THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA
MINISTRY OF CITY PLANNING, WATER SUPPLY AND HIGHER EDUCATION
MINISTRY OF NATIONAL POLICIES, ECONOMIC AFFAIRS, RE-SETTLTEMENT & REHABILITATION, NORTHERN PROVINCE DEVELOPMENT AND YOUTH AFFAIRS
NATIONAL WATER SUPPLY AND DRAINAGE BOARD

PREPARATORY SURVEY ON SRI JAYAWARDENAPURA KOTTE SEWERAGE CONSTRUCTION PROJECT

THE PROJECT FOR THE STRATEGIC MASTER PLAN UNDER THE SEWERAGE SECTOR IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA (PHASE 2)

FINAL REPORT - ADVANCE VERSION-

(ADDITIONAL STUDY ON NUWARA ELIYA SEWERAGE DEVELOPMENT)

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ABBREVIATIONS AND TERMINOLOGY

ADB	Asian Development Bank
Addi. GM	Additional General Manager
AFD	Agence Française de Development
AGM	Assistant General Manager
ARAP	Abbreviated Resettlement Action Plan
ATP	Affordability To Pay
BIQ	Basic Information Questionnaire
BNR	Biological Nutrient Removal
BOD	Biochemical Oxygen Demand
BOI	Board of Investment
B/C	Benefit Cost Ratio
CBO	Community Based Organization
CCNUCC	Convention-Cadre des Nations Unies sur les Changements Climatiques
CEB	Ceylon Electricity Board
CEA	Central Environmental Authority
CMC	Colombo Municipal Council
COD	Chemical Oxygen Demand
DB	Design Build Method
DGM	Deputy General Manager
DSD	Divisional Secretary Division
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMoP	Environmental Monitoring Plan
EMP	Environmental Management Plan
EPC	Environmental Pollution Control
EPL	Environmental Protection License
EPZ	Export Processing Zone
ERD	Department of External Resource
FIRR	Financial Internal Rate of Return
F/S	Feasibility Study
GAP	Gender Action Plan
GCS	Greater Colombo Sewerage Section
GND	Grama Niladhari Division
GOSL	Government of Sri Lanka
IBRD	International Bank for Reconstruction and Development
ICB	International Competitive Bidding
IEE	Initial Environmental Examination
IFRS	International Financial Reporting Standard
IPCC	Intergovernmental Panel on Climate Change
IRP	Income Restoration Program
IRR	Internal Rate of Return
JCC	Joint Coordinating Committee
JET	JICA Expert Team
JICA	Japan International Cooperation Agency

JPU	Japan Project Unit
JPY	Japanese Yen
LAA	Land Acquisition Act
LCB	Local Competitive Bidding
LKR	Sri Lanka Rupee
M&E	Mechanical and Electrical
M/M	Minutes of Meeting
MASL	Mahaweli Authority of Sri Lanka
MC	Municipal Council
MCF	Methane Correction Factor
MEPA	Marine Environment Protection Authority
MO	Sewerage Management Office
MOF	Ministry of Finance
MoHNIM	Ministry of Health, Nutrition & Indigenous Medicine
MRT	Minimum Rate Test
NIRP	National Involuntary Resettlement Policy
NPV	Net Present Value
NWSDB	Notional Water Supply & Drainage Board
O&M	Operation and Maintenance
OD	Oxidation Ditch
OECD	Organisation for Economic Co-operation and Development
PAA	Project Approving Agencies
PAPs	Project Affected Persons
PAU	Project Affected Units
PMU	Project Management Unit
PPP	Public Private Partnership
PS	Pradeshiya Sabha
RAP	Resettlement Action Plan
RDA	Road Development Authority
ROA	Return on Asset
ROE	Return on Equity
RSC	Regional Support Centre
SC	Statutory Compensation
SCADA	Supervisory Control And Data Acquisition
SCAPC	Standing Cabinet Appointed Procurement Committee
SHIFT	Sanitation and Hygiene Initiative for Towns
SJK	Sri Jayawardenepura Kotte
SLAS	Sri Lankan Accounting Standard
SLS	Sri Lanka Standard
SS	Suspended Solids
STEP	Special Terms for Economic Partnership
STP	Sewage Treatment Plant
TA	Technical Assistance
TN	Total Nitrogen
TOR	Terms of Reference
TSS	Total Suspended Solids
UC	Urban Council
UDA	Urban Development Authority

UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
WAS	Waste Activated Sludge
WB	World Bank
WHO	World Health Organization
WTP	Willingness to Pay

EXECUTIVE SUMMARY

1. BACKGROUND

In Sri Lanka, water pollution problems caused by rapid population increase and Urban development are becoming serious issues. To face this challenge the Government of Sri Lanka (GOSL) sought assistance from the Government of Japan to develop a Strategic Master Plan in the sewerage sector to improve the water environment in Sri Lanka. The Japanese government accepted to support the study for the Strategic Master Plan under the sewerage sector as a technical cooperation project performed in two phases.

During Phase I, (from January 2016 to May 2017), two master plan studies were carried out. The first study, called the "Strategic Sewerage Master Plan for Sri Lanka" investigated the entire country to identify cities with high necessity of sewerage systems. This Master Plan (2017) set the target for sewerage population coverage at 7.0% by 2035. It identified 15 priority cities for sewerage system development by the year 2035 by considering key criteria such as population and population density (Urbanization), water supply coverage ratio and water born disease ratio (Sanitation), city development importance grade (Urban Development), water bill collection ratio (Sustainability of sewerage service), and impact on drinking water supply source (Water Environment). It presented the development process of sewerage systems for the 15 cities, including Nuwara Eliya Municipal Council (MC) and Sri Jayawardenapura Kotte Municipal Council (MC).

The second study was called the "City Sewerage Master Plans (M/P) for 5 cities". Requirement for selection from 15 cities to 5 cities was that the city did not already have donor assistance for sewerage development in order to avoid overlapping international assistances.

Based on the M/P for 5 cities, Sri Jayawardenapura Kotte MC and Nuwara Eliya MC for sewerage development due to the above criteria as well as land availability for sewage treatment plant and sludge disposal sites were selected. GOSL requested two yen loans for the implementation of sewerage projects for the two cities under the special terms for economic partnership (STEP) in the year 2017. Phase II started in June 2017 at the request of the GOSL to collect information for the evaluation of project feasibility.

2. OBJECTIVE OF THE STUDY

This study collects information for a project formation based on the "City Sewerage M/P for Nuwara Eliya". The purpose of the project, project components and costs were analyzed and compiled in the study report.

3. SEWERAGE SECTOR STATUS AND ISSUES

Currently, only 2.4%[1] of the population of Sri Lanka has access to sewerage collection systems, mainly in the Colombo MC area and its suburbs. Some 96.0% of the population relies on on-site sanitation systems, which are mainly toilets connected to septic tanks. Type of sanitation facility for the remaining 1.6% is unknown. Since most of the septic tanks are not effective[2], effluent from septic tanks is discharged to drains and groundwater eventually contaminating rivers and other water bodies.

[1] Population of sewage treatment is 0.2% in 2.4% sewerage system population. There are four sewage treatment plants (Ratmalana/Moratuwa, Ja-Ela/Ekala, Kataragama, Hikkaduwa) excluding small housing and industrial park scheme plants in Sri Lanka.

[2] Insufficient tank capacity cannot secure the treatment time and /or septic tanks installed below ground water level directly discharge sewage to ground water and pollute water.

Therefore, fecal coliform levels caused by human waste were found to be 70,000 times higher than the water environment standards (1,000 MPN/100 ml) at Badulla MC of Uva Province, 10 times higher in Maya Oya, in northern Negombo MC, and 700 times higher in Anuradhapura MC, North Central Province. Also, ammonia-nitrogen levels were five times higher than the standard. The deterioration of water quality throughout Sri Lanka is significant.

4. POLICY AND PROJECT

Following the Sustainable Development Goals (SDGs) (2015) to improve sewage treatment quality for water quality improvement of public water bodies, Notional Water Supply & Drainage Board (NWSDB) (2017) prepared the "Strategic Sewerage Master Plan for Sri Lanka" in which 15 priority cities including Sri Jayawardenapura Kotte MC and Nuwara Eliya MC were identified as priority cities for sewerage system development with sewage treatment plants.

GOSL set sanitation facility to treat sewage as one of the key infrastructures required to support sustainable economic growth through advanced sewage treatment in its "Vision 2025" (2017) for new developments in Sri Lanka.

Hence, the sewerage project has strong relevance to NWSDB's higher level planning and the national government policy.

5. NEED FOR THE PROJECT

In its national policy enacted in 2010, Sri Lanka aims to achieve 100% access to adequate sanitation through on-site and off-site sanitation facilities by 2025. NWSDB's service plan sets the objective to achieve 7.0% piped sewer coverage by 2020.

The United Nations sets Sustainable Development Goals (SDGs) as the next development agenda for the Millennium Development Goals (MDGs). The goal related to sanitation and hygiene is to ensure universal access to safely and sustainably managed water and sanitation by 2030, and some of the specific targets include:

- By 2030, achieve access to adequate sanitation and hygiene facilities for all.
- By 2030, improve water quality by halving the proportion of untreated wastewater.

As of 2012, coverage of piped sewerage remains at 2.4% in Sri Lanka. Nuwara Eliya has no sewerage system, and relies only on septic tanks and other on-site facilities, which, do not function adequately in densely-populated urban areas. Increasing levels of BOD and coliform bacteria are detected in Lake Gregory situated at the centre of the city.

Nuwara Eliya MC is a world renowned tourist destination and is recognized as an emerging tourist hub in Sri Lanka, evidenced by the increasing number of international and domestic tourists. In 2014, there were at least 600,000 foreign and local tourists in Nuwara Eliya. Apart from admission fees, tourists also contribute to revenues of hotels, restaurants, transportations, souvenir shops, and related businesses. Tourism revenues are rapidly increasing and can be quite substantial. This increase is expected to bring about further deterioration of public water bodies and other touristic resources. Therefore, sewerage development is necessary to protect and improve the water environment. Moreover, Japan has supported solid waste management and water supply projects in the MC. These two projects are expected to produce synergistic effects on environment conservation in Nuwara Eliya.

