KERALA SUSTAINABLE URBAN DEVELOPMENT PROJECT

DESIGN AND SUPERVISION CONSULTANCY SERVICES FOR

PACKAGE 1

THIRUVANANTHAPURAM & KOLLAM

PROPOSED SEWAGE TREATMENT PLANT AT

THIRUVANANTHAPURAM

INITIAL ENVIRONMENTAL EXAMINATION

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PROPOSED SEWAGE TREATMENT PLANT AT THIRUVANANTHAPURAM
INITIAL ENVIRONMENTAL EXAMINATION

1.00 INTRODUCTION

Kerala Sustainable Urban Development Project (KSUDP) has been launched in Kerala with the assistance of Asian Development Bank (ADB) covering 5 major cities in Kerala namely Thiruvananthapuram, Kollam, Kochi, Kozhikode & Thrissur. The 5 cities have been grouped into two packages, namely Package-1 comprising Thiruvananthapuram & Kollam and Package-2 comprising Kochi, Kozhikode & Thrissur.

Project components in these cities have been established for implementation through a PPTA study conducted by ADB and the components are picked up from the sector:-

- ✓ Water Supply Upgradation
- ✓ Sewerage System Upgradation including Sewage Treatment Plant
- ✓ Solid Waste Management Improvement
- ✓ Storm Water Drainage System Upgradation
- ✓ Roads Upgradation
- ✓ Community Infrastructure Development.

Among above, water supply component is not included in case of Thiruvananthapuram.

A comprehensive environmental screening was conducted through Initial Environmental Examination (IEE), during the PPTA study for project formulation. This IEE is an updation of the report submitted along PPTA study and addresses the potential environmental impacts pertaining to the proposed Sewage Treatment Plant at Valiyathura locality in Thiruvananthapuram.

2.00 NEED FOR THE SEWAGE TREATMENT PLANT

Thiruvananthapuram Municipal Corporation presently comprises an area of 141.74 sq. km of which 30% is covered by a piped sewerage system, which serves the core city area. Sewage disposal methods from the households in un-sewered areas of the Corporation include septic tanks, borehole latrines and community toilets. There are also many houses without any sanitation facilities.

Presently most part of the sewage, about 50 mld reaches the only sewage disposal facility, in the form of a Sewage Farm at Valiathura locality in Thiruvananthapuram. The quantity of sewage from the city, conveyed through a system of sewer network aided by pumping stations, reaches a stilling chamber located at Muttatharai. From where the sewage flows by gravity to reach the Sewage Farm after crossing Parvathy Puthanar Canal (TS Canal). The Sewage Farm is located on the south bank of the canal (Ref. Fig 1).

The sewage farm designed for a capacity of 8 mld was commissioned in 1945. The Farm is now overloaded with 6 times higher quantity of sewage. The soil due to prolonged load of sewage and lack of maintenance provision has substantially lost its porosity. Consequently the raw sewage remains stagnated within the Farm for prolonged period developing septicity.

Occasionally such sewage spill over to adjacent area specially to the TS Canal.

The area is in the grip of severe mosquito nuisance. Stagnation of waste water is a potential source of contamination of ground water.

Present situation is that of a serious health hazard and a threat to ecology. With increased quantity of water to be made available to the population through another project and extension of sewerage network under this project (Estimated to be 107mld) the situation is likely to deplete manifold.

Installation of a Sewage Treatment facility with appropriate technology is of immediate need.

3.00 LEVEL OF ENVIRONMENTAL ASSESSMENT

Depending upon the potential level of significance of the associated environmental impacts, projects identified for assistance by ADB are categorized under 4 categories namely A, B, C or F1, as are pre-screened to avoid significant environmental impacts.

The Sewage Treatment Plant is proposed with Extended Aeration configuration of Activated Sludge Process, which is a time tested proven technology with sustainable functional capability to generate effluent of high quality standards conforming to regulations. This component has been categorized through PPTA study to be under 'B' category requiring Initial Environmental Examination.

4.00 CURRENT REGULATORY PROVISIONS

4.01 Environmental Impact Assessment

In 1986, a comprehensive Environmental Protection Act was promulgated which established a framework for environmental clearance, requiring that EIAs be conducted for new development projects with a cost of Rs.100 crore (approximately US $.25 million) or more an for capacity expansion/modification with a cost of Rs.50 crores (approximately US $.12.5 million). Specific project types were enumerated in a 1994 EIA Notification issued by the Ministry of Environment and Forests which were updated in subsequent amendments. The earlier Notification identified 32 categories of projects for which proponents must conduct EIAs and receive a clearance from the central government. These include a range of manufacturing facilities, power plants, highways, ports, airports, dams and tourist development in coastal areas.

The Notification does not require EIAs for urban environmental infrastructure projects (UEIP) because these are assumed to result in positive environmental impacts

In addition to central government requirements, some states, regional development authorities and municipal corporations have established their own EIA requirements for projects under their jurisdiction. These requirements vary widely from one jurisdiction to another. Environmental clearance generally falls under the jurisdiction of the State Pollution Control Boards in each state. Some states require EIAs for certain types of UEIPs, others do not. Those that do require

environmental clearance for UEIPs, generally specify sewage treatment and solid waste disposal. The situation is similarly mixed at the regional and municipal levels.

In Kerala there is no specific recommendation on EIA requirement for UEIPs. However, every project requires a "consent to establish" from the State Pollution Control Board under the Water (Prevention and Control of Pollution) Act and the Air (Prevention and Control of Pollution) Act .

The key distinction between Indian central government and development agency decision making regarding EIAs lies in the threshold mechanism. For the Indian government, it is the project type and funding level (Rs.100 crores); for development agencies like ADB, it is the project type and the finding of the initial environmental examination.

4.02 Water Quality

The most important regulatory concerns for the projects under the KSUDP concern the impact on the receiving water quality under the Water (Prevention and Control of Pollution) Act, 1974. The prescribed standards for the different receiving water quality depending on the designated use of the receiving water are summarized in **Annex A**.

4.03 Ambient Noise and Air Quality Requirements

The Noise Pollution (Regulation and Control) Rules 2000 were promulgated under the authority of the Environment (Protection) Act 1986. In essence they require that:

1) The ambient air quality standards in respect of noise for different areas/zones shall be such as specified in the Schedule annexed to these rules (presented at **Annex B**).
2) The State Government [shall categorize] the area into industrial, commercial, residential or silence areas/zones for the purpose of implementation of noise standards for different areas.
3) The State Government shall take measures for abatement of noise including noise emanating from Vehicular movements and ensure that the existing noise levels do not exceed the ambient air quality standards specified under these rules.

4) All development authorities, local bodies and other concerned authorities while planning developmental activity or carrying out functions relating to town and country planning shall take into consideration all aspects of noise pollution as a parameter of quality of life to avoid noise menace and to achieve the objective of maintaining the ambient air quality standards in respect of noise.
5) An area comprising not less than 100 meters around hospitals, educational institutions and Courts may be declared as silence area/zone for the purpose of these rules.
6) The implementing authority shall be responsible for the enforcement of noise pollution control measures and the due compliance of the standards in respect of noise.

National Ambient Air Quality Standards have been instituted by G.S.R.176 (E), dated 2nd April, 1996. These standards are also listed in **Annex B**. These standards nominate levels of air quality necessary within adequate margin of safety, to protect the public health, vegetation and property.

"Whenever and wherever two consecutive values exceed the limit specified above for the respective category, it shall be considered adequate reason to institute regular/continuous monitoring and further investigations."

4.04 Coastal Management

There is a Coastal Zone Management Plan for Kerala which addresses the coastal strip 500m inland from high water mark and the foreshores (50m) of backwater lakes and wetland areas. Within these broad areas, Coastal Regulation Zones (CRZs) are nominated depending upon the environmental assets, degree of development, degree of disturbance and coastal hazard (e.g. sea level rise) potential. This category covers all the developed areas within the Corporation which have been substantially built up.

The intention of the plan is for developments in these zones to be subject to regulatory/approval procedures by a nominated government authority. The Kerala Plan was approved in 1998. Developments in CRZs require the approval of Central/State Coastal Zone Management Authority constituted by the MoEF.

5.00 COMPONENT DESCRIPTIONS

Various tasks performed under KSUDP have led to the identification of deficiencies in the existing sewerage and sanitation system as well as the needs for augmentation and improvements. The overall scenario, of the current status is highlighted below.

The sewage farm is a non-acceptable environmental solution for city and primitive in nature. The sewage farm was installed in 1945 for 8MLD capacity and is currently well over a safe operating capacity.

Various studies have shown that Parvathy Puthanar canal is highly polluted by the sewage farm discharge. This canal is also polluted by excess raw sewage overflowing into drains, which joins it. The fish and fresh water benthic flora in the canal now have suffered extensive environmental damage as a result, with little life present currently.

The sewage farm is underlain by sand, over a base of hard laterite rocks. The highly porous nature of this sandy loam allows ready seepage of raw sewage, with organic contents removed by filtration and also by uptake in the root zone. The filtered waste water percolates down to a system of porous earthenware pipes which act as carriers and sub-carriers to discharge the water into Parvathi Puthanar through an efficient collection channel. The original design of the sewage farm also incorporated dilution by using water of Parvathi Puthanar canal.

The System, however, due to overloading and prolonged use is malfunctioning and is a source of severe contamination to TS Canal Water.

A 107 MLD capacity Sewage Treatment Plant with Activated Sludge Process (with extended Aeration process) is proposed to be executed under this project over 13 Ha land area covered out of the 52 Ha available at the present Sewage Firm at Valiyathura.

