397396, Email: environment@wapcos.co.in