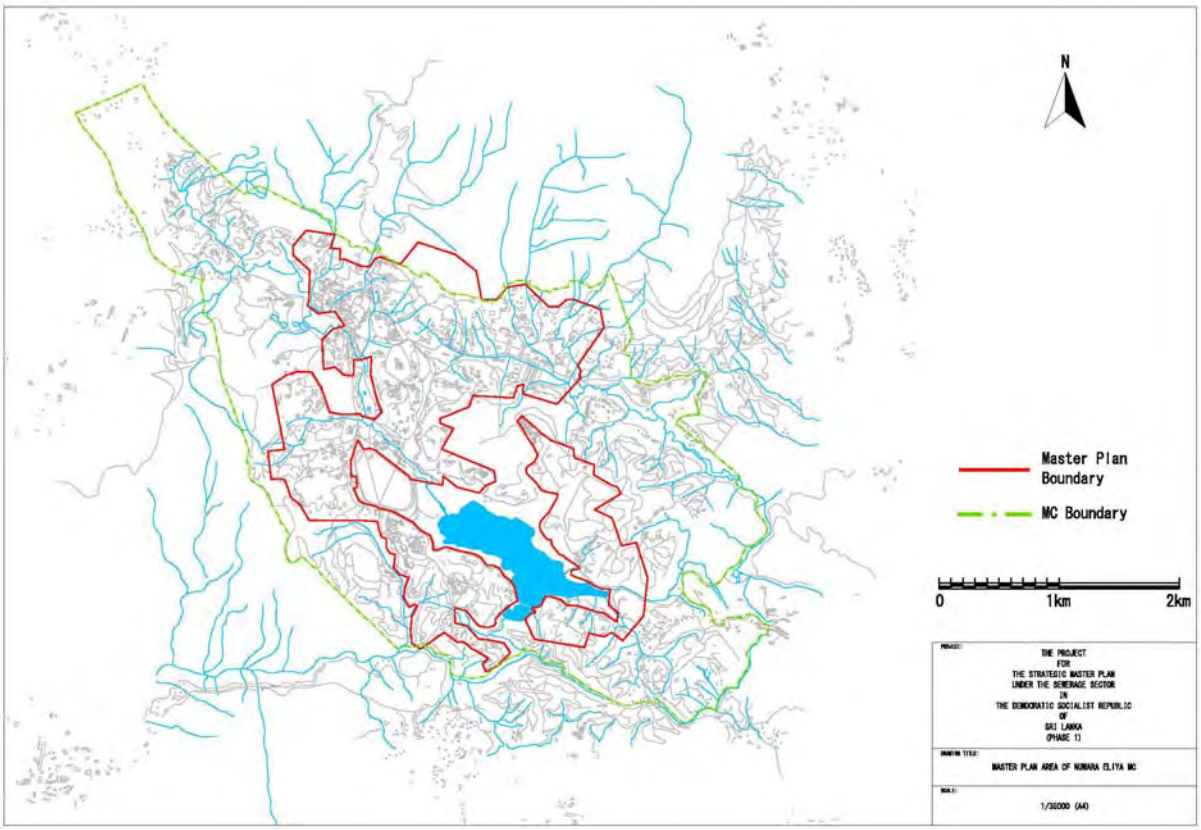
Consequently, Nuwara Eliya MC is considered as a candidate for further survey for the formulation sewerage project.

6. CONDITIONS OF PROJECT PLANNING

(1) Service Area Selection

The sewerage service area selected for the Master Plan is shown in **Figure S-1** and includes:

- developed and populated areas that will be almost fully saturated by 2046
- city centre including large-scale commercial areas, large-scale facilities, such as schools, hotels, housing estate, religious and institutional buildings
- high density residential areas
- areas suitable for applying centralized sewerage system.



Source: JET based on data of Survey Department of Sri Lanka

Figure S-1 Service Area Selected in the M/P for Nuwara Eliya MC

(2) Planned Sewage Volume

Sewage volume in the entire service area is estimated as follows based on the population projection.

- Population of the total service area = 19,100.
- Sewage volume of the total service area (daily maximum) = 4,700 m^3/d.

7. FACILITY PLANNING

(1) Sewer and Pumping Station

A total of about 97 km of sewer pipes will be required to collect sewage in the service area. The required collection facilities including sewer pipes and pumping stations are as shown in **Table S-1,**

Table S-2 and **Table S-3**.

Table S-1 Required Sewer Pipes

Type		Dia (mm)	Sewer Length (m)		
			Open Cut	Micro Tunnelling	Total
Trunk Sewer	Gravity Sewer	200	2,597	519	3,116
		250	537	3	540
		300	467	213	680
		400	2,848	24	2,872
		450	123		123
		sub-total	6,572	759	7,331
Trunk Sewer	Force Main	80	10,248		10,248
		100	966		966
		150	1,386		1,386
		250	1,299		1,299
		sub-total	13,899		13,899
	Trunk Sewer sub-total		20,471	759	21,230
Branch Sewer	Gravity Sewer	200 mm	76,856		76,856
	Trunk Sewer sub-total		76,856		76,856

Source: JET,

Table S-2 Required Major Pumping Station

Item No.	Design Flow	Total Pump Head	Unit	Land Requirement
MPS-01	Approximately 0.8 m^3/min	60 m	2+(1)	0.30 ha
MPS-02	Approximately 3.2 m^3/min	30 m	2+(1)	0.30 ha

(1): One pump unit for stand-by

Source: JET

Table S-3 Required Manhole Type Pumping Station

	Type 1 Less than 2.0 m^3/min	Type 2 Less than 1.0 m^3/min	Type 3 Less than 0.5 m^3/min	Type 4 Less than 0.2 m3/min	Total
Number	1	4	40	40	85

Source: JET

Micro Tunnelling Method has been considered for the areas/sections where it would be difficult to apply open-cut method, such as:

- underground depth more than 4.5 m
- high security areas, and
- heavy traffic areas

(2) Sewage Treatment Plant (STP)

The sewage treatment process is selected based on the treated water quality required by Central Environmental Authority (CEA). Main processes were selected by the following reasons;

- Oxidation Ditch process (OD) is chosen for its nitrogen removal potential and lower energy costs.
- Chlorination disinfection is selected for its low construction cost and equivalent annual cost.
- Sludge treatment is planned for agricultural reuse (as fertilizer).

The projected daily maximum sewage inflow for Nuwara Eliya is 4,700 m^3/d. The most commonly used process for such small-scale treatment plant is the OD process. The OD process can be modified to remove nitrogen. Kandy STP, under construction, has adopted the OD process with nitrogen removal ability.

8. IMPLEMENTATION SCHEDULE AND PROJECT COST

This project includes construction works and consulting services. Construction works are divided into 3 packages, considering various factors including type of works, required technologies and scale of contract amount.

As for the bidding method, "International Competitive Bidding (ICB)" is considered for one package that requires advanced technologies. "Local Competitive Bidding (LCB)" is considered for other two packages. **Table S-4** outlines possible packaging and respective bidding method.

(1) Construction Contracts

Construction contracts are undisclosed.

(2) Consulting Services

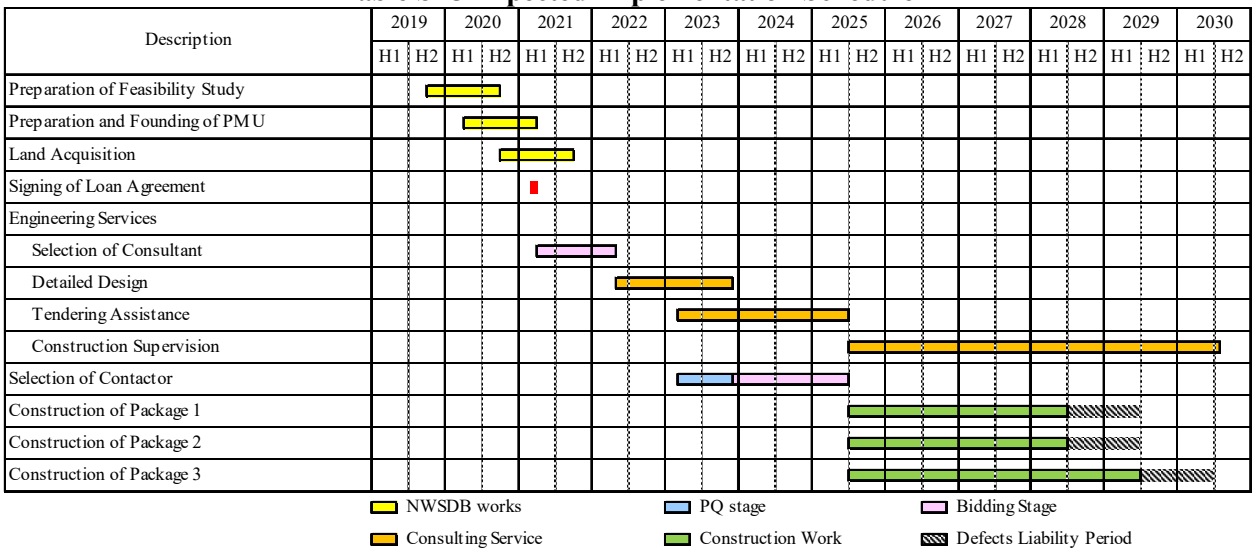
Consulting services are undisclosed.

Table S- 4 Packaging of Project Components and Bidding Methods

Table S-4 is undisclosed.

It will take 10 years to implement the starting with consultant selection to the completion of house connections as shown in **Table S-5**. Assuming the Project starts after the signing of loan agreement in the beginning of 2021, the main facilities in the sewerage treatment plant and pumping stations should be commissioned by 2028.

Table S- 5 Expected Implementation Schedule



Source: JET

Consulting Services will cover the detailed design and tender assistance for all of the construction works. Construction supervision including one-year liability period for all packages will also be covered. Construction supervision for Package 3 in private houses should be supported by NWSDB staffs.

Project costs including indirect costs and price escalation over the duration of the Project are presented in **Table S-6**.

Table S- 6 Estimated Project Costs

Table S-6 is undisclosed.

9. FINANCIAL AND ECONOMIC ANALYSES

Financial and economic analyses are undisclosed.

Table S-7 Results of Economic Analysis

Table S-7 is undisclosed.

10. MEASURES FOR ANTICIPATED EFFECT OF THE PROJECT

Effect indicators are recommended to monitor and evaluate progress in achieving the intended benefits of the Project.

Targets for the proposed indicators are determined according to the nature of the project and should generally be achieved 2 years after the project becomes operational. The project is expected to achieve its intended targets by the year 2031. Indicators and proposed targets are shown in **Table S-8**.

Table S- 8 Indicators and Targets

Indicator	Present (year 2019)	Target (year 2031)
Volume of Sewage Treated (m^3/d)	0	4,700 m^3/day
Population Served (Persons)	0	19,100 persons
Quality of Treated Effluent	BOD_5: －	BOD_5 ＜15 mg/l
	SS : －	SS ＜15 mg/l
		NO_3-N＜10 mg/l
		TP ＜ 5 mg/l

Source: JET

11. CONCLUSIONS AND RECOMMENDATION

This Project will reduce pollution of public water bodies, improve sanitation and public health conditions, and subsequently bring about further sustainable economic development. The Project satisfies national priorities for this area and has many positive environmental/social impacts.

The following recommendations are made for future feasibility study, detailed design and construction stages :

(1) Detailed geotechnical investigations should be carried out during the detail design stage.

(2) NWSDB should conduct public awareness activities on the importance of sewage treatment and hold frequent meetings with related organizations to share information on the Project for deepening the understanding of the project's purpose, promoting land acquisition and the

resettlement of residents, and accelerating house connection.

(3) NWSDB should share information and coordinate with relevant agencies to avoid potential delays.

(4) NWSDB should accept sludge from septic tanks and treat them in the STP to bring the benefit of the project to people without sewerage services.

(5) NWSDB should add surveys of ”Institutional Arrangements for Project Implementation”, “Environmental and Social Considerations” and “Abbreviated Resettlement Action Plan” in the future feasibility study if necessary during the feasibility study stage.

CHAPTER 1 BACKGROUND AND OBJECTIVES

1.1 BACKGROUND

In Sri Lanka, water pollution problems caused by rapid population increase and land development are becoming serious issues. To face this challenge the Government of Sri Lanka (GOSL) sought assistance from the Government of Japan to develop a Strategic Master Plan in the sewerage sector to improve the water environment in Sri Lanka. The Japanese government accepted to support the study for the Strategic Master Plan under the sewerage sector as a technical cooperation project performed in two phases.