The proposed plant will have following units.

i. Inlet Chamber
ii. Detritus Chamber
iii. Aerators
iv. Secondary Settling Tanks
v. Centrifuges and Filter Press
vi. Sludge Drying Beds
vii. An office control room & laboratory.

The site for the STP is shown in Fig-1.

The Plant Layout is presented in Fig-2.

6.00 ENVIRONMENTAL SETTING

6.01 Regional Environmental Setting

6.01.1 Biophysical Environment

The project cities are located in the lowland geophysical division of Kerala. This is the coastal plain below the 7.5m contour and supports 26% of the population.
The zone is characterized by marine landforms of beach ridges, beaches, swamps and lagoons. The coastal wetland areas support rain-fed and irrigated rice. Coastal dry-lands support coconut/tapioca/cashew plantations. Reclaimed backwater areas are used for coconut plantations.

Climate

The lowland areas have 4 typical seasons; the dry weather from December to February, hot weather from March to May, South-West and North-East monsoon prevailing from June to November. The area has a moderate climate with the average annual temperature of 27^0C where as annual temperature range is 27.8 to 33^0C as a maximum and a range of 22.3-26.1^0C as a minimum. The South-West monsoon provides heavy and reliable rainfall with the average annual rainfall about 3,100 mm, within an average of 115 rainy days.

The monthly mean value of relative humidity varies from 75-96% in the morning (08:30 hrs) to 65-91% in the afternoon (17:30 hrs). Excessive rain during June to August causes frequent floods in the rivers and canals in the area, submerging low-lying areas.

Water Resources

Rainfall in Kerala concentrates on the high ranges of the Western Ghats. Because the coastal plain is narrower in the north of the state, with the highlands in closer proximity to the coast, the rainfall is highest on the north coast and generally decreases towards the southern end of the coast.

Surface water drainage is predominantly westward from the mountains (41 rivers out of a total of 44). They are monsoon fed and fast flowing. Therefore, in periods of high rainfall the high volume of water in the rivers draining the highlands supplement the in-situ rainfall – making the relatively lower rainfall areas in the south as susceptible to flooding as the higher rainfall northern coastal cities.

Floods in Kerala have been increasing in severity because of land use changes and ill-planned flood protection works, which move the impact downstream. A major flood in 1992 in south Kerala resulted in 75 deaths, more than 7,000 houses lost, and Rs.1,000 crore in damages.

The annual runoff yield is 77,900 million m3, however not all runoff is usable for water supply. In the thickly populated coastal belt, water storage space is not available and in the summer salinity intrusion makes the waters of the coastal reaches of rivers unusable. "The entire runoff below the 15m contour may be considered un-utilizable. In the midlands between 15m and 75m contours experience has shown that about 50% of the runoff may be considered utilizable directly or through storage." Whereas most of the runoff in the highlands is usable (Nampudripad, 1996).

Groundwater Resources

Large groundwater resources exist in the coastal zone. These comprise three deep aquifers:

Warkallai	Used for drinking water in Alleppey and Kuttanard – in south Thiruvananthapuram district
Thiruvananthapuram	Deeper than Warkallai aquifers and underlying them in parts
Vaikom	Large aquifer, between Thiruvananthapuram and Kayamkulam in the north. Brackish in its northern reaches.

In addition, unconsolidated aquifers occur throughout the coastal strip under water table conditions are tapped by open wells, at a density of 100-250 wells/km2.

Overuse of groundwater has permanently lowered the water table and allowed subsequent intrusion of salinity into coastal aquifers. This is mainly due to bore wells withdrawing water directly from the water table rather than from the deeper aquifer. Sand quarrying from river beds throughout the coastal strip has also contributed to lowering of the water table.

Fisheries Resource

Inland fisheries are made up of estuarine/backwater and freshwater fisheries.

"The vast stretch of brackish water lakes that exists along the coastal belt of Kerala consists of 30 identifiable backwaters. They constitute nearly 70% of the inland water resource of the state and are considered to be a life support system for about 2 lakh population belonging to more than 32,000 fisher families" (Nair, 1996).

It is estimated by Nair (Nair, 1996) that around 50,000 fisherman work full or part-time in these brackish waters. The take is 80% prawns (both marine and freshwater species). The fish are predominantly mullet, horse mackerel, pearl spot, milk fish, grassy perchlet, and anchovy. Clams, mussels and backwater oysters are also collected. All inland fisheries production is consumed within the state of Kerala (Jayakumar et al, 2002).

Mangroves

Kerala mangroves have high species diversity (32 different mangrove species), although two species have disappeared over the last decades, and more are threatened.

The mangrove ecosystems are biologically rich. The zooplankton strata are represented by almost all groups of aquatic forms like protozoans, sponges, carnivorous coelenterates (clenophora, hydromedusae, and polychaetes). Fishes are plentiful. Crustaceans include crabs, shrimps and barnacles; mollusks include clams, oysters, mussels and their larvae. Decapod crustaceans like the Uca and Scylla are numerous. Otters, water snakes, tortoises, resident and migratory birds water fowls form the characteristic vertebrate fauna.

Indiscriminant reclamation of backwater wetlands during the past few decades has reduced the extent of mangroves from 700 km2 to only 50 km2. The majority of the remaining mangroves stands are distributed, unevenly, among the districts containing the five project cities.

Coastal Erosion

Three hundred and seventy kilometers of the Kerala coast are subject to erosion. Beach abrasion rates are as high as 5.2 m/yr (at Chellanam) and 3.1 m/yr (at Thottappally). These are also small areas of accretion which offset this trend but do not balance it.

6.01.2 Social and Cultural Resources

The state exhibits a steady increase in urban population from 16.24% in 1971 to 25.97% in 2001, which is slightly lower than the national average of 28% (Census 2001). However, the percentage of the urban population has witnessed a decline from 26.39% in 1991 to 25.97% in 2001 and accounts for lowest decadal urban growth rate of 7.6% in comparison to the decennial growth of 60.89% between 1981to 1991. The reason for the decline in the urban population in 2001 has been due to the reduction in number of census towns and the change in jurisdiction in statutory urban areas in the state.

Reflecting similar pattern of urban growth in the state, the trend of total population in Kerala also reveals a low decadal growth rate of 9.42% (1991-2001), which has been the least growth rate in comparison to all the states of India. It accounts for an increase of 0.94% annual growth rate during this period, which is significantly lower than the national average of 2% too. These growth rates of the state demonstrate that whilst net migration has been a contributing factor to urban population growth, natural increase has been the dominant explanatory factor in 1991-2001.

Trend of Urban Population of India and Kerala: 1971-2001

Year	India			Kerala		
	Total	Urban	% of Urban Pop.	Total	Urban	% of Urban Pop
1971	548,159,652	109,113,977	19.91	21,300,560	3,459,211	16.24
1981	683,329,097	159,462,547	23.34	25,453,680	4,770,020	18.74
1991	846,302,688	217,611,012	25.71	29,098,518	7,680,294	26.39
2001	1,027,015,247	285,354,954	27.78	31,838,619	8,267,135	25.97

Census of India: 1971, 1981, 1991, and 2001.

The spatial distribution of population in Kerala according to Census 2001 reveals that the majority of people reside in rural areas accounting for 74.03% (Census 2001). Despite this, Kerala has a large and growing urban population. In line with expected trends in India, urbanization in Kerala is expected to intensify over the coming decades. It has been estimated that over the twenty-year period (2001-2021), even after the estimating the current annual rate of 0.76% increase, the population growth would reveal 15.2% increase in absolute terms. Hence, the

urban population would likely to exceed 9.53 million by the design year of the Project, 2021.

Poverty

In 1973-74, Kerala was amongst the five poorest states, with nearly 62% urban poverty. Since then, conditions in Kerala have improved and it is now amongst the states with very low percentage of population below the poverty line. As per the NSSO (1999-2000) Kerala has poverty figures of 9.38% in rural areas and 20.27% in urban areas, where as the All India figures are 27.09% in rural areas and 23.62% in urban areas.

For the year 1999-2000, the Below Poverty Line (BPL) for urban areas of Kerala had been estimated at Rs.477.06 per capita per month. In 1999-2000, 20.27% of the State's urban population was living below the poverty line in comparison to 23.62% for the country as a whole. Urban poverty was higher than rural poverty with a 20.27% and rural reflecting 9.38%. In both the cases i.e. urban and rural the percentage of BPL population has been lower than national average respectively.

Cultural Heritage

Items of cultural heritage, resources for traditional purposes, structures or sites that are of natural, historical, archaeological, scientific, or architectural significance have been listed in the Coastal Management Plan (1995). The IEEs have used this reference to check on potential impacts on heritage items.

6.01.3 Developmental Setting

The first ever National Human Development Report (NHDR), 2001 by the Planning Commission estimated the value of Human Development Index (HDI) for the states and the UTs of India. HDI for the country as a whole has improved from 0.302 in 1981 to 0.472 in 2001. Kerala a middle-income state remains at the top of the NHDR table with an achievement of HDI of 0.638, an increase from 0.500 in 1981.

So far as the urban-rural gap is concerned, the national index for rural areas has gone up from 0.263 to 0.340 and for urban areas from 0.442 to 0.511. The rural-urban gap was at the minimum in case of Kerala and maximum for Madhya Pradesh.

Human Development Index of India and Kerala: 1981-2001

Year	Kerala	India
1981	0.500	0.302
1991	0.591	0.381
2001	0.638	0.472

Source: Tenth Five Year Plan 2002-2007.