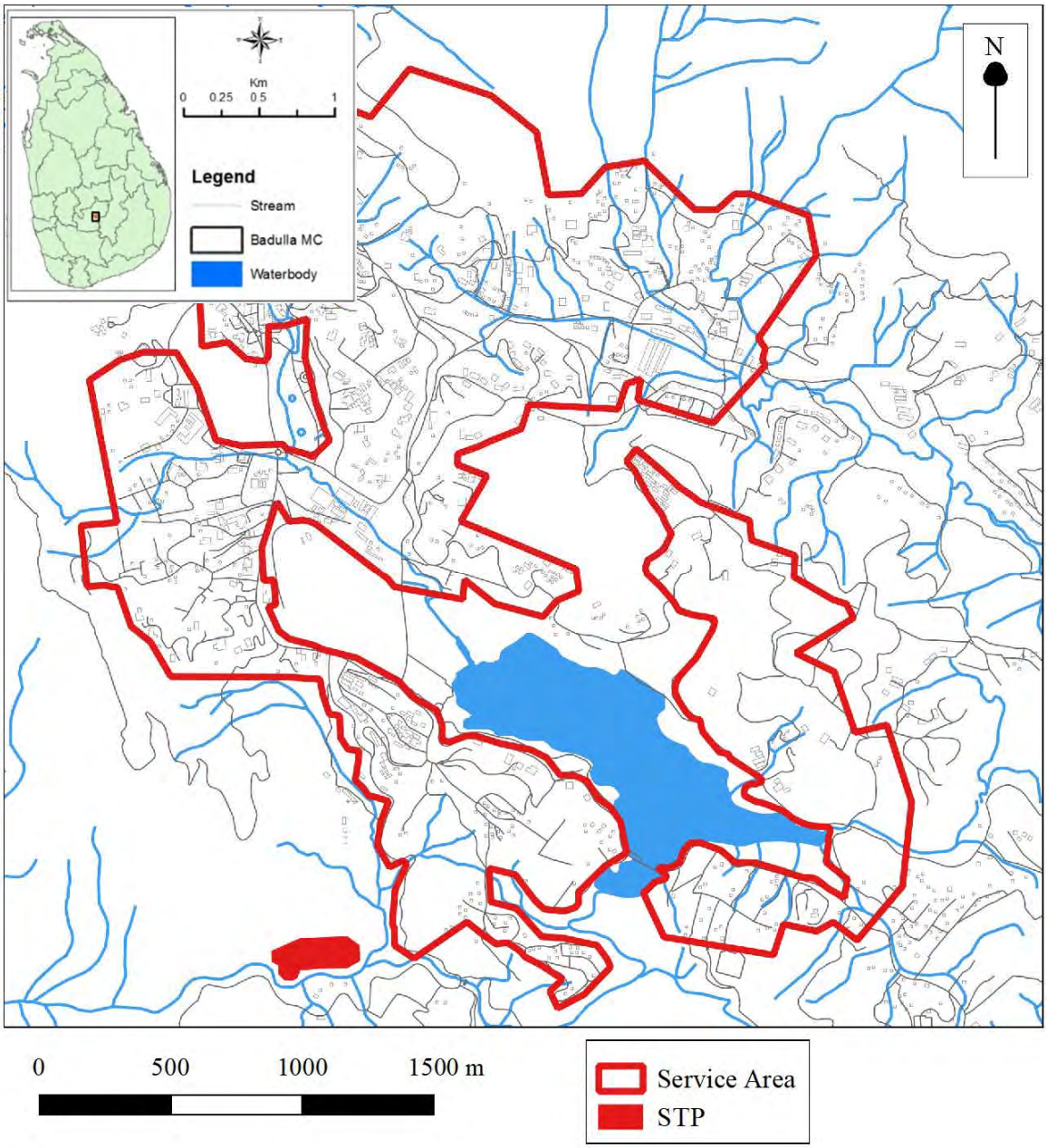
During Phase I, (from January 2016 to May 2017), two master plan studies were carried out. The first study, called the "Strategic Sewerage Master Plan for Sri Lanka" investigated the entire country to identify cities with high necessity of sewerage systems. This Master Plan (2017) set the target for sewerage population coverage at 7.0% by 2035. It identified 15 priority cities for sewerage system development by the year 2035 by considering key criteria such as population and population density (Urbanization), water supply coverage ratio and water born disease ratio (Sanitation), city development importance grade (Urban Development), water bill collection ratio (Sustainability of sewerage service), and impact on drinking water supply source (Water Environment). It presented the development process of sewerage systems for the 15 cities, including Nuwara Eliya Municipal Council (MC).

The second study was called the "City Sewerage Master Plans (M/P) for 5 cities". It built upon the findings of the first study, further narrowing the selection from 15 cities to just two. One important requirement for selection was that the city did not already have donor assistance for sewerage development in order to avoid overlapping international assistances.

The study resulted in the selection of two cities, Nuwara Eliya MC and Sri Jayawardenapura Kotte MC for sewerage development due to the above criteria as well as land availability for sewage treatment plant and sludge disposal sites. GOSL requested two yen loans for the implementation of sewerage projects for the two cities under the special terms for economic partnership (STEP) in the year 2017. Phase II started in June 2017 at the request of the GOSL to collect information for the future project formation for Nuwara Eliya MC, and for the evaluation of project feasibility for Sri Jayawardenapura Kotte MC.

1.2 OBJECTIVES AND SCOPE

This study collects information for a project formation based on the "City Sewerage M/P for Nuwara Eliya". The purpose of the project, project components and costs were analyzed and compiled in the study report. **Figure 1.2-1** shows the map of service area.



Source: JET

Figure 1.2-1 Map of Service Area

1.3 TERMS OF REFERENCE OF THE STUDY

The Terms of Reference of the study are summarized below.

(1) Collection and analysis of relevant materials and information
(2) Preparation of inception report (IC/R)
(3) Explanation and discussion of IC/R
(4) The status of and problems with the sewerage sector in Sri Lanka, and the impact of this project on its development
(5) Assistance from other donors

(6) Social and economic conditions in the service area
(7) Status and prospect of water supply system development
(8) Volume of sewage generation and sewage treatment capacity
(9) Long-term projection of sewage generation
(10) Sewage discharge and impacts on sanitation, living environments and economic activities
(11) Contributions from the project
(12) Facility design
(13) Procurement plan
(14) Permits and licenses for the project implementation
(15) Implementation schedule
(16) Estimated project costs
(17) Evaluation of executing agency and organization for operation and maintenance
(18) Project outcomes
(19) Needs for technical assistance(TA)
(20) Risk identification and mitigation measures
(21) Safety measures
(22) Preparation, explanation and discussion of draft final report (DFR)
(23) Preparation, explanation and discussion of final report (FR)

1.4 STRUCTURE OF THE REPORT

The JICA Expert Team (JET) carried out the investigations and analyses as listed in the above TORs from June 2017. The field investigation was conducted in Nuwara Eliya. This report presents the project scope, cost estimates, procurement schedules and economic analyses for the Project. The four key components of the report are:

(1) Chapter 1, 2, and 3

These chapters describe the general background, objectives and scope, Terms of Reference, and sanitation sector status including laws and regulations relevant to the projects in the survey area, national policy related to sanitation, and NWSDB program. Chapter 3 describes the physical, socio-economic, and environmental conditions, the existing sewerage system as well as the justification for the project.

(2) Chapters 4 through 8

The planning basis for the sewerage system, including the design for type of sewage collection system, sewage flow and quality is presented and discussed in Chapter 4. Chapter 5 describes the proposed sewage collection and treatment facilities, and their operation and maintenance requirements. Procurement packages for the project are identified. Other project components, including engineering services such as detailed design, construction supervision, and capacity building (C/B) are presented in Chapter 7. Total project costs and required funding are calculated based on estimated construction and maintenance costs. Chapter 8 covers the financial and economic analysis. The expected outcomes of the Project are described in Chapter 8.

(3) Chapter 9

The final chapter presents the conclusions of the study and the recommendations for the project, including risk and mitigation measures.

CHAPTER 2 NATIONAL POLICY AND STANDARDS

2.1 OUTLINE

- The sewerage system coverage is only 2.4% of the national population. 96.0% use septic tanks. Type of sanitation facility for the remaining 1.6% is unknown (2.2.1).
- Sewage from only 0.2% of the domestic population is treated in sewage treatment plants. The rest of the collected sewerage is discharged to the ocean without biological treatment (2.2.1).
- Fecal Coliform values in public water bodies of Sri Lanka exceed that of "Revised Ambient Water Quality Standards". Because fecal coliform is related to human waste, water pollution by human is strongly suspected (2.2.2).
- Laws and regulations relevant to the sewerage sector have been developed after the National Environmental Act No 47 (1980) (2.2.3).
- The National Water Supply & Drainage Board (NWSDB) is the implementing authority for the national policies for the water supply and sanitation sector except for the local authorities (LAs) that have their own water supply and sewerage systems (2.2.4).
- The government of Sri Lanka (GOSL) established "Vision 2025" (2017) for new developments in different industries based the government's economic vision. In it sewage pollution reduction was identified as one of the key infrastructures necessary to support sustainable economic growth with equity (2.3.1).
- NWSDB set a target of 7.0% sewerage coverage for the entire nation by 2035 in the "Strategic Sewerage Master Plan for Sri Lanka" (2017) (2.3.2).
- The "Strategic Sewerage Master Plan for Sri Lanka" surveyed 79 cities, including all Municipal Councils, Urban Councils, and selected Pradeshiya Sabhas. Subsequently, 15 cities to achieve 7.0% sewerage coverage were identified as having urgent needs for sewerage investment based on the following criteria: urbanization, sanitation, urban development, service sustainability, and water environment factors (2.3.3).
- Of the 15 cities, 5 cities which did not have assistance of other donors but did have urgent sewerage needs in terms of urbanization, sanitation, urban development, service sustainability, and water environment factors were selected for the formulation of the "City Sewerage Master Plans (M/P) for 5 cities". They were Sri Jayawardenapura Kotte, Dehiwala-Mount Lavinia, Anuradhapura, Badulla, and Nuwara Eliya Municipal Council areas (2.3.3).
- Of the City Sewerage M/P for 5 cities, Sri Jayawardenapura Kotte and Nuwara Eliya were selected as candidates for Japanese financial assistance for sewerage development because they had no donor, and land was available for sewage treatment plant and sludge disposal sites (2.3.3).
- World Bank and ADB are supporting sewerage system development in Colombo MC. JICA, AFD, and China are supporting sewerage system developments in other locations (2.3.2).

2.2 SANITATION SECTOR STATUS

2.2.1 Existing Sanitation Situation

Table 2.2-1 describes the sanitation infrastructure in Sri Lanka. Most sewerage systems consist only of sewers and pumping stations, without treatment. The sewerage system coverage is only 2.4% of the national population. 82.3% of the population relies on on-site sanitation, such as septic tanks. 13.7% have shared toilets or use public toilets. A total of 96.0% use septic tanks. There is no information on sanitation for the remaining 1.6%.

Table 2.2-1 Sanitation Infrastructure in Sri Lanka

Type of Sanitation	Estimated Population Coverage	
	Nos.	%
Pipe-borne sewerage facility (off-site)	510,339	2.4
On-site sanitation facility	17,731,171	82.3
Other sanitation* (including sharing with another household, common/public toilets)	2,947,298	13.7
Unknown sanitation types	344,483	1.6
Total Population in 2017	21,533,291	100

Source: NWSDB Corporate Plan 2016-2020,
*Note: It is assumed that the number of other sanitation is modified by the sum of 2,411,383 of 2012 Data and the differences of population, 709,643 between 2012 and 2017 population. Other data are 2017 data. Population of 2012 is 20,277,597.

Regarding septic tanks, about 80% of the septic tanks in use do not meet Sri Lanka Standards on septic tank (Sri Lanka Standards (SLS) 745) in terms of structure and installation, according to a survey conducted in Gampaha City (Source: Journal of Environment Professionals Sri Lanka, Vo.2, 2013). Therefore, septic tanks are not effective in achieving their pollution reduction purpose. The main reason for this deficiency is that although septic tanks are inspected and approved on paper, most are not inspected on site at the time of construction and inferior or undersized units are installed to save costs or accommodate the small land plot sizes.

Sewerage systems used by 2.4% of the population in Sri Lanka are presented in **Table 2.2-2**. Generally, sewerage systems in Sri Lanka do not have sewage treatment plants. Sewage collected by the systems is discharged to the ocean through sea outfalls. Sewage in Colombo, Dehiwala-Mount Lavinia, and Kolonnawa is discharged to the ocean without biological treatment.

In the 1980's when sea outfall without treatment was first regulated, the natural purification capacity of rivers and the sea exceeded the volume of untreated sewage. Sewage naturally decomposed in rivers and sea with minimal environmental impact. However, rapid population growth has caused rapid increase in sewage volumes. The natural purification capacity has been exceeded, and untreated sewage has started to accumulate and pollute water bodies. There is an urgent need to start treating the collected sewage.

At present, sewage from Ratmalana/Moratuwa, and Ja-Ela/Ekala, and a handful housing scheme is biologically treated in sewage treatment plants. This accounts for a mere 0.2% of the national domestic population.

Table 2.2-2 Population Coverage by Sewerage Systems

Sewerage System	City	Total Population	Population Covered	Population of Sewage Treatment	STP Process
Greater Colombo Sewerage System	Colombo	561,314	428,014	-	Screen + Ocean Outfalls
	Dehiwala/Mt. Lavinia	184,468	26,250	-	
	Kolonnawa	60,044	20,355	-	

Sewerage System	City	Total Population	Population Covered	Population of Sewage Treatment	STP Process
	Ratmalana/Moratuwa	168,280	15,445	15,445	Extended Aeration with BNR*
	Ja-Ela/Ekala	9,000	8,483	6,600	Extended Aeration with BNR
Kataragama	Kataragama	18,220	5,045	5,045	Waste Stabilization Pond
Hikkaduwa	Hikkaduwa	27,075	3,490	3,490	Waste Stabilization Pond
Hantana / Digana Village Housing Schemes	Kandy/Senkadagala	163,244	3,257	3,257	Trickling Filter / Waste Stabilization Pond
Total			510,339 (2.4%=510,339/ 21,533,291*100)	33,837 (0.2%=33,837/ 21,533,291*100	

Note: * BNR: Biological Nutrient Removal
Population Coverage is calculated based on the year 2017.
Source: MIS Report (December, 2017) of Sewerage Division/NWSDB, NWSDB Corporate Plan 2016-2020 and Statistical Information of District Secretariats.

Table 2.2-3 shows the distribution of sanitation facilities in Nuwara Eliya MC. About 97% of the households (6,852) have water sealed toilets (i.e. with traps to block odour) connected to septic tanks.

Table 2.2-3 Sanitation Facilities in the Project Area

No.	Name of GND	Total	Water Trap Toilet	Pour Flush Toilet (Not Water Trap)	Direct Pit	Other	Not Using Toilet
1	Hawaeliya East	580	570	10	0	0	0
2	Bambaralkele	787	721	65	0	0	1
3	Nuwara Eliya West	578	493	70	15	0	0
4	Kalapura	840	721	119	0	0	0
5	Nuwara Eliya	272	262	7	1	0	2
6	Nuwara Eliya Central	1,017	965	52	0	0	0
7	Hawaeliya North	542	530	12	0	0	0
8	Hawaeliya West	490	482	8	0	0	0
9	Bulu Ela	429	420	9	0	0	0
10	Sandathanna	683	610	68	0	0	5
11	Kalegala	453	437	16	0	0	0
12	Kalukele	289	277	12	0	0	0
13	Magasthota	377	364	13	0	0	0
	Total	7,337	6,852	461	16	0	8

Source: Census of Population and Housing 2012, DCS

Nuwara Eliya MC has no sewerage system. Blackwater (toilet waste) is treated in septic tanks while greywater from kitchens and bathrooms is discharged untreated to a river via public canals.

In urban centers and densely populated areas, blackwater is not properly treated due to lack of space for installing septic tanks. During rainy season, overflows from septic or infiltration tanks often occurs, as the ground is saturated.

Sludge is taken from septic tanks by the MC at the request of the home owner, and disposed of at the

Moon Plain landfill.

As to hospital wastewater, Nuwara Eliya General Hospital operates its own sewage treatment system, consisting of aeration/ sedimentation/anaerobic-degradation tanks and sludge drying beds. The treated sewer is disinfected with chlorine and discharged to a drainage canal and finally to a river.

There are no factories in Nuwara Eliya MC that have adverse impact on the water environment. Industrial wastewater from automobile repair shops, hotels, slaughterhouses, as well as hazardous wastewater from hospitals, is treated as required under the Environmental Protection License (EPL), issued by Nuwara Eliya District Office of the Central Environmental Agency (CEA).

2.2.2 Water Quality of Public Water bodies

(1) Water Quality

The Sri Lanka National Water Development Report (2006) pointed out a variety of water quality concerns in Sri Lanka, including contamination by nitrate and bacteria in underground and surface waters, mainly due to poor sanitation and untreated wastewater or insufficient wastewater treatment. Eutrophication of lakes and reservoirs was also pointed out (Source: UNESCO and MoAIMD).

According to the City Sewerage M/P for 5 cities (2017), fecal coliform levels 70,000 times higher than allowed in the "Revised Ambient Water Quality Standards[3)]" (1 x 10^3 MPN/100 ml) were recorded in Badulla MC, Uva Province located in central Sri Lanka. In Maha Oya, located in northern Negombo, fecal coliform levels were 10 times higher (Source: CEA Web-site, Surface Water quality Monitoring). In Anuradhapura MC located northern central Sri Lanka, fecal coliform levels were 700 times higher, and Ammonia-nitrogen level of 3.2 mg/l was recorded, 5 times higher than the standard value of 0.59 mg/l. These findings confirm water pollution due to human waste exists and is significant in Sri Lanka.

Water quality at sampling stations from 1 to 4 in Nuwara Eliya is shown in the **Table 2.2-4**. The locations of sampling stations are shown in the **Figure 2.2-1**. The water quality surveys were conducted in the dry seasons due to expected water quality deterioration in both Aug. 2016 and Apr. 2018. The detail of water quality survey is shown in **APPENDIX2-1**.

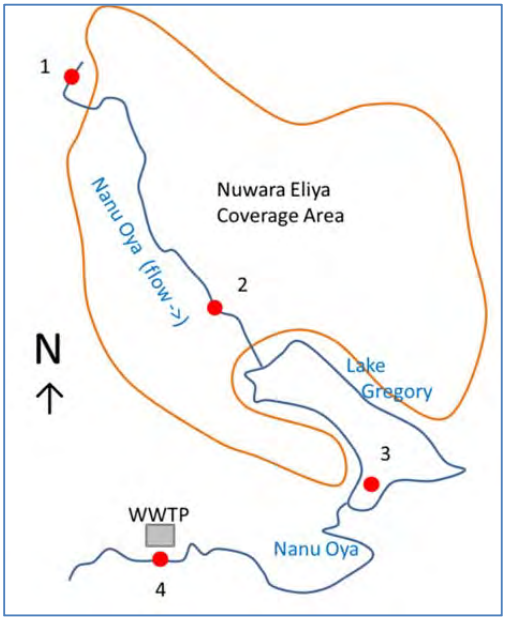
Table 2.2-4 Surface Water Quality (Nuwara Eliya)

Nuwara Eliya		1		2		3		4		-
		'16	'18	'16	'18	'16	'18	'16	'18	
pH	-	8.5	7.0	8.5	7.2	8.8	8.1	8.4	8.1	-
Temp.	°C	17.3	20.0	18.1	19.3	22.1	23.2	20.7	24.1	-
Odour	-	unobjectionable								ND
Color	mg Pt/L	30	-	<15	-	<15	-	27	-	100
EC	uS/cm	69	200	126	270	124	230	127	240	700
Turbidity	NTU	6	-	10	-	56	-	27	-	-
Total Suspended Solids TSS	mg/l	3	2	12	3	34	10	14	11	40
TDS	mg/l	56	133	90	174	80	151	90	154	-
DO	mg/l	6.1	5.4	2	2.8	7.7	5.7	7.0	7.3	5
BOD	mg/l	<4	5	<4	10	12	6	<4	6	4
COD	mg/l	<4	13	19	14	44	51	42	23	15

[3)] Revised Ambient Water Quality Standards are Water Quality Standards to discharge wastewater to water bodies under revision by Ministry of Mahaweli Development and Environment, Central Environmental Authority and other related institutions. As of May 2017, this is waited for the Cabinet Approval.

Nuwara Eliya		1		2		3		4		-
		'16	'18	'16	'18	'16	'18	'16	'18	
Nitrate	mg/l	0.64	-	1.22	-	0.3	-	1.22	-	10
Ammonia	mg/l	0.08	<0.01	0.11	3.40	<0.02	0.90	0.32	0.48	0.59
Total Phosphorus T-P	mg/l	0.05	0.144	0.13	<0.005	0.19	<0.005	0.15	<0.005	-
PO_4^{3-} - P	mg/l	0.04	-	0.11	-	0.13	-	0.11	-	0.4
Cl	mg/l	2.5	-	7	-	7	-	7.7	-	600
Total Nitrogen T-N	mg/l	0.75	3.99	0.85	3.90	0.36	2.94	1.60	3.61	-
Fecal Coli.	/100ml	93	$3.5x10^3$	$3x10^2$	$2.4x10^3$	$3x10^2$	$2.2x10^2$	100	$3.5x10^3$	$1x10^3$
Total Coli.	/100ml	$18x10^4$	$9.2x10^3$	$68x10^4$	$5.4x10^3$	$20x10^5$	$2.7x10^2$	$10x10^5$	$5.4x10^3$	$1x10^4$