Infrastructure Index. The infrastructure index brings out a composite comparative profile of the availability of physical, social and institutional infrastructure in the state. It has been viewed that amongst all the states, Goa had the highest infrastructure index of 200.57 and Kerala had the third highest infrastructure index of 178.68. The other states with highest infrastructure index include Punjab (187.57), Gujarat (124.31) and Haryana (137.54). The highest index means the best placed state in terms of infrastructure facilities.

The target for Net State Domestic Product (NSDP) growth is 7% per year, with primary, secondary and tertiary sectors targeted at 4%, 8% and 9% respectively. Plan outlays are focused heavily on social services, energy and irrigation, but in rural rather than urban sectors.

6.02 City Environmental Settings

6.02.1 Climate

Thiruvananthapuram city, as is the case with whole state, has a fairly uniform and pleasant climate throughout the year with a relatively high temperature and high humidity condition prevailing through out the year. The city climate falls under a tropical humid maritime climatic, characterized by a fairly hot summer, moderate winter and a tropical rainy season. The average annual rainfall is 1,803 mm which include rains during both prominent seasons.

The average annual temperature ranges between 22.3°C to 33°C with mean relative humidity being 82% in the morning and 75% in the evening. The winds are moderate to strong during monsoon months and light to moderate during other seasons. During hot months, the area lying close to the coast experience on shore high winds especially in the afternoon.

The dominant wind direction is from the north in the morning and north-west in the evening with dominant wind speed varying from 12 to 19 km per hour. Such climatic condition reflects that the natural dispersion capacity of the atmosphere in this coastal city is high.

6.02.2 Atmospheric Air Quality

Trends of Air Quality of Thiruvananthapuram

Annual Average Concentration (µg/m^3)															
Name and type of Stake	1998			1999			2000			2001			2002		
	SPM	SO_2	NOx	SPM	SO_2	NOx	SPM	SO_2	NOx	SPM	SO_2	NOx	SPM	SO_2	NOx
Residential (Palmood)	144	6.6	2.2	121	12.8	21.0	13	10.3	23.0	<50	9.2	15.0	<50	11.8	9.4
Industrial (SV Raja School)	179	26	19.1	158	26.1	21.1	16	20.3	25.5	<50	13.6	18.6	<50	15.5	15.6

NB: Index used for categorization of pollute level

Ambient Air Quality Standards

Parameter	SO_2	NOx	SPM
Low (L)	0-40 µ/m^3	0-40 µ/m^3	0-70
Moderate (M)	40-80 µ/m^3	40-80 µ/m^3	70-140
High (H)	80-120 µ/m^3	80-120 µ/m^3	140-210
Critical	>120 mg/m	>120 mg/m	>210

In Thiruvananthapuram, the ventilation rates are quite high because of high winds prevailing during prolonged monsoon period (about 5 to 6 months). The land and sea breeze component will not permit excess pollution built up the city zone over a long period.

The major air pollution sources in Thiruvananthapuram are vehicular emissions. Long-term trends indicate that as far as primary pollutants are concerned, the ambient concentrations of SO_2 and NO_x are lower than the standard of (80 g/m^3) The annual ambient concentration average for suspended particulate matter is generally very low (less than 50 g/m^3).

6.02.3 Noise Environment

The major source of sound pollution is the vehicles and indiscriminate use of loud speakers. The trend of sound level in the city, indicate that the sound level is above the limits prescribed all over the city area.

Noise Level (Leq) at Various Locations at Thiruvananthapuram

Location	Area Classification	Sound Level (Leq) dBA			
		Day Time		Night Time	
		Standard	Observed Value	Standard	Observed Value
General Hospital Jn	Sensitive Zone	50	70.82	40	56.01
S.M.V.High School Jn	Sensitive Zone	50	74.29	40	67.9
Medical College Jn	Sensitive Zone	50	70.63	40	47.73
Pattom	Residential	55	75.91	45	60.61
Thambanoor	Commercial	65	72.31	55	65.18
East Fort Jn	Commercial	65	75.56	55	51.39

Source: KSPCB, 2002.

6.02.4 Physiography and Soil

Thiruvananthapuram city is characterized by a highly undulating topography, with a gradual down ward slope towards the sea. Only the lands near to the coastal region have near flat terrain. The maximum elevated region of Thiruvananthapuram Corporation lies in its North Easter region and consists of Mudavanmugal, Thrikannapuram, Thirumala, Pangode, Vattiyoorkavu, Vazhuthacaud, Kanjirampara, Sasthamangalam, Kawdiar, and Kuravankonam wards. Poonthura Bimapally, Valiathura, Sanghumugham and Vettukadu wards lie in the coastal area and are at low elevation. The area on the eastern side constitutes a part of the lateritic midland, and it merges with the coastal plains in the west. Isolated hillocks composed of crystalline rocks are also found. The Vilapilsala, the location of the MSW disposal site lies towards eastern side of the city, where steep slopes are prevalent. The undulating characters of this site provide ample opportunity for waste disposal.

Soil Characteristics of Thiruvananthapuram Corporation is predominately Trivandrum series, where soil is a gravely sandy loam to gravely clayey loam, with moderate permeability. The Land Fill Site (LFS) area is patched with soil of series like a maravilla, Marukil and Kunnathukal. In general the South-Western region of the city is characterized by sandy loam where as North-Eastern region is

a brown loam. The central parts of Thiruvananthapuram are brown loam of laterite origin, where as eastern parts are brown loam of granite origin.

6.02.5 City Drainage

The characteristic undulating topography of the city has made the area well-drained. As discussed earlier, the area has 2 major rivers with a number of smaller streams and channels flowing through various parts of the city. The soil being porous also helps in quick removal of the accumulated water. The rivers Killiar and Karamana meet the sea at Edayar, in Thiruvallam Panchayat. Another channel known as Parvathi Puthanar (T.S.Canal) running parallel to the coast also meets the Karamana River at this point. The Parvathi Puthanar is connected to the sea at both ends: one end through Karamana River and the other through Veli. Formation of intervening bars, or sand bars, near the estuarine mouths are common features particularly produced by littoral drift of sand during the period of south-west monsoon. Nevertheless, the high volume of discharge during the period of south-west monsoon permits flow of water into the sea. At all other times the tidal effect is almost negligible. As a result, the discharge from the canal remains in the river water for a very long time and this is compounded be solid waste disposal in the canals, blocking the free flow of water.

6.02.6 Ground Water Status

The prominent ground water aquifers occur in the alluvium, laterite to weathered crystalline rods and semi confined to confined aquifers, occurring in the deeper fractural rocks and tertiary sediments. The secondary water data reported in the Table below (Water Level Data of the Observation wells Network in Thiruvananthapuram**)** represents the period of 1985-1993, observed in a permanent network of hydrograph stations established at Vazhuthakad, Kochuveli and Poonthura. This network comprises 31 wells, 20 wells in laterites, 9 in alluvium and 2 wells in crystalline belt.

Water Level Data of the Observation wells Network in Thiruvananthapuram

Area	Depth to Water Level (B.M.P)												
	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Trivandrum	1985	13.65			13.10				11.67			16.69	
Khondalite	1986		12.76		13.43				12.16			11.77	
	1987	13.25			13.42				10.73			10.40	
	1988		11.20					10.90	11.90			11.45	
	1989	11.22				13.88			12.92			10.91	
	1990	11.10				14.30			15.05			12.25	
	1991	13.94			14.20				10.11			11.70	
	1992				15.23				13.20			13.56	
	1993	13.30			14.20				13.57			10.71	
Kokchuveli	1985	5.72			5.92				4.81			4.32	
Coastal	1986		5.07		5.57				4.55			4.75	
Alluvium	1987	5.50			Dry				5.67			3.55	
	1988		6.49						3.64			3.77	
	1989	4.15				3.00			3.53			3.67	
	1990	3.61				3.70			3.53			2.63	
	1991	3.41								2.39		3.06	
	1992				4.10				3.13			3.03	
	1993	3.04			3.90								
Poonthura	1985	4.32			4.15				4.31			3.02	
Coastal	1986		4.24		4.15				4.55			3.88	
Alluvium	1987	4.18			4.32				3.90			4.12	
	1988		4.34				3.99		4.35			4.25	
	1989	4.20				4.28						4.00	
	1990	4.13				3.50			4.24			3.30	
	1991				3.07					3.38		3.79	
	1992				4.01				4.25			3.83	
	1993	3.19			3.10								

Source: CGWB

Ground Water Source. From the hydro geological study (Report on Environment Impact Assessment for Trivandrum Sewage Component 1994) it was established that the laterite being cavernous and porous, is more easily recharged and drained off during heavy showers and dry period respectively. The depth to water table in this formation generally ranges from 2.37m to 5.00m below ground level (BGL) and depths of well vary from 3.13m to 20m. The maximum depth occurring along the laterite well rocks. In crystalline, the occurrence of ground water is restricted

to the space available in the weathered and issued portion, joint planes and fracture. The depth of water table in this formation varies from 4.96m to 7.58m BGL and the depth of the wells range from 7.40m to 8.57m BGL. The coastal alluvium along the coast generally shows a depth to water table variation of 1.2 to 4.5m BGL and depth variation of 1.90 to 5.16m BGL.

The ground water level fluctuation in the city is being monitored through there observational wells and data to 1985-1993 is shown in Table above. The data reflects that the maximum depth of water table is during the month of April and minimum in November. The rise in wells in the crystalline strata for the monsoon half year (April-November) is 1.67m to 4.00m and the levels recede to 1.67m to 3.49m during the remainder of the year. Alternatively, in the alluvium zone, (sewage farm located in this zone) the monsoon rises in water table are between 0.2 to 1.00 meters where as, the decline is only 0.18 to 0.82 meters.