*) Worse than the criteria
Source: JET



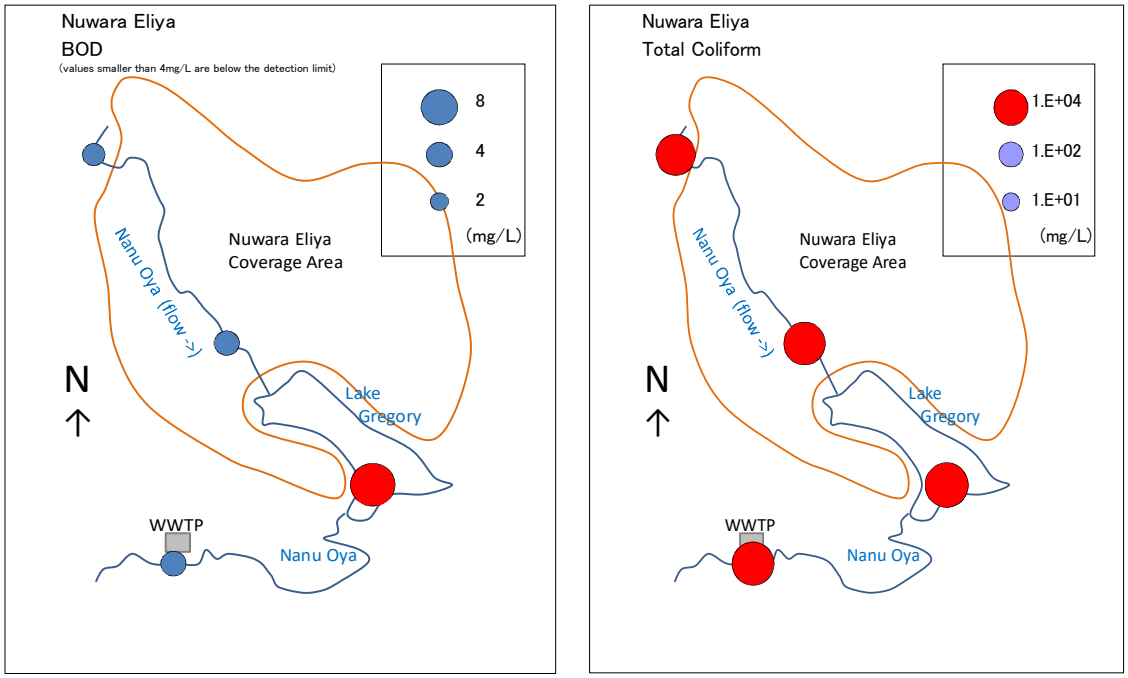
Source: JET

Figure 2.2-1 Water Sampling Locations

The criteria for evaluating water quality are based on the "National Environmental Regulations, No.1 of 2014" and "Draft Revised Ambient Water Quality Standards (2016)". The values are chosen from Category C (Fish and Aquatic Life Water) for normal environmental standards. The value should be satisfied for commercial and municipal fishing waters which are widely used for fishing purpose by local fisher and other water bodies which are locally known or identified as habitats of fishes or other aquatic products being consumed by humans or are being used for the propagation of such. Figure 2.2-2 shows the BOD and total coliform levels at all 4 sampling locations exceed the standard values.

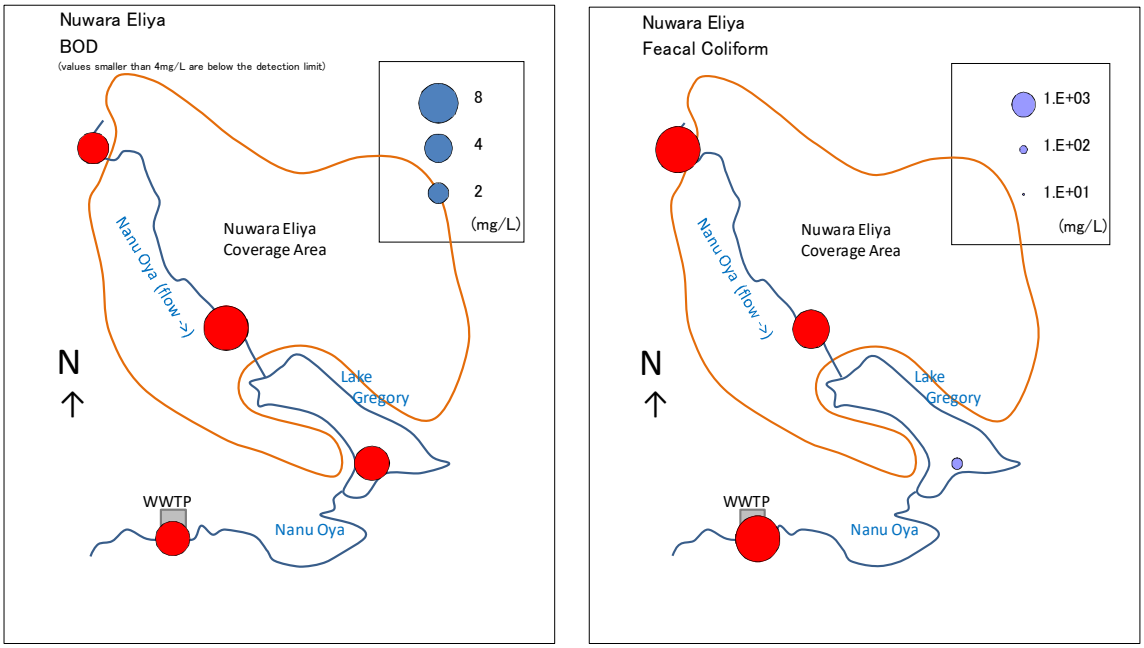
Sampling station 1 is upstream and 2 is downstream of the planned coverage area. 3 is in the lake near the outlet and 4 is downstream of the planned STP discharge area. All four locations show some level of pollution (**Figure 2.2-2 & Figure 2.2-3**).

Especially pollution level of Gregory lake on BOD and coliform is high. Since BOD is related to human activity, and coliform is related to human feces, the treatment of septic tank does not work effectively to reduce pollutions related to human activity.



*) Red indicators show the values are above the criteria
Source: JET

Figure 2.2-2 Water Pollution in Nuwara Eliya(2016)



*) Red indicators show the values are above the criteria
Source: JET

Figure 2.2-3 Water Pollution in Nuwara Eliya (2018)

(2) Effect of Implementing a Sewerage System

Sewage treatment will deal with the typical types of pollution in Nuwara Eliya MC such as BOD, total coliform, DO and COD. Sewage treatment carried out at the STP decomposes organic and will reduce the BOD load in the lake and the COD load in the river and the lake. Total coliform will be reduced by chlorination. Water with low DO will be improved by aeration in the reactor tank at the STP.

The sewerage system will contribute to improvement of water environment in Nuwara Eliya MC.

2.2.3 Laws and Regulations Relevant to the Sewerage Sector

After the National Environmental Act No 47 (1980) was enacted, effluent quality regulations were developed. The Sri Lanka Standards regulate effluent quality standards to different water bodies, as summarized in the table below. Currently, the tightening of effluent quality standards for sea outfalls is under discussion in the Ministry of Mahaweli Development and Environment.

Table 2.2-5 Effluent Quality Standards

Receiving Water Body	Standard
Tolerance Limits for Industrial and Domestic Effluents discharged into Marine Coastal Area	SLS721 of 1985
Tolerance Limits for Inland Surface Waters used as Raw Water for Public Water Supply	SLS 722 of 1985
Tolerance Limits for Industrial Effluents discharged on Land for Irrigation Purposes	SLS776 of 1987

Source: JET

NWSDB has developed design guidelines for sewerage systems based on the effluent quality regulations. In 1989, NWSDB Manual D7 describing design factors of sewer and pumping stations and outlining sewage treatment was prepared. The sewage treatment section was revised in 2012. These relevant Sri Lankan laws and regulations are summarized in **APPENDIX 2-2**.

2.2.4 Organization Relevant to the Sewerage Sectors

Central Government Ministries, Agencies related to the sewerage sector and their respective functions and responsibilities are shown in **Table 2.2-6**.

Ministry of City Planning, Water Supply and Higher Education formulates the national policies for the water supply and sanitation sector, while managing the National Water Supply & Drainage Board (NWSDB) as its implementing authority. NWSDB, being the leading organization, is responsible for implementing the Central Government's policies and water supply and sewerage projects in the country.

According to Municipal Council Ordinance No. 29 of 1947, the Urban Council Ordinance No. 61 of 1939 and Pradeshiya Sabha Act No. 15 of 1987, all Local Authorities (LAs) have the responsibility to carry out regulatory and administrative functions related to public health and utility services such as waste collection, public conveniences etc. aiming to promote public health. However, only the Colombo MC implements the sewerage project by itself. Other LAs depend on NWSDB to implement sewage projects. According to the NWSDB, it is because the budget scale of those LAs is insufficient for the implementation of meaningful sewage projects.

The construction and O&M of sewerage facilities must comply with the environmental standards regulated by the Central Environmental Authority (CEA) which comes under the authority of the Ministry of Mahaweli Development and Environment. Especially with respect to O&M of sewerage facilities, operators must meet CEA requirements and CEA issues Environmental Protection Licenses (EPL) to ensure that those requirements are complied with.

As for sites of sewage treatment plants and pumping stations, the Urban Development Authority (UDA) under the Ministry of Megapolis and Western Development are the key urban planning and implementing agencies to issue permits for securing these sites.

Table 2.2-6 Ministries/Agencies in Sewerage Sector

Ministry	Department/Statutory Organization	Responsibilities
Ministry of City Planning, Water Supply and Higher Education	1.National Water Supply & Drainage Board (NWSDB)*1	NWSDB has the following responsivities to municipal council areas and urban council areas. 1. Formulation of policies, programs and projects based on national policies and assistance in implementation of programs and projects in urban area 2. Investigation, planning, design, construction and O&M of water supply and sewerage projects in urban area
	2. Community Water Supply and Sanitation Project - (CWSSP)*2	CWSSP has the following responsivities to Pradeshiya Sabhas (PSs) areas. 1. Formulation of policies, programs and projects based on national policies and assistance in implementation of programs and projects in rural area. 2. Investigation, planning, design, construction and O&M of water supply and sewerage projects in rural area.
Ministry of Internal & Home Affairs and Provincial Councils & Local Government	1. Provincial Councils (PCs)	1. Granting loans to LAs for public utility works. 2. Government functions relating to local authorities.
	2. Municipal Councils (MCs)	MCs have the following responsibilities to only their MC. The contents of their responsibilities are same as other local authorities, but the region under their jurisdiction is different. 1. Implementation of policies, plans and programs related to sanitation services. 2. Government functions relating to local authorities.
	3. Urban Councils (UCs)	UCs have the following responsibilities to their USs. 1. Implementation of policies, plans and programs related to sanitation services. 2. Government functions relating to local authorities.
	4. Pradeshiya Sabhas (PSs)	PSs have the following responsibilities to their PSs. 1. Implementation of policies, plans and programs related to sanitation services. 2. Government functions relating to local authorities.
Ministry of Mahaweli Development and Environment	1.Central Environmental Authority (CEA)	1. Implementation of policies, plans and programs related to environmental and natural resources. 2. Environmental protection and management. 3. Conservation of river catchments and major reservoirs. 4. Conservation and sustainable development of natural resources.
	2. Marine Environment Protection Authority(MEPA)	1. Prevention of marine pollution.
Ministry of Megapolis and Western Development	1.Urban Development Authority (UDA)	1. Formulation of policies, programs and projects in physical planning, urban development and assistance in implementation of such programs and projects. 2. Urban planning and development.

Ministry	Department/Statutory Organization	Responsibilities
	2.Urban Development and Low Income Housing Project (UDLIHP)	1. Urban planning and development. 2. Provision of public utility services to under-served settlements.
	3.Colombo Environment Improvement Project (CEIP)	1. Environmental improvement in Colombo Metropolitan Area.
	4.Sustainable Cities and Township Development Project (SCTDP)	1. Assistance to LAs in improvement of urban infrastructure facilities and housing. 2.Provision of water supply and sanitation services in rural areas.

*1: NWSDB is responsible for water supply and sanitation mainly in urban area
*2: CWSSP is responsible for water supply in rural community area
Source: NWSDB

2.3 NWSDB PROGRAM AND JICA STUDY

2.3.1 NWSDB Program

The "NWSDB Corporate Plan for 2016 – 2020" (2015) aimed to develop sewerage systems to achieve the 3.3% sewerage coverage target using funds from JICA, World Bank, AFD, China, and other donors.

NWSDB sets the following objectives in "NWSDB Corporate Plan for 2016 – 2020":

- Objective 1.1: To achieve piped water supply coverage of 60.0% (49.1% by the NWSDB) and piped sewerage coverage of 3.3 % of the total population of Sri Lanka by 2020
- Objective 1.2: To prepare water safety plans to ensure high degree of water security with respect to quality and quantity for all water supply schemes

The following projects shown in **Table 2.3-1** and **Table 2.3-2** are described in "NWSDB Corporate Plan".

Table 2.3-1 On-going Sewerage Projects and Funding Sources

Project Name	Population	Source of Fund	Project Description
Kandy City Wastewater Management Project	205,000 (including floating population)	JICA	Location: Kandy MC Type of finance: loan Components: construction of trunk sewers, branch sewers, house connections, pumping stations, and sewage treatment at 14,000 m³/day capacity.
GPOBA (The Global Partnership on Output Based Aid)	35,000	World Bank	Location: Colombo MC Type of finance: grant Components: construction of house connections for low income settlements in the Greater Colombo area to connect to the sewerage networks
Greater Kurunegala Water Supply & Sewerage Project	25,000	China EXIM Bank	Location: Kurunegala MC Type of finance: loan Components: construction of trunk sewers, branch sewers, pumping stations, and sewage treatment at 4,500 m³/day capacity.
Kataragama Wastewater Disposal Project	110,000 (including floating population)	Austria	Location: Kataragama MC Type of finance: loan Components: construction of trunk sewers, branch sewers, pumping stations, and sewage treatment at 3,000 m³/day capacity (Aerated Lagoon Maturation Pond).

Expansion of sewerage coverage of Moratuwa & Ratmalana	45,500	AFD	Location: Moratuwa MC Type of finance: loan Components: construction of trunk sewers and branch sewers to increase sewage volume to meet the treatment capacity of 17,005 m^3/d of the Ratmalana /Moratuwa STP.
Sanitation and Hygiene Initiative for Towns (SHIFT) Project (Galle, Negombo, Kelaniya-Peliyagoda)	200,000	AFD	Location: Negombo MC Type of finance: loan Components: construction of trunk sewers, branch sewers, house connections, pumping stations, a sewage treatment at 33,600 m^3/d capacity, feasibility study for Galle and Kelaniya-Peliyagoda, and capacity development of NWSDB sewerage section
Greater Colombo Wastewater Management Project	Rehabilitation Work	ADB	Location: Colombo MC, Dehiwala/Mt Lavinia MC and Kollonnawa UC Type of finance: loan Components: construction of trunk sewers and branch sewers Note: The Project in Colombo MC is carried out by Colombo MC and projects in the other two municipalities are carried out by NWSDB.

Source: JET

Table 2.3-2 Projects Ready for Implementation and Expected Funding Sources (to be confirmed)

Project Name	Population	Source of Fund	Project Description
Hambantota Wastewater Disposal Project	117,000	China EXIM Bank	Location: Hambantota MC Type of finance: loan Components: construction of sewers and pumping stations for Hambantota Town including Sea Port area with a sea-outfall of 12,000 m^3/day capacity
Kattankudy Wastewater Disposal Project	47,000	China EXIM Bank	Location: Kattankudy UC Type of finance: loan Components: construction of sewers and pumping stations for a 10,000 m^3/day capacity. Construction of a sewage treatment plant is unknown.
Maharagama-Borelesgamuwa Wastewater Disposal Project	45,000	China EXIM Bank	Location: Maharagama MC Type of finance: loan Components: construction of sewers leading to the sea-outfall of 6,675 m^3/day capacity
Chilaw & Puttalam Wastewater Disposal Project	63,000	China EXIM Bank	Location: Chilaw UC/Puttalam UC Type of finance: loan Components: construction of sewers leading to the sea-outfall of 2,700 m^3/day capacity
Expansion of Sewerage Coverage in Dehiwala/Mt Lavinia area.	50,000	ING Bank, Netherlands	Location: Dehiwala/Mt.Lavinia MC Type of finance: loan Components: construction of sewers for 50,000 people leading to the sea-outfall of 26,000 m^3/d capacity in Mt. Lavinia

Source: JET

NWSDB set a target of 7.0% sewerage coverage for the nation by 2035 in the "Strategic Sewerage Master Plan for Sri Lanka" (2017), based on the Sustainable Development Goal (SDG) of improving sewage treatment quality for water quality improvement of public water bodies. The reduction of pollution to improve water quality is one of the sanitation targets in the SDGs (2015). The specific targets are as follows:

- By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations
- By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing

release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally

In the "Strategic Sewerage Master Plan for Sri Lanka" (2017), the 15 priority cities including Nuwara Eliya MC and Sri Jayawardenapura Kotte MC were identified as priority cities for sewerage system development with sewage treatment plants.

Also in 2017, the GOSL established its "Vision 2025" (Source: Ministry of Mass Media) for development of different industries, describing the government's economic vision. In it sewage pollution reduction was identified as one of the key infrastructures necessary to support sustainable economic growth with equity.

In this context, sewerage development is relevant and supported by national policies.

Table 2.3-1 and **Table 2.3-2** show projects related to other donors in sewerage development. JICA, AFD, and China are supporting sewerage system development projects in Municipal Councils managed by NWSDB. World Bank (WB) and ADB are supporting sewerage developments in Colombo MC. WB is supporting a house connection project for low income households, and ADB is supporting sewerage system development in Colombo MC. Except for Colombo MC, there is no overlap of the sewerage projects by foreign donors.

There is no Public Private Partnership (PPP) project on sewerage, but NWSDB has planned a Welivita Water Supply Project as a PPP project. As of February 2019, the selection of a suitable partner was implemented under conditions with Design-Build-Operation doe 30 years. NWSDB is assisted with Technical Assistance by a consultancy Team provided through the World Bank.

2.3.2 Strategic Sewerage Master Plan

The Strategic Master Plan was formulated in 2 stages. First, NWSDB formulated the "Strategic Sewerage Master Plan for Sri Lanka" (2017) with assistance of JICA. The "Strategic Sewerage Master Plan for Sri Lanka" surveyed 79 cities, including all Municipal Councils and Urban Councils, and some selected Pradeshiya Sabhas in certain districts where no Municipal or Urban Councils exist. Subsequently, it identified 15 priority cities (**Table 2.3-3**) for sewerage system development by the year 2035 by considering key criteria (**Table 2.3-4**) such as population and population density (Urbanization), water supply coverage ratio and water born disease ratio (Sanitation), city development importance grade (Urban Development), water bill collection ratio (Sustainability of sewerage service), and impact on drinking water supply source (Water Environment). It presented the development process of sewerage systems for the 15 cities, including Sri Jayawardenapura Kotte MC and Nuwara Eliya MC.

Table 2.3-3 Cities for Sewerage System Development to 2035

Local Government Authority	Population (2012)	Population served by water supply system (2012)	Necessity of Sewerage System	Note
Colombo MC	561,314	561,314	Biggest city in Sri Lanka National growth centre District capital	Sewerage system has been developed (ADB and WB).
Kandy MC	98,828	96,060	Regional growth centre District capital World famous tourist area Water intake located downstream	Sewerage system is under construction (JICA).
Sri Jayawardenapura Kotte MC	107,925	107,925	National capital Significant impact of pollution load on public water body	Sewerage system has been planned.
Anuradhapura MC	65,345	47,676	National growth centre District capital World famous tourist area Water intake located downstream Significant impact of pollution load on public water body	Sewerage system is being planned (AFD).
Badulla MC	42,237	42,237	Regional growth centre District capital Water intake located downstream	Sewerage system has been planned.
Kelaniya PS	109,603	109,603	Regional growth centre Famous tourist area Water intake for Colombo located downstream Significant impact of pollution load on public water body	Sewerage system has been planned (AFD).
Nuwara Eliya MC	23,804	23,804	District capital World famous tourist area Ground water as a water source	
Galle MC	86,333	86,333	Regional growth centre District capital World famous tourist area Water intake located downstream	Sewerage system has been planned (AFD).
Dehiwala/Mt. Lavinia MC	184,468	184,468	Large population Adjoining city to Colombo	Sewerage system partially has been developed and has been planned (Netherlands).
Negombo MC	142,449	142,449	World famous tourist area	Sewerage system has been planned (AFD).
Kotikawatta-Mull eriyawa PS	131,643	131,643	Water intake for Colombo located downstream	
Rathnapura MC	47,105	36,112	District capital World famous tourist area Water intake located downstream	
Hambantota MC	23,236	23,326	National growth centre District capital World Famous Tourist Area	Sewerage system has been planned (China).
Trincomalee UC	48,351	48,351	National growth centre District capital World famous tourist area	
Maharagama UC	196,423	169,902	Significant impact of pollution load on public water body	Sewerage system has been planned (China).
Total		1,811,103		7.1%(=1,811,103*0.9/22,645,723*100)

Source: THE PROJECT FOR THE STRATEGIC MASTER PLAN UNDER THE SEWERAGE SECTOR IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA(PHASE 1)

Table 2.3-4 Criteria for Selection of Priority Cities

Criteria	Parameter
1. Urbanization	Population density (Water Supply area)
	Population (Equivalent population based on water supply)
2. Sanitation	Incidence of water borne diseases
	Water supply coverage ratio
3. Urban Development	Presence of tourist attractions
	Presence of growth centres and industrial zones
4.Sustainability of Sewerage Services	Water bill collection ratio as indication of willingness to pay
	Median household income as ability to pay sewerage services
5. Water Environment	Presence of drinking water supply source and environmental protection area
	Potential pollution to public water body

Source: THE PROJECT FOR THE STRATEGIC MASTER PLAN UNDER THE SEWERAGE SECTOR IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA(PHASE 1)

In consultation with the Ministry of City Planning,Water Supply and Higher Education and NWSDB, 5 cities without assistance from other donors (**Table 2.3-5**) were selected from the 15 cities with high necessity based on criteria given in the "City Sewerage Master Plan (M/P)" (**Table 2.3-4**). These 5 cities were Sri Jayawardenapura Kotte, Dehiwala-Mount Lavinia, Anuradhapura, Badulla and Nuwara Eliya Municipal Council areas.

Table 2.3-5 Five Cities for City Sewerage Master Plan

Local Government Authority	Description
Sri Jayawardenapura Kotte MC	National capital Significant impact of pollution load on public water body
Anuradhapura MC	National growth centre District capital World famous tourist area Water intake located downstream Significant impact of pollution load on public water body
Badulla MC	Regional growth centre District capital Water intake located downstream
Nuwara Eliya MC	District capital World famous tourist area Ground water as a water source
Dehiwala/Mt. Lavinia MC	Large population Adjacent to Colombo

Source: JET

The second study was called the "City Sewerage Master Plans (M/P) for 5 cities". It built upon the findings of the first study, further narrowing the selection from 15 cities to just two. One important requirement for selection was that the city under consideration did not already have donor assistance for sewerage development in order to avoid overlapping international assistances. Sri Jayawardenapura-Kotte and Nuwara Eliya were selected as candidates for feasibility studies for Japanese financial assistance for sewerage development. The major justifications are as follows:

- Sri Jayawardenapura Kotte MC is the national capital. It has no sewerage system and no other potential donor. Its large and growing population with its associated environmental impacts are affecting the area, including pollution of the lake surrounding the parliament. Many infrastructure development projects are planned in this area, which are expected to exacerbate pollution issues. Currently, high fecal coliform values related to waterborne disease have been found. Since water quality is expected to decrease in the future, a sewerage system to reduce pollution load and coliform causing waterborne disease is considered to be highly necessary. Therefore, Sri Jayawardenapura Kotte MC was selected as a candidate for feasibility study for Japanese assistance.