The ground water in the network wells was found of good quality when comparing the electrical conductivity levels, the average observed was in 390 micro m/cm at 25°C and the chloride value ranged between 43 and 30 mg/l.

6.02.7 Solid Waste

The physical composition of household waste and commercial waste in typical Kerala cities is shown below in **Figures 3** and **4**. The data show the high potential for composting for both waste sectors.

Figure 3: Composition of Household Waste

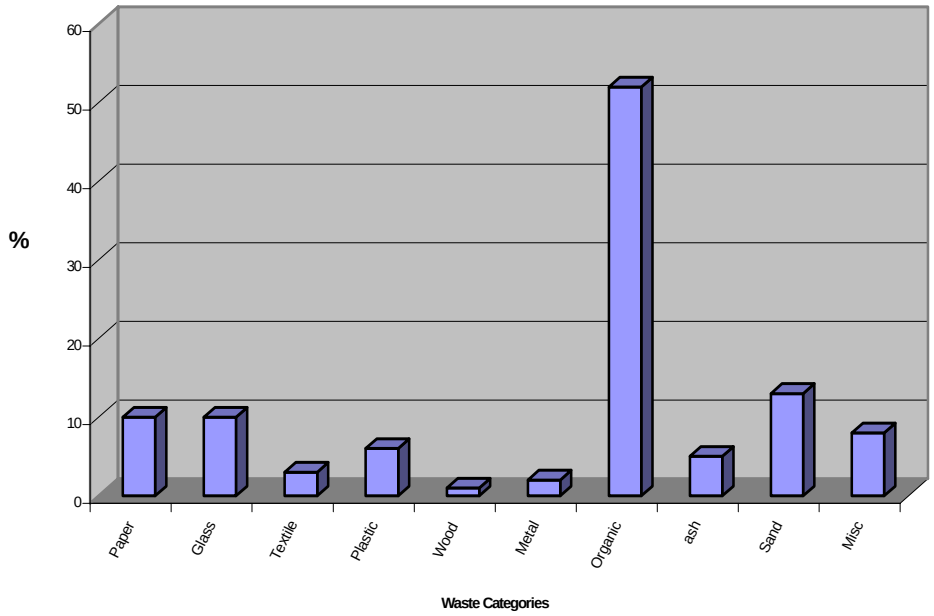
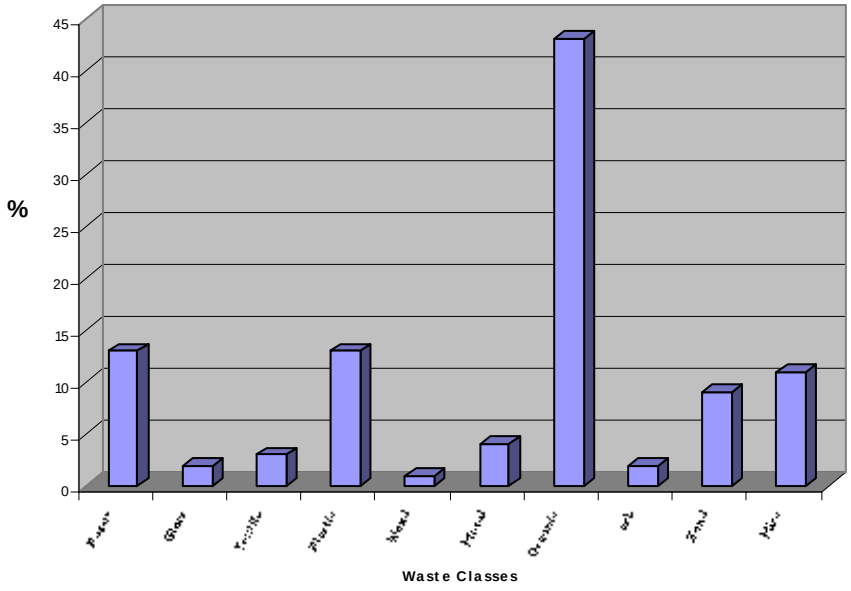


Figure 4: Composition of Commercial Waste

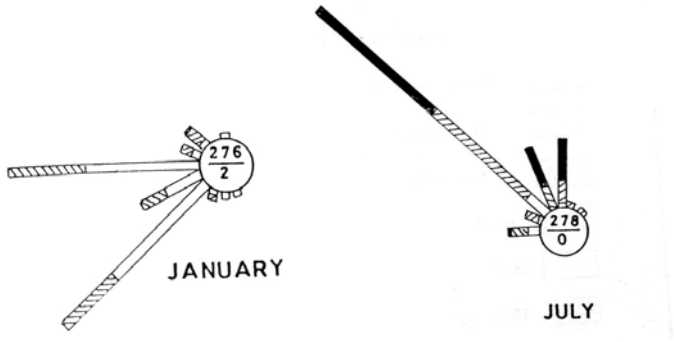


6.03 Site Environment Settings

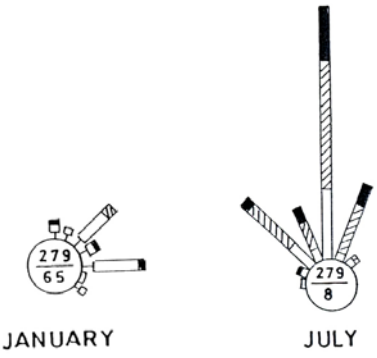
6.03.1 Climate

The site borders the 500m coastal zone and is subject to onshore coastal climatic conditions. From November to March, the mornings are generally calm, and in the afternoons an offshore wind achieves speeds of up to30 km/h. In the cooler and rainy season (April to October) the wind is generally onshore all day with velocity increasing in the afternoon. The stronger winds (commonly exceeding32 km/h) tend to blow in a north-westerly direction, i.e. parallel to the coast. The gentler morning winds are more onshore, blowing towards the north.

Figure 5: Wind Roses for STP Site



Wind roses for Trivandrum at 08:30 hours representing dry season and wet season conditions



Wind roses for Trivandrum at 17:30 hours representing dry season and wet season conditions

6.03.2 Terrain and Drainage

The topography of the STP site, being a long-term sewage farm, is generally flat. It is about 2m above sea level and is drained by the adjoining Parvathi Puthanar.

Sub-surface drainage in the sewage farm area has been designed to allow surface water to percolate through the topsoil and drain towards the south-western (coastal) edge of the farm where it is intercepted by deep channels and redirected inland to Parvathi Puthanar (T.S. Canal). Although the sub-surface drainage structures in the sewage farm area would almost certainly be in some disrepair after 50 years since their construction, changes in the subterranean environment over the years would have consolidated this drainage pattern, and continued drainage towards the coastal edge of the site will need to be accounted for in project design and implementation.

6.03.3 Surface Water

Surface water flows at the site are centered upon the waters of the Parvathi Puthanar (both as a source of input water, and as receiving waters) and the sewage flows from the Trivandrum sewerage system.

The waters of Parvathi Puthanar are theoretically used as dilution water to reduce the concentration of sewage before it is applied to the sewage farm. However the waters of Parvathi Puthanar are already heavily polluted from direct runoff and from uncollected domestic waste from Trivandrum directed to the canal via the Thekkanekara canal and the drain from the Eanchakkal Pumping Station. Therefore the dilution mechanism has not been operating as planned, and the effluent load entering the sewage farm area as irrigation water has always been higher than design expectations. Additionally, the partially treated sewage being directed back into the Parvathi Puthanar has further polluted the canal (see below).

Investigation of waters of Parvathi Puthanar in 1994 made the following measurements for the canal downstream of the sewage farm:

Downstream Measurements of Parvathi Puthanar (1994)

Color	Odor	TSS (ppm)	TDS (ppm)	BOD (ppm)	COD (ppm)	pH	E coli	NH4 (ppm)	NO3 (ppm)	Phenol (ppm)	Phosphate (ppm)
Grey/green	Faint	61.3	627.0	10.0	22.5	7.2	980	1.1	3.2	0.01	0.6

However, the water quality at the take-off point for dilution water to add to the sewage flow is just downstream of one of the sewage farm's treated water outlet points. Not surprisingly, organic pollution levels are elevated here:

Measurement of Parvathi Puthanar, New STP Outlet Point (1994)

Color	Odor	TSS (ppm)	TDS (ppm)	BOD (ppm)	COD (ppm)	pH	E coli	NH4 (ppm)	NO3 (ppm)	Phenol (ppm)	Phosphate (ppm)
Grey	Smell	53.3	224.0	20.0	32.2	7.2	350	1.7	2.6	0.025	1.1

Recently, the combination of rising pollution levels in Parvathi Puthanar and the deterioration of pumping infrastructure have resulted in the discontinuation of the use of dilution water and sewage (only diluted to varying degrees by the inflow of storm waters into the system) has flowed into the farm direct from the sewerage lines. The sewage effluent itself comprises the remaining surface water associated with the site. This has been extensively sampled and results from the 1994 survey are as follows:

Surface Water Measurements at STP Site (1994)

Location	Color	Odor	TSS (ppm)	TDS (ppm)	BOD (ppm)	COD (ppm)	pH	E coli	NH4 (ppm)	NO3 (ppm)	Phenol (ppm)	Phosphate (ppm)
At inlet	Grey/ black	foul	277.7	454.4	220	380	7.3	710	28.7	3.9	0.17	2.8
North section	blackish	foul	550.0	256.0	180	320	7.1	400	13.4	8.4	0.15	1.8
West section	blackish	foul	2,206.6	288.0	200	320	7.3	450	21.1	3.2	0.14	2.1
South section	blackish	foul	136.3	370.4	180	280	7.2	610	27.1	8.7	0.15	1.8

Sampling Results – KWA (2006)

Sl. No.	Determinant	Unit	Sewage coming into the farm [Inlet]	Sewage coming out the farm [Outlet]
1	BOD [3 day at 27ºC]	Mg/l	182	154
2	COD	Mg/l	400	464
3	pH	-	6.03	6.2
4	Temperature	ºC	30	30
5	Suspended Solids	Mg/l	270	318
6	Volatile Solids	Mg/l	61	48
7	Nitrates	Mg/l	BDL	BDL
8	Phosphates as P	Mg/l	1.56	1.72

The range and concentrations of heavy metals in the sewage entering the sight is low. In 1994 among nine metals sampled, only zinc, manganese and iron were in measurable amounts in all areas of the farm. Additionally, a low concentration of mercury was found in only the raw sewage sample. However, a greater range and concentration of heavy metals (again with the exception of Hg and Cr) was found

in sewage sludge in all parts of the sewage farm – indicating that metals are present in the sewage in the form of settle able organic particles which precipitate rapidly in the sludge.

Sampling Results – KWA (2006)

Sl. No.	Parameter	Raw Sewage Characteristics
1	BOD5 at 20ºC (mg/l)	300
2	COD (mg/l)	500
3	Total Suspended Solids (mg/l)	400
4	Oil and Grease (mg/l)	100

Studies were also conducted in 1994 for the impact of sewage releases on the biological environment of the canal. The benthic flora and the fish catch in the canal were sampled.

In the sewage discharge zone of Parvathi Puthanar toxic algae such as *Lyngbya* sp. *Microystis* sp. and *Anabaena* sp. were found in large amounts.
Variations in fish populations were found and correlated with the distance from the discharge point from the sewage farm. The study found that dissolved oxygen level of the water was so low during disposal periods that fish did not visit the discharge area. However in periods when discharge was suspended, fish moved into feed.

6.03.4 Surface Geology

The site is sandy coastal alluvium overlaying laterite. The depth of coastal sediments is up to 20m. In the locality of the STP site, the depth to the water table is 3-5m below ground level. The soil on site is predominantly sand/sandy silt, although the 1994 EIA for the development of a STP on site typifies the surface soil as more than 50% clay and clay loam. It is unlikely that the original preparation of the soil bed for the sewage farm would have included large areas of clay, since this would impede filtration of the sewage through the soil profile. A possible explanation for the presence of clay is through gradual deposition of clay sediments in the waste water (which contains a high proportion of storm water) over the life of the installation. This possibility is supported by the data in the 1994 EIA that the subsoil is sandy all over the site.

Though 50 years of saturation the soil is highly contaminated, with salt accumulation, high nitrogen profile, acid trend, and heavy metal contamination (copper, zinc, lead, mercury and chromium in elevated levels). The concentration of heavy metals in the input acres and sewage, especially in the sludge, over such a long period has led to build-up of these materials in topsoil and subsoil (Table below).

Load of Heavy Metals at STP Site (1994)

Portion of Sewage Farm	Cu	Zn	Pb	Hg	Cr	Cd	Ni	Mn	Fe
South	0.8	2.0	ND	ND	ND	ND	ND	6.0	64.0
North east	4.0	16.0	2.2	ND	ND	ND	0.8	16.0	928.0
Mid east	2.4	12.8	2.8	ND	ND	ND	0.6	10.0	820.0
South east	4.0	12.4	1.8	ND	ND	ND	ND	12.0	840.0
West	3.8	12.8	2.0	0.4	0.2	0.1	ND	12.0	680.0
North	8.8	20.0	1.8	0.4	ND	ND	ND	14.0	800.0
West	2.0	16.0	2.0	ND	ND	ND	6.6	12.0	720.0

NB: All data in ppm

6.03.5 Groundwater

An intensive survey of groundwater and well water quality in and around the sewage farm for the 1994 EIA demonstrated clear evidence that the operation of the farm was contaminating groundwater. The attenuation of pollution levels in groundwater with distance away from the site, as well as comparison with a control well in Anayara (about 3 km northwest of the site) confirmed this conclusion.

Characteristics of ground water samples in and around sewage farm area

Location of Collection	Color	Odor	TSS (ppm)	TDS (ppm)	BOD_5 (ppm)	COD (ppm)	pH	E. coli	NH_4-N (ppm)	NO_3-N (ppm)	T.A. (ppm)	Phenol (ppm)	Phosphate (ppm)
Sub surface	Slight Yellow	Slight Smell	13.2	422.4	18.0	37.5	7.0	660.0	4.1	12.7	112.0	0.013	0.50
East (6 m)	Yellow	Smell	96.5	275.2	12.5	25.0	7.2	430.0	6.7	9.1	98.0	0.013	0.40
East (30 m)	Slight Yellow	Slight Smell	1.0	332.8	8.0	20.0	7.1	520.0	7.9	12.3	90.0	0.012	0.30
East (75 m)	Almost Clear	-	70.3	108.8	6.5	15.0	7.2	170.0	0.6	4.0	88.0	0.013	0.25
North	Almost Clear	Slight Smell	47.4	179.2	7.0	14.5	7.3	280.0	1.1	6.4	86.0	0.013	0.30
North East	Slight Yellow	Smell	15.0	332.0	6.8	17.0	7.1	520.0	0.6	7.5	156.0	0.012	0.40
South West	Slight Red	Slight Smell	28.6	403.0	6.5	16.14	7.1	630.0	0.4	7.2	88.0	0.012	0.40
Anayara (control)	Almost Clear	--	18.2	140.8	4.8	12.0	7.1	220.0	0.3	2.7	52.0	0.002	0.20

Concentrations (ppm) of some metals in ground water samples

Location	Metals (ppm)								
	Cu	Zn	Pb	Hg	Cr	Cd	Ni	Mn	Fe
Subsurface	0.02	0.22	ND	ND	ND	ND	ND	0.07	0.30
East (6 m)	ND	0.23	ND	ND	ND	ND	ND	ND	0.38
East (30 m)	ND	0.14	ND	ND	ND	ND	ND	ND	0.32
East (75 m)	ND	0.35	ND	ND	ND	ND	ND	0.63	0.36
North	ND	0.17	ND	ND	ND	ND	ND	0.02	0.24
North-East	ND	0.16	ND	ND	ND	ND	ND	0.01	0.28
South-West	ND	0.19	ND	ND	ND	ND	ND	0.02	0.30
Anayara	ND	0.18	ND	ND	ND	ND	ND	0.11	0.36

ND = Not Detectable

6.03.6 Land Cover

The sewage farm site is covered almost entirely by macrophytic grass fodder species including:

Pennisetum purpureum	Napier Grass
Urochloa mutica	Para Grass

The bunds and elevated tracks dividing up the fodder areas support coconut trees and *Poinsiana* species. The site is bounded on all but the northeast boundary by

roads and poor residential areas. This is an almost unbroken canopy of Coconut trees and, to a lesser extent, mangoes in these areas.

The northeast boundary borders the Parvathi Puthanar, which is clogged by duckweed (*Lemma* spp), giant water fern (*Salvinia molesta*), and water hyacinth (*Eichhornia crassipes*). Beyond the northeast boundary is an area of ground used for playing fields.

7.00 SCREENING OF POTENTIAL ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

Objective of Thiruvananthapuram Sub-Project components assisted by KSUDP is to improve urban environmental conditions. As such, there are many environmental benefits to the proposed works. This section, however, focuses on the identification of potential adverse environmental impacts short and long term. Mitigation measures are proposed with recommended monitoring actions to be conducted during implementation to minimize any adverse environmental impacts. The mitigation measures will form the basis for an environmental monitoring plan during the implementation stages of the components.

The screening for environmental impacts is broken down into four categories, coinciding with the major phases of the project:

- Location impacts: those impacts associated with site selection, and include loss of on-site biophysical array and encroachment either directly or indirectly on adjacent environments. It also includes impacts on people who will lose their homes or livelihood by the development of that site.
- Design impacts: those impacts arising from project design, including technology used, scale of operation/throughput, waste production, discharge specifications, pollution sources and ancillary services.
- Construction impacts: those impacts caused by site clearing, earthworks, machinery, vehicles and workers. Construction site impacts include erosion, dust, noise, traffic congestion and waste production.
- O & M impacts: those impacts arising from the operation and maintenance activities of the infrastructure facility. These include routine management of operational waste streams, and occupational health and safety issues.

7.01 Location Impacts

Impact:- The site is with high boundary wall and hence no aesthetic impact is envisaged. Setting up of a properly functioning STP will improve environment in the surroundings and hence no adverse impact on property value envisaged.

Mitigation Measures:- Provision of a buffer zone plantation will enhance the aesthetics.

7.02 Design Impacts:-

Impact:- Inadequate protection of receiving water body leading to improvement of downstream beneficial uses.

Mitigation Measures:- Extended Aeration configuration of Activated Sludge Processes has been proposed for the STP, which is proven and time tested technology to generate effluent of high quality. Strict quality monitoring mechanism will have to be maintained to ensure that there is a consistent discharge standard stipulated by KSPCB as below:-

BOD<30 mg/L

TSS<50 mg/L

Fecal coliform<1000/100 ml.

Impact:- Overflow/bypass arrangement leading to contamination of environment and flooding .

Mitigation Measures:- Bypassing will be required only on exceptional situations. The plant will be provide with adequate power supply back up arrangement. Bypass will be through the Sewage Farm System before discharging into the local through an appropriately designed outfall system.

Impact:- Inadequate method of sludge disposal may lead to environmental pollution.

Mitigation Measures:- Extended Aeration Process generates low quality of digested sludge not requiring any treatment. The plant will be provided with sludge thickeners and centrifuges for sludge.