- Nuwara Eliya MC is a world renowned tourist destination and is recognized as an emerging tourist hub in Sri Lanka, evidenced by the increasing number of international and domestic tourists. This increase is expected to bring about further deterioration of public water bodies and other touristic resources. Therefore, sewerage development is necessary to protect and improve the water environment. Moreover, Japan has supported solid waste management and water supply projects in the MC. These two projects are expected to produce synergistic effects on environment conservation in Nuwara Eliya. Therefore, Nuwara Eliya MC was selected as a candidate for additional survey.
- Regarding Anuradhapura MC and Dehiwala/Mount Lavinia MC, other donors expressed intentions for assistance in sewerage development during the preparation of City Sewerage M/P for 5 cities. Therefore, they were not considered for Japanese assistance to avoid overlapping of international assistance. Regarding Badulla MC, there is no appropriate solid waste disposal site. Disposal of sludge from sewage treatment will present a problem that has to be resolved before any development can be considered. Therefore, the further feasibility of the project was not considered at that time.

Consequently, Jayawardenapura Kotte MC and Nuwara Eliya MC are candidates for further study for the formulation of ODA projects for sewerage development.

CHAPTER 3 PRESENT CONDITIONS AND NEED FOR THE PROJECT

3.1 OUTLINE

- Nuwara Eliya lies in the Central Province of Sri Lanka, bordered by Kandy District to the north, Kegalle District to the north-west, Ratnapura District to the south-west and Badulla District to the east (3.2.1).
- Nuwara Eliya is a famous tourist destination in the country, blessed with a cool climate and beautiful sceneries. In 2014, there were at least 600,000 foreign and local tourists in Nuwara Eliya. Apart from admission fees, tourists also contribute to revenues of hotels, restaurants, transportations, souvenir shops, and related businesses. Tourism revenues are rapidly increasing and can be quite substantial (3.2.9(7)).
- The piped water supply system covers 96% of the households (3.2.10).
- Nuwara Eliya has a well-organized solid waste management system. Waste is collected from curb side and transported to a disposal site, 4 km from the town centre. The disposal site was constructed in 2003 as a JICA pilot project (The Study on Improvement of Solid Waste Management in the Secondary Cities in Sri Lanka (3.2.11).

3.2 DESCRIPTION OF THE SERVICE AREA

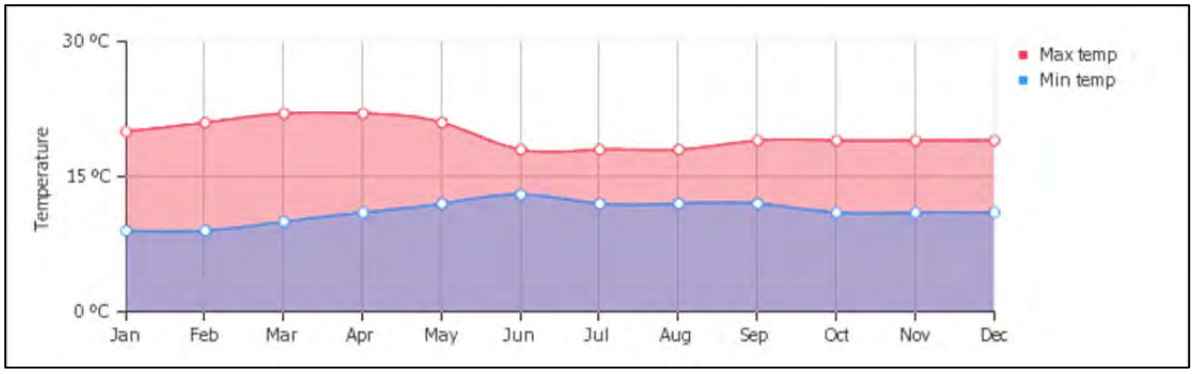
3.2.1 Location

Nuwara Eliya lies in the Central Province of Sri Lanka, bordered by Kandy District to the north, Kegalle District to the north-west, Ratnapura District to the south-west and Badulla District to the east. It records the highest rainfall and the lowest temperature in the country.

3.2.2 Climate

(1) Temperature

Temperatures vary from 10°C to 22°C for most of the year. February temperature can go down to 7.2°C or below freezing.

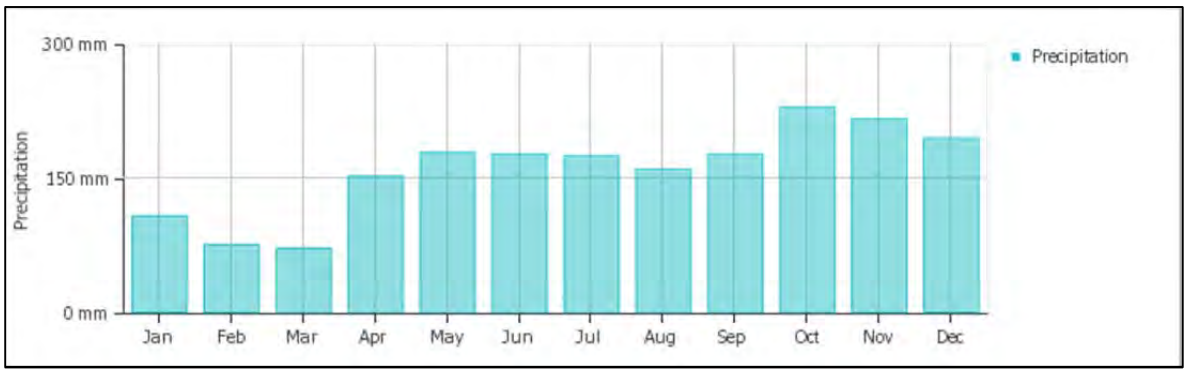


Source: JET, using Department of Meteorology data

Figure 3.2-1 Average Monthly Maximum and Minimum Temperatures

(2) Precipitation

Southeast and northwest monsoons bring heavy rain. Northeast monsoon starts in June and lasts until September, bringing heavy rain and wind to the area. Annual average rainfall is 2,500 mm. Watawala has the highest annual rainfall, exceeding 5,588 mm.



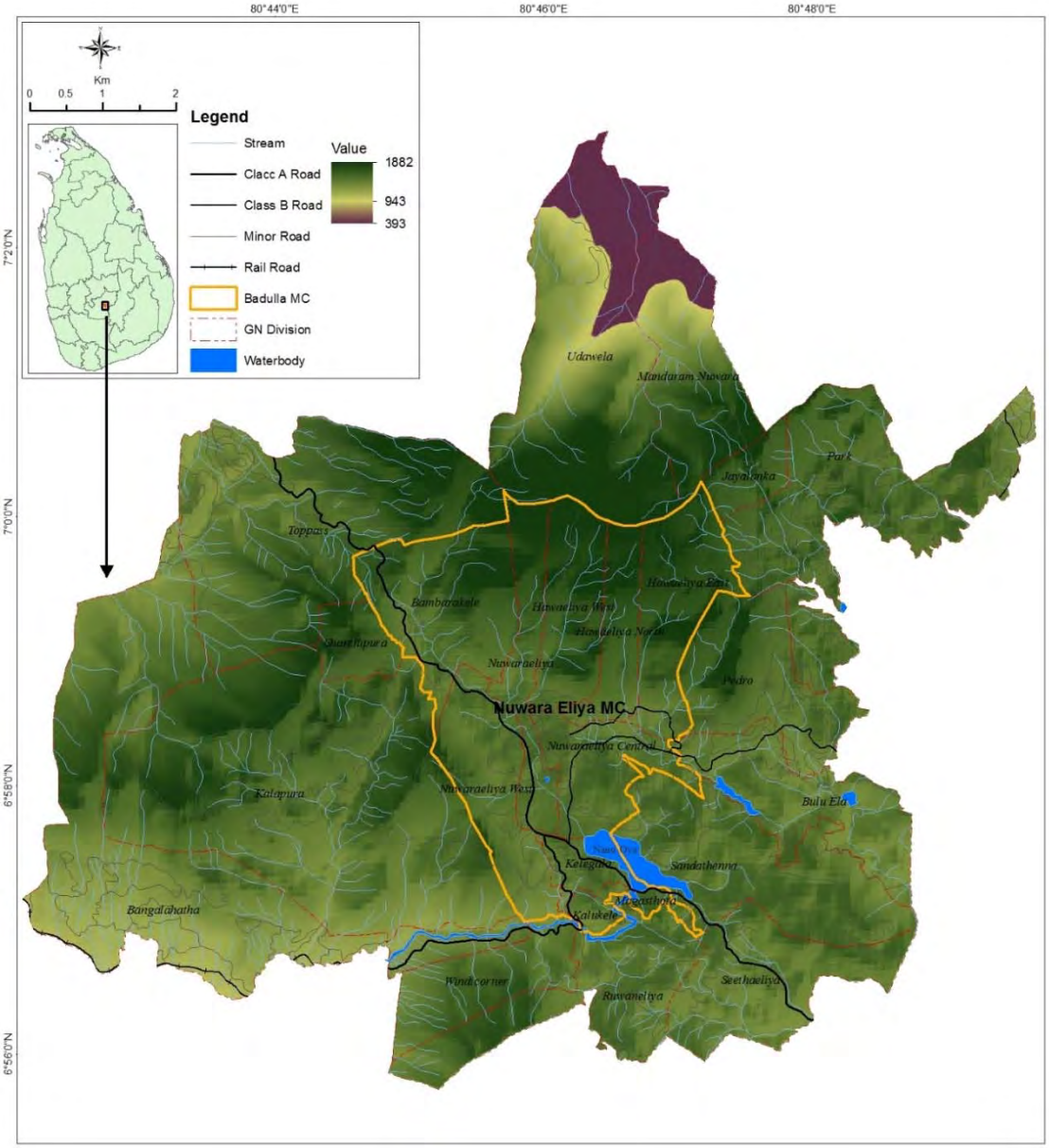
Source: JET, using Department of Meteorology data

Figure 3.2-2 Average Monthly Precipitation

3.2.3 Topography

Nuwara Eliya is situated 1,868 meters above sea level. An elevation map of the area is given in **Figure 3.2-3**.

Nuwara Eliya is in the middle of the country's highest Peneplain. The surrounding area consists of massive mountain ranges, plateaus, valleys, basins and escarpments. Horton Plains, Hawa Eliya, Mipilimana, Sita Eliya and Ambewela are the high plains. Rivers are fast flowing except for the Mahaweli River, which cuts across the central mountains.