7.03 Construction Impacts

Impact: Existing site contamination (soil) endangering health of construction workers.

Mitigation Measure: Strategy and Plan for management of site contamination will be prepared and implemented. Plan will cover options for:

- Investigation/detailed survey of extent of site contamination.
- Treatments required for contaminated areas, including:

  - Removal of contaminated material from site and safe disposal; and
  - Immobilizing (sealing) contaminated material on-site.
- Use of protective gears by workers will be enforced

Impacts: Potential impacts during construction comprise:

- Silt runoff from construction operations causing soil erosion plus damage to water quality/land values;
- Noise and dust from construction activities;
- Road blocking and/or increased traffic during construction of facilities and laying/rehabilitation of sewerage carriers; and.
- Construction waste materials.

Mitigation Measures: Mitigation of silt runoff from exposed excavations includes scheduling works during the dry season to minimize the risks of silt runoff from excavations into adjacent streams. Mitigation of generation of dust from construction sites includes spraying water on dry sites or covering sands to manage dust generation and controlling moisture content of fill and stockpiled materials for construction. Mitigation of noise from traffic and construction activities includes stockpiling construction materials in a manner to minimize traffic blockages. The construction waste materials will be disposed off safely as per Construction Site Management Plan. Construction of STP will involve only moderate size structures, hence the impact is likely to be nominal only.

Interaction with the public will be encouraged through continuous dialogue and information exchange, establishing a procedure for recording and dealing with complaints, and workers instruction. Good health and hygiene practices at work and reduced work accidents will be achieved by means of an Occupational Safety Plan, which will include safety equipment, personnel basic training and first aid provisions.

7.04 Operation & Maintenance Impacts

Impacts: Specific impacts in this phase include hazards to health/safety of workmen.

Mitigation Measures to address the health/safety of workmen are: preparation and implementation of an Occupational Safety Plan for workforce which will include:

- Provision of appropriate protective gear to workers on the site.
- Training for workers on site dangers, including potential health effects from sludge.

7.05 Summary of Mitigation Measures

Table below summarizes the impacts and corresponding mitigation measures

Summary of Mitigation Measures

Location Impacts	**Mitigation Measures**
Loss of amenity (aesthetics, property values) to neighbors	Provision of a buffer zone green belt and landscaping to provide physical separation and a visual screen for the development.
Design Impacts	**Mitigation Measures**
Inadequate protection of receiving waters leading to impairment of downstream beneficial uses	Strict treatment technology and monitoring to ensure consistent discharge standard as set out in the Water Act, 1974 will be employed.
Overflow/bypassing hazards leading to contamination of environment plus flooding	Bypass arrangement will be through existing Sewage Farm and with appropriate outfall structure in Canal.
Inadequate methods for sludge disposal leading to environmental pollution	Design has included appropriate sludge management and disposal. Sludge will only be disposed of as compost or other agricultural use or in sanitary landfill. A Sludge Management Plan will be produced which includes provisions for on-site handling; maximized re-use of sludge (for agricultural manure or composting);
Construction Impacts	**Mitigation Measures**
Existing site contamination (soil) endangering health of construction workers	Prepare and implement Strategy and Plan for management of site contamination. Plan should cover options for: Investigation/detailed survey of extent of site contamination Range of treatments for contaminated areas, including: Removal of contaminated material from site and safe disposal Immobilizing (sealing) contaminated material on-site. Enforce use of protective gears by workers
Silt runoff from construction operations causing soil erosion plus damage to water quality/land values	Implement construction Site Management (through provisions in contracts for STP construction Site preparation, which minimizes clearing and disturbance to adjoining vegetation and natural areas. Protection of unstable soil surfaces from high velocity runoff (interception drains and temporary

	stabilization) Siting of construction material stockpiles and access routes to avoid and disturbance to adjoining vegetation and natural areas. Disposal of construction wastes to be determined on a case-by-case basis. Recycled use or landfill disposal should be sought.
Road blocking and/or increased traffic during construction of facilities and laying/rehabilitation of sewerage carriers	Implement construction Site Management (through provisions in contracts for STP construction) to cover traffic management and nuisance minimization
Noise and dust from construction activities	Implement construction Site Management (through provisions in contracts for STP construction) to cover dust and noise management (including water spraying and scheduling of activities).
Operation and Maintenance Impacts	**Mitigation Measures**
Hazards to health/safety of workmen	Operational management will include preparation and implementation of Occupational Safety Plan for workforce which will include: Provision of appropriate protective gear to workers on the site. Training for workers on site dangers, including potential health effects from sludge.

8.00 INSTITUTIONAL REQUIREMENTS AND ENVIRONMENTAL MONITORING PLAN

8.01 Institutional Requirements for Environmental Monitoring Plans

The executing agency for KSUDP subprojects is the Local Self Government Department (LSGD). A state-level Project Management Unit (PMU) has been established for this purpose. The implementing agency for components in Thiruvananthapuram will be the Thiruvananthapuram Municipal Corporation. A Project Implementation Unit (PIU) has been established in the Corporation to oversee the implementation of all subprojects under KSUDP in the Thiruvananthapuram Corporation area. An Empowered Committee (EC) has been constituted under the chairmanship of Minister for Local Self Government. This committee comprises state heads of all the concerned agencies to oversee & monitor the project at the State level. The PIU will be supported by a city-level steering committee (SC) comprising line agencies. Operation and management of the assets will be vested with the Municipal Corporation.

During the planning and detailed design stages of the project, the Thiruvananthapuram Corporation will primarily be responsible for implementing mitigation measures and monitoring their performance. Technical and institutional mitigation measures will be incorporated into site layout planning and designs.
During the construction phase, the Project Implementation Unit (PIU) of the Corporation will monitor the performance of the contractor who will be contracted to construct the works in a manner that mitigates adverse environmental impacts during the construction phase. Mitigation measures of a planning, functional, institutional and procedural character will have been included in the tender documents and in the supplementary activity plans. The PIU, with the support of the Project Management Unit (PMU), will be responsible for monitoring and enforcement during construction.

During the operational phase, the Corporation, with the assistance of line agencies will be responsible for monitoring the performance of the infrastructure components.

For monitoring of an issue, which is critical to the environmental soundness of the activity, whether in response to potential locational, design, construction or O&M impacts, the PMU has been given a primary role.

The environmental monitoring capacity of Thiruvananthapuram Municipal Corporation is low, although it has on staff engineers with an appreciation of good

practice in design, construction and operation. Being the state capital, Thiruvananthapuram Corporation has ready access to state environmental agencies to assist in monitoring. To assist the Corporation's PIU in component planning, implementation and monitoring, an Environmental Officer will be recruited by the PMU. The responsibilities of the Environmental Officer will be to work closely with the PIU in all project phases and will include training PIU personnel in environmental monitoring duties.

8.02 Environmental Monitoring Plan

The following tables provide a summary of recommended environmental monitoring program for the proposed Sewage Treatment Plant, based on responses to potential adverse impacts identified in Section 7.0.

Mitigation Measures	Parameters to be Monitored	Location	Measurements	Frequency	Responsibility
Provision of a buffer zone on vulnerable perimeters with earthworks and landscaping to provide physical separation and a visual screen for the development.	Site design and site preparation	Corporation offices and STP site.	Visual inspection of design plans and of site preparation activities	One-off inspection of plans. Weekly site inspection during site preparation	PIU (assisted by DSC)
Employ strict treatment technology and monitoring to ensure consistent discharge standard	Water quality at discharge point and receiving waters	Treated water discharge points in STP	BOD, TSS and Fecal coliform levels will be measured and compared against notified standards: BOD <30mg/l TSS <50mg/l Fecal coliform <1000/100ml	Continuous as part of plant operation.	Corporation/PCB
Design to include appropriate sludge management and disposal. Sludge will only be disposed of as compost or other agricultural use or in sanitary landfill. A Sludge Management Plan will be produced which includes provisions for on-site handling; maximized re-use of sludge (for agricultural manure or composting); analysis of sludge for heavy metals; locations and prohibitions on the disposal of surplus sludge.	Sludge Management and Disposal Plan documentation and progress of implementation	STP and disposal areas.	Inspection of plan documentation Inspection of sludge handling procedures Inspection of sludge disposal sites checking for consistency with plan	Bi-monthly or more frequent if sludge production is higher than normal	PMU and PCB

Mitigation Measures	Parameters to be Monitored	Location	Measurements	Frequency	Responsibility
Prepare and implement Strategy and Plan for management of site contamination. Plan should cover options for: Investigation/detailed survey of extent of site contamination Range of treatments for contaminated areas, including: Removal of contaminated material from site and safe disposal Immobilizing (sealing) contaminated material on-site.	Site Contamination Strategy and Plan documentation and progress of implementation (Cu, Zn, Pb, Hg, Cr, Cd, Ni, Mn, Fe)	Thiruvananthapuram sewage farm site and wells in adjoining areas (as per plan) Work site & disposal site.	Visual inspection of Plan documentation Inspection of plan implementation activities Sampling of groundwater in adjoining village areas for heavy metals Laboratory Analysis	One-off plan verification Monthly during construction phase Six-monthly following plan implementation Fortnightly during construction phase.	PMU and PCB PMU/PCB
Implement construction Site Management (through provisions in contracts for STP construction) to cover: Site preparation, which minimizes clearing and disturbance to adjoining vegetation and natural areas. Protection of unstable soil surfaces from high velocity runoff (interception drains and temporary stabilization) Siting of construction material stockpiles and access routes to avoid and	Inclusion of site management provisions in Contract and environmental performance of construction activities	All work sites	Visual inspection of activities and work methods	Daily	PIU (assisted by DSC)

Mitigation Measures	Parameters to be Monitored	Location	Measurements	Frequency	Responsibility
disturbance to adjoining vegetation and natural areas. Disposal of construction wastes to be determined on a case-by-case basis. Recycled use or landfill disposal should be sought.					
Operational management will include Occupational Safety Plan for workforce which will include: Provision of appropriate protective gear to workers on the site. Training for workers on site dangers, including potential health effects from sludge.	Inclusion of occupational safety provisions in Contract and environmental performance of construction activities	All work sites	Visual inspection of activities and work methods	Daily	PIU (assisted by DSC)
Quality assurance of work to ensure appropriate materials and site finishing/drainage	Materials used as per specifications	All work sites	Visual inspection of activities and work methods	At procurement milestones	PIU (assisted by DSC)

9.00 COMMUNITY CONSULTATION AND INFORMATION DISCLOSURE

During the Project scoping exercise considerable dialogue was had with the Municipal Corporation Mayors and technical staff as well as state line agencies during PPTA Study.

Community priorities were examined through a Baseline Socio-Economic Survey. The 1% sample household survey included questions on municipal service delivery and priorities for improvement.

Community Municipal Service Priorities for Thiruvananthapuram

City / Sector	Social Category	Water Supply	Sewerage / Sanitation	Urban Drainage	Solid Waste Management	Roads & Transport
Thiruvananthapuram	Poor	1	2	3	4	5
	Non-Poor	4	1	2	3	4

Source: Loyola College of Social Sciences, Thiruvananthapuram (2004). KSUDP - Socio-Economic Study 2004.

The PMU will undertake community mobilization and awareness program to make the public aware of the short-term inconveniences and long-term benefits of the Project in order to gain full support of the beneficiaries for the Project. Beneficiaries will also be made aware of preventive care to avoid environmental health-related hazards.

In addition, a domestic Project Performance Management Consultant (PPMS) firm will be required to help the PMU in generating baseline data which will be monitored to assess impact of the Project and providing guidance for mid course correction, if required, and assess benefits on commissioning of the Project.

10.00 CONCLUSIONS

All proposed components in Thiruvananthapuram Corporation area will greatly improve the overall environmental quality of the Municipality. The Project is considered not to have significant environmental impacts and classification B is considered appropriate.

It is concluded that the proposed components should proceed, with appropriate mitigation measures and monitoring programs identified in the IEE and the above recommendations.

PROPOSED SEWAGE TREATMENT PLANT AT THIRUVANANTHAPURAM

INITIAL ENVIRONMENTAL EXAMINATION

Annexes

Annex A **Ambient Water Quality Standards**

Annex B **Noise Pollution and Ambient Air Quality Standards**

Annex A Ambient Water Quality Standards

Designated-Best-Use	Class	Criteria
Drinking Water Source without A conventional treatment but after disinfections	A	1. Total Coliforms Organism MPN/100 ml shall be 50. 2. pH between 6.5 and 8.5. 3. Dissolved Oxygen 6mg/l or more. 4. Biochemical Oxygen Demand 5 days 20^0C 2mg/l.
Outdoor bathing (Organized)	B	1. Total Coliforms Organism MPN/100ml shall be 50. 2. pH between 6.5 and 8.5. 3. Dissolved Oxygen 5mg/l or more. 4. 4. Biochemical Oxygen Demand 5 days 20^0C 3mg/l.
Drinking water source after conventional treatment and disinfections	C	1. Total Coliforms Organism MPN/100 ml shall be 50. 2. pH between 6 to 9. 3. Dissolved Oxygen 4 mg/l or more. 4. Biochemical Oxygen Demand 5 days 20^0C 3mg/l.
Propagation of Wild life and Fisheries	D	1. pH between 6.5 to 8.5. 2. Dissolved Oxygen 4mg/l or more. 3. Free Ammonia (as N). 4. Biochemical Oxygen Demand 5 days 20^0C 2mg/l.
Irrigation, Industrial Cooling, Controlled Waste disposal	E	1. pH between 6.0 to 8.5. 2. Electrical Conductivity at 250C micro mhos/cm. 3. Sodium absorption Ratio Max.26. 4. Boron Max. 2mg/l.
	Below E	Not Meeting A, B, C, D & E Criteria.

SW-II WATERS (For Bathing, Contact Water Sports and Commercial Fishing)

Parameter	Standards	Rationale/Remarks
PH range	6.5 – 8.5	Range does not cause skin or eye irritation and is also conducive for propagating aquatic lives.
Dissolved Oxygen	4.0 mg/1 or 50%. Saturation value, whichever is higher	Not less than 3.5 mg/1 at any time for protection of aquatic lives.
Color and Odor	No noticeable color or offensive odor	Specially caused by chemical compounds like creosols, phenols, naphtha, benzene, pyridine, toluene, etc. causing visible coloration of water and tainting of and odor in fish flesh.
Floating Matters	Nothing obnoxious or detrimental for use purposes.	None in concentration that would impair usages specially assigned to this class.
Turbidity	30 NTU (Nephelo Turbidity Unit)	Measured at 0.9 m depth.
Fecal Coliform	100/100 ml (mpn)	The average value not exceeding 20/100 ml. In 20 per cent. Of samples in the year and in 3 consecutive samples in monsoon months.
Biochemical Oxygen Demand {BOD) {3 days at 27^0C}	3 mg/1	Restricted for bathing (aesthetic quality of water). Also prescribed by IS: 2296-1974.

SW-III WATERS [For Industrial Cooling, Recreating (non-contact) and Aesthetics]

Parameter	Standards	Rationale/Remarks
PH range	6.5-8.5	The range is conducive for propagation of aquatic species and restoring natural system.
Dissolved Oxygen	3.0 mg/1 or 40%. Saturation value, whichever is higher	To protect aquatic lives.
Color and Odor	No noticeable color or offensive odor	None in such concentration that would impair usages specifically assigned to this class.
Floating Matters	No visible, obnoxious floating debris, oil slick, scum	

SW-IV WATERS (for Harbors Waters)

Parameters	Standards	Rationale/Remarks
pH range	6.5-9.0	To minimize corrosive and scaling effect.
Dissolved Oxygen	3.0 mg/1 or 40%. Saturation value, whichever is higher.	Considering bio-degradation of oil and inhibition to oxygen production through photosynthesis.
Color and Odor	No visible color or offensive odor	None from reactive chemicals, which may corrode paints/metallic surfaces.
Floating materials Oil, grease and scum (including Petroleum products)	10 mg/1	Floating matter should be free from excessive living organisms, which may clog or coat operative parts of marine vessels/equipment.
Fecal Coliform	500/100 ml (MPN)	Not exceeding 1000/100 ml. In 20 per cent of samples in the year and in 3 consecutive samples in monsoon months
Biochemical Oxygen Demand (3 days at 27^0C)	5 mg/1	To maintain water relatively free from pollution caused by sewage and other decomposable wastes.

SW-V WATERS (For Navigation and Controlled Waste Disposal)

Parameter	Standards	Rationale/Remarks
pH range	6.0-9.0	As specified by New England Inter-State Water Pollution Control Commission
Dissolved Oxygen	3.0 mg/1 or 40 per cent. Saturation values whichever is higher.	To protect aquatic lives.
Color and Odor	None in such concentrations that would impair any usages specifically assigned to this class	As in (1) above.
Sludge deposits, Solid refuse, floating solids, oil, grease & scum	None except for such small amount that may result from discharge of appropriately treated sewage and / or industrial waste effluents.	As in (1) above.
Fecal Coliform	500/100 ml (MPN)	Not exceeding 1000/100 ml in 20 per cent. Of samples in the year and in 3 consecutive samples in monsoon months.

Annex B Noise Pollution and Ambient Air Quality Standards

Ambient Air Quality Standards In Respect Of Noise

Category of Area/Zone	Limits in dB(A) Leq*	
	Day Time	Night Time
Industrial area	75	70
Commercial area	65	55
Residential area	55	45
Silence Zone	50	40

1) Day time shall mean from 6.00 a.m. to 10.00 p.m.
2) Night time shall mean from 10.00 p.m. to 6.00 a.m.
3) Silence zone is an area comprising not less than 100 meters around hospitals, educational institutions, Courts, religious places or any other area which is declared as such by the competent authority.

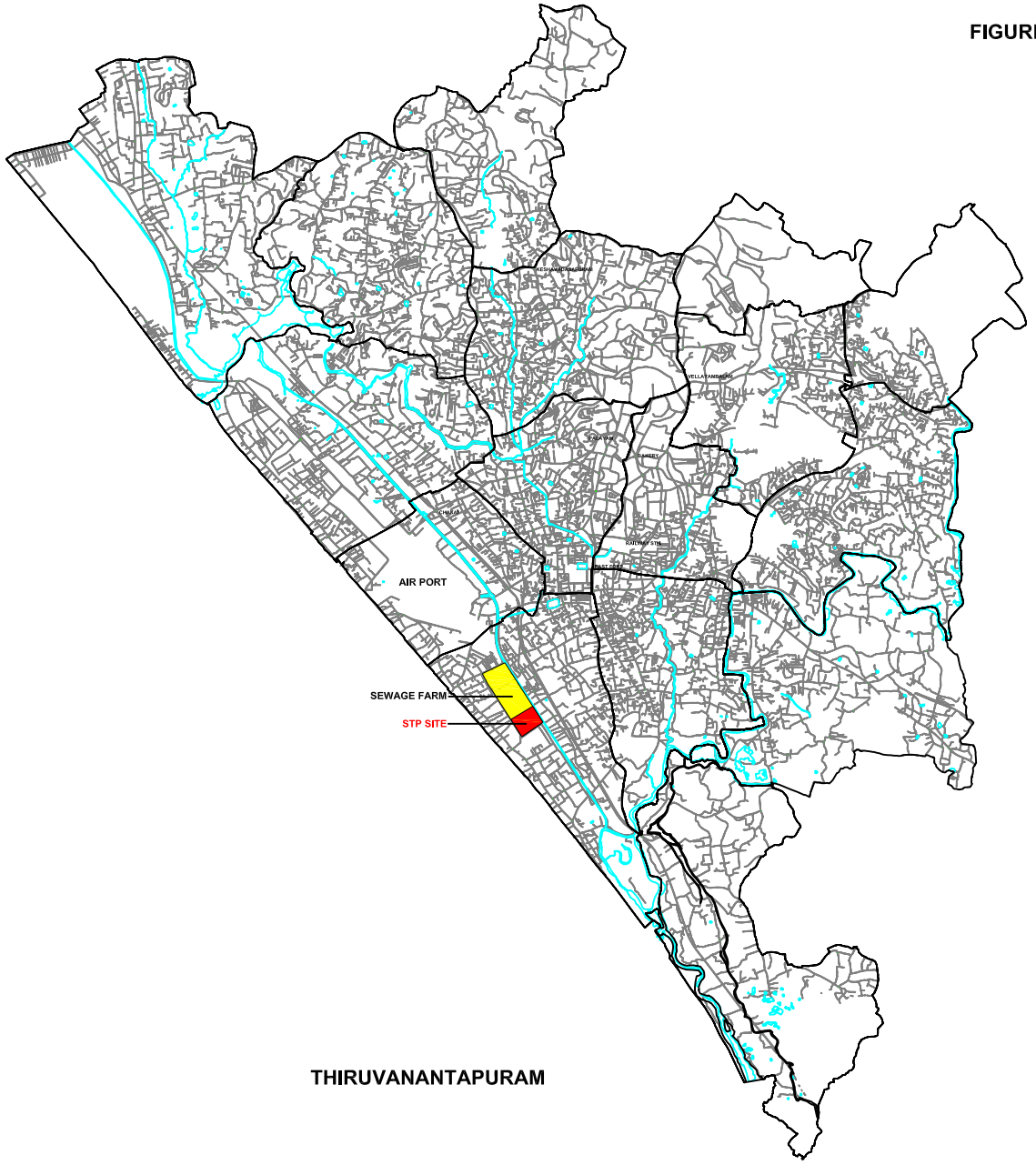
National Ambient Air Quality Standards (NAAQS)

Pollutant	Time Weighted Average	Concentration in Ambient air Industrial Area	Residential, Rural and other area	Sensitive Area	Method of measurement
Sulphur Dioxide $(SO)_2$	Annual Average *	80 µg/m^3	60 µg/m^3	15 µg/m^3	_Improved West and Gaeke method
	24 hours**	120 µg/m^3	80 µg/m^3	30 µg/m^3	-Ultra-violet fluorescence
Oxides of nitrogen as NO_2	Annual Average**	80 µg/m^3	60 µg/m^3	15 µg/m^3	-Jacob Hochhiser Modified {Na-Arsenite method).
	24 hours**	120 µg/m^3	80 µg/m^3	30 µg/m^3	-Gas phase Chemilum inescence.
Suspended particulate matter (SPM)	Annual Average*	360 µg/m^3	140 µg/m^3	70 µg/m^3	-High Volume Sampling
	24 hours**	500 µg/m^3	200 µg/m^3	100 µg/m^3	-Average flow rate not less than 1.1 m^3/-minute.]
Respirable Particulate matter {size less than 10 um) {RPM}	Annual Average*	120 µg/m^3	60 µg/m^3	50 µg/m^3	-Respirable particulate matter sampler
	24 hours**	150 µg/m^3	100 µg/m^3	75 µg/m^3	
Lead {Pb}	Annual Average*	1.0 µg/m^3	0.75 µg/m^3	0.50 µg/m^3	- AAS Method after sampling using EPM 2000 or equivalent filter paper.
	24 hours**	1.5 µg/m^3	1.00 µg/m^3	0.75 µg/m^3	
Carbon Monoxide	8 hours*	5.0 mg/m^3	2.0 mg/m^3	1.0 mg/m^3	-Non-diabersive, infrared spector-scopy.
	1 hour	10.0 mg/m^3	4.0 mg/m^3	2.0 mg/m^3	

* Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.

* * 24 hours/8 hourly values shall be met 98% of the time in a year. 2% of the time, it may exceed but not on two consecutive days.

FIGURE -1 STP SITE



CLIENT
KERALA SUSTAINABLE URBAN DEVELOPMENT PROJECT

PROJECT
SEWERAGE SCHEME THIRUVANANTHAPURAM

SCALE 1:1

ENVIRONMENTAL ENGINEERING

DEALT	SIGN. S.RAMESH	SITE PLAN OF SEWERAGE TREATMENT PLANT AT VALIYATHURAI (ASP WITH EXTENDED AERATION)
CHECKED	SIGN. K.S HITHA	
APPROVED	SIGN. K.VIJAYACHANDRAN	DRG.NO: Rev. P1/T1/R1

CONSULTING ENGINEERING SERVICES (INDIA) PVT. LIMITED
NEW DELHI

STC SHAH TECHNICAL CONSULTANTS PRIVATE LIMITED
MUMBAI

CENTRE FOR ENVIRONMENT AND DEVELOPMENT
THIRUVANANTHAPURAM

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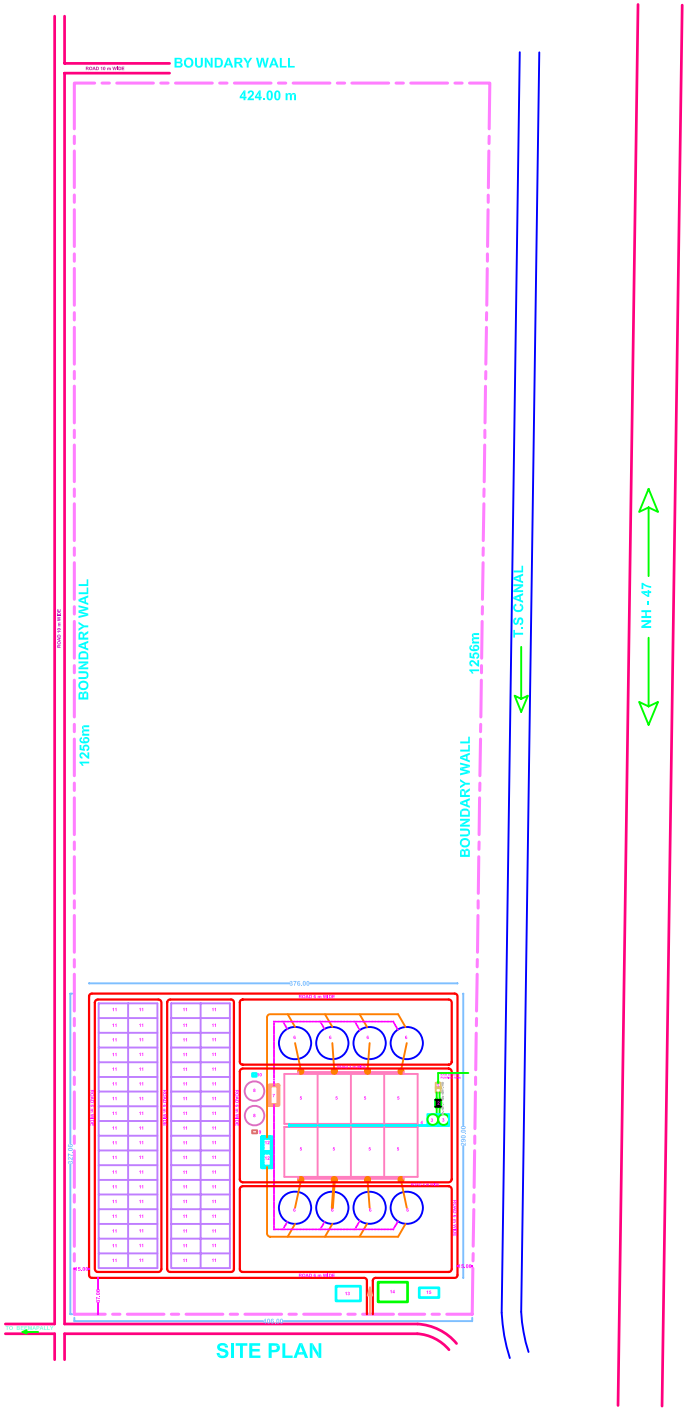
FIGURE –1 STP SITE



LEGEND :-

SL.NO	DESCRIPTION
1	INLET CHAMBER
2	SCREEN CHEMBER a. MECHANICAL b. MANUAL
3	GRIT CHAMBER
4	PARSHALL FLUME
5	AERATION TANK
6	SECONDARY CLARIFER
7	SLUDGE SUMP & PUMP HOUSE
8	SLUDGE THICKENER
9	SLUDGE DILUTION TANK
10	THICKENED SLUDGE PUMP HOUSE
11	SLUDGE DRYING BED
12	CENTRIFUGE ROOM
13	OFFICE & LABORATORY (GROUND FLOOR) CONTROL ROOM (FIRST FLOOR)
14	TRANSFORMER YARD
15	GENERATOR ROOM

NOTE :-

ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED

CLIENT

KERALA SUSTAINABLE URBAN DEVELOPMENT PROJECT

PROJECT

SEWERAGE SCHEME THIRUVANANTHAPURAM

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FIGURE –1 STP SITE