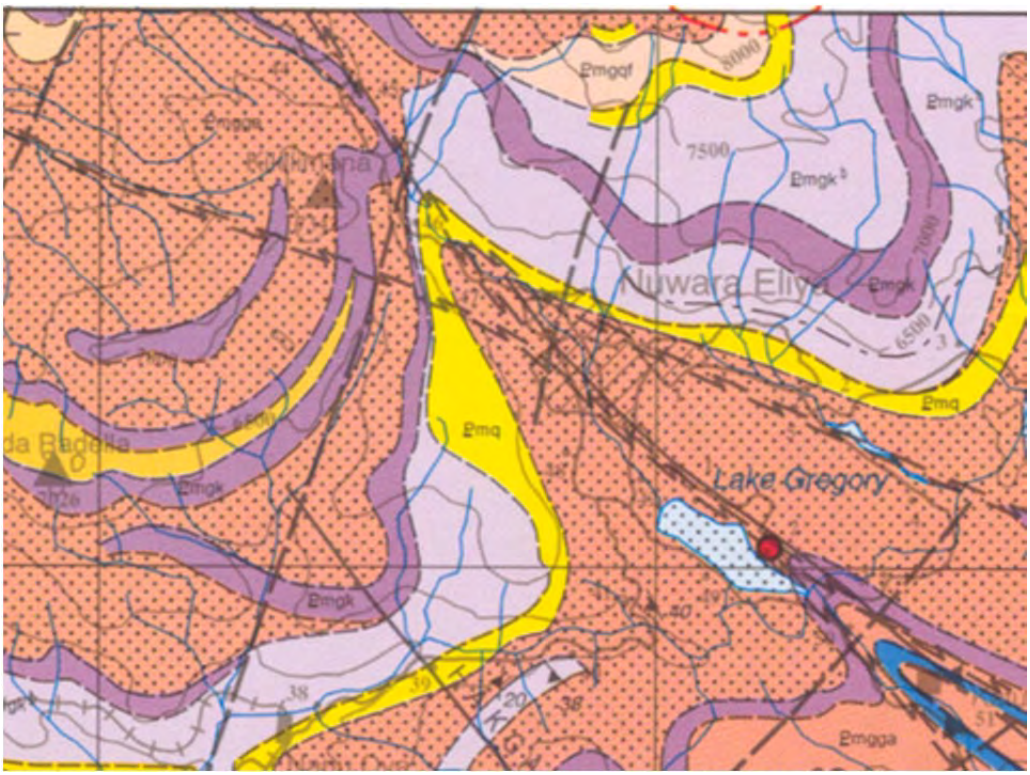
Source: Survey Department of Sri Lanka

Figure 3.2-3 Elevation Map of the Project Area

The southern edge of the highest Peneplain forms the southern wall of the hill country, stretching for more than 50 miles from Adam's Peak or Sri Pada (2,243m) on the west to the Nine Peaked Mountain (1,938m) on the east, and as high as 2,388m (Kirigalpotta) to 2,524m (Pidurutalagala).

3.2.4 Geology

The area is situated in the highland series of the Precambrian Complex. The granulite facies rocks (gneisses, sillimanite-graphite gneisses, quartzite, marbles, and some charnokites) make up most of the area of Nuwara Eliya. The area is generally covered by dense soil, and the bed rock is not visible in most places. The quartzites give rise to frequent landslides. Regional geology of the area is shown in **Figure 3.2-4**.



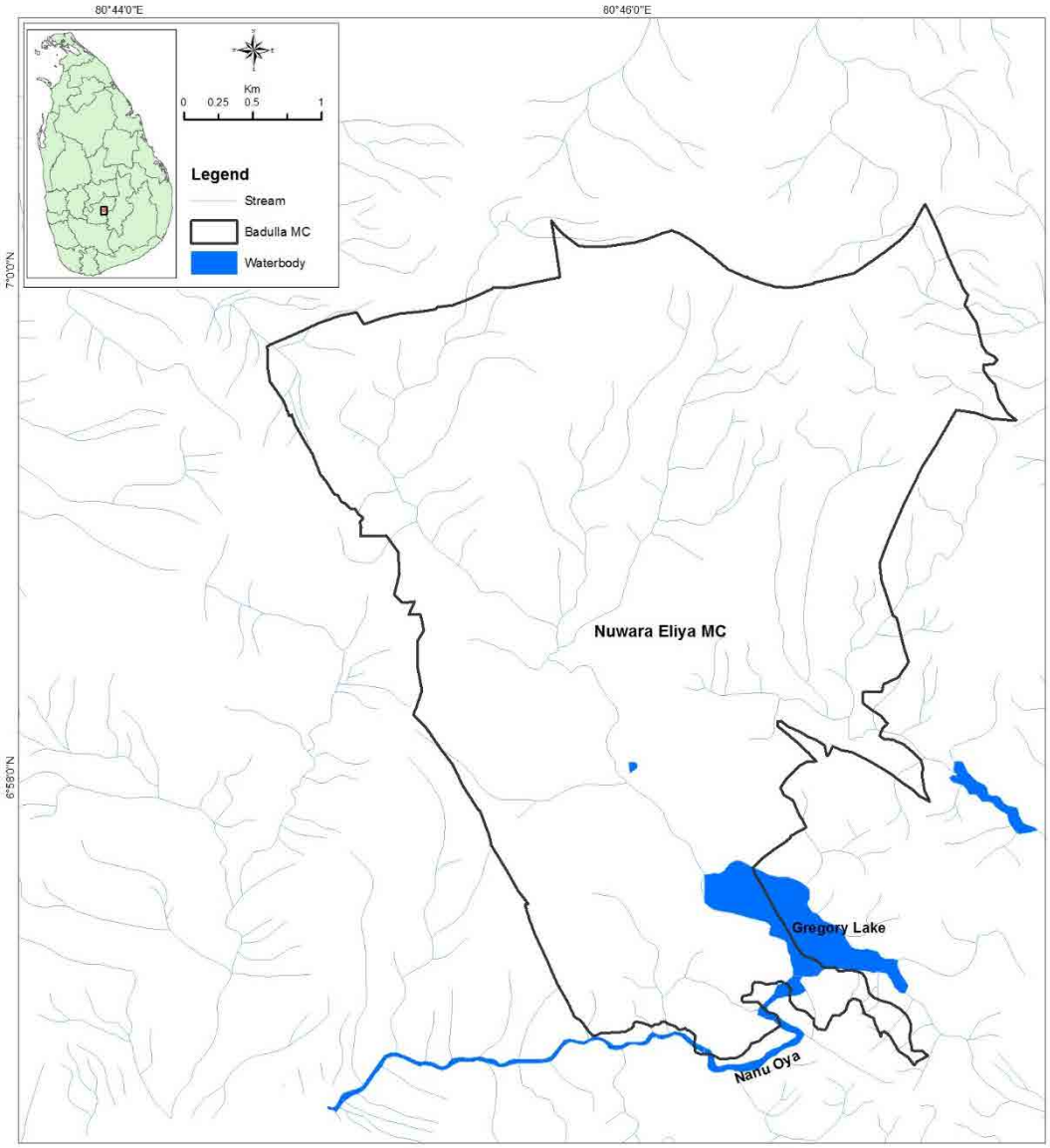
Pmq- Quartzite
Pmgga- Garnet Sillimanite Biotite Gneiss
Pmgk- Charnockckitik Gneiss
Source: Geological Surveys and Mines Bureau

Figure 3.2-4 Regional Geology

3.2.5 Hydrology

The district of Nuwara Eliya is drained by head streams of the Mahaweli, Kelani and Walawe river systems. Cross faults resulting in steep escarpments allow the streams to descend steeply from one level to another, forming cascades of waterfalls.

All the main drainage paths flow towards Lake Gregory, a small, man-made lake, located within the Nuwara Eliya Municipality. Nanu Oya stream, which originates from Pidurutalagala Peak, is a major tributary. Most of the streams in the catchment area have been changed over the years because of commercial agriculture. Drainage network and surface water bodies in the area are shown in **Figure 3.2-5**.



Source: Survey Department of Sri Lanka

Figure 3.2-5 Drainage Network and Surface Water Bodies in the Project Area

3.2.6 Environmental Quality

(1) Air Quality

No recent records on air quality measurements in the Nuwara Eliya area are available.

Vehicle movements along A5 highway (Peradeniya-Badulla-Chenkaladi highway), A7 highway (Awissawella-Hatton-Nuwara Eliya highway), B332 (Uda Pussellawa Road) and side roads and trains contribute to elevated levels of air pollutants, such as dust, particulate matter and smoke, especially during peak hours when traffic is very congested. Solid wastes thrown in the canals rot and produce foul odours, especially during dry weather when water level is low.

Volatile pesticides used in agriculture can easily escape into the air. As the area receives heavy rainfall, the accumulation of these pollutants in the atmosphere for long periods are quite unlikely.

(2) Noise and Vibration

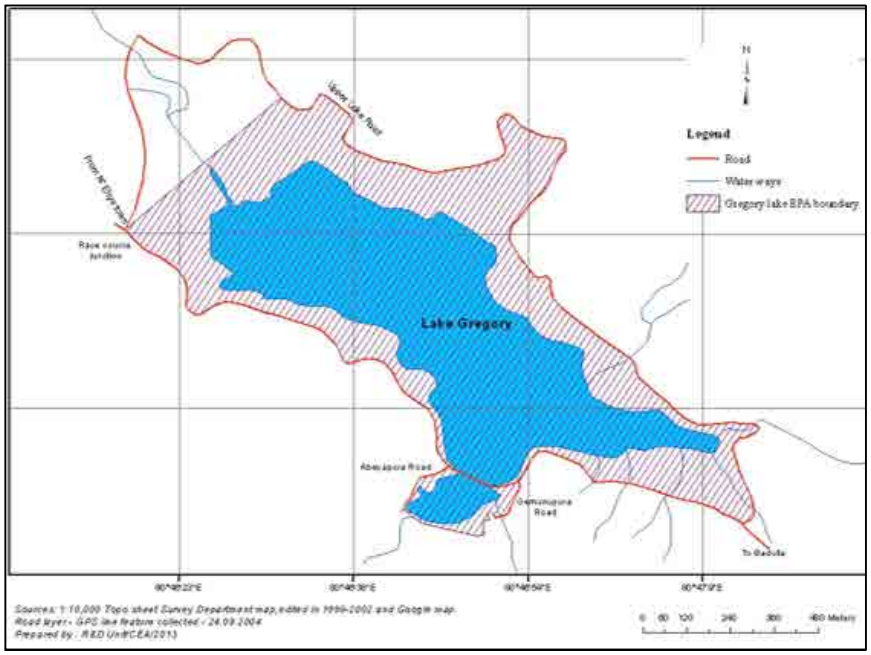
No records on noise level or vibration measurements in Nuwara Eliya area are available.

Ambient noise and vibration levels are as expected for urban areas with light industries, businesses, hotels, and restaurants. There is also traffic noise from A5 highway (Peradeniya-Badulla-Chenkaladi highway), A7 highway (Awissawella-Hatton-Nuwara Eliya highway), B332 (Uda Pussellawa Road) which are congested during peak hours. All these urban activities contribute to high noise levels in the project area.

3.2.7 Protected Areas

(1) Gregory Lake Environmental Protection Area

Gregory Lake was built by damming the Nanu Oya in 1872-1877 during the British Colonial Period . The Lake was declared as a protected area by the Central Environmental Authority, the Order published under Section 24 C and 24 D of National Environmental Act in the Government Gazette Notification Number 1487/10 dated 5th March 2007.



Source: CEA

Figure 3.2-6 Environmental Protection Areas of Lake Gregory

(2) Galway's Land National Park

Galway's Land National Park is a small national park (0.29 km^2) within the city limits of Nuwara Eliya. It was declared a wildlife sanctuary on 27 May, 1938 and elevated to national park status on 18th May 2006 to conserve the montane ecosystems. Field Ornithology Group of Sri Lanka considers Victoria Park and Galway's Land as two of the most significant birding sites in the country. Galway's Land harbours about 20 rare migrant bird species and 30 native species. The park also has valuable floral species of native and foreign origins.

3.2.8 Fauna and Flora

Fauna and flora of the general area as documented in literature and site surveys are summarized in

Table 3.2-1 and **Table 3.2-2**. Further investigation is necessary to identify the fauna and flora specific to the project sites.

Table 3.2-1 Survey of Fauna in the Project Area

Class	Type	Taxa		Significant Species (common name)	Conservation Status (IUCN 3.1)
		Family	Species		
Birds		phasianidae		*Gallus lafayeti* (Sri Lankan Jungle Fowl)	LC
		Turnicidae		*Turnix suscitator* (Barred button quail)	LC
		Picidae		*Dendrocopos nanus* (Brown capped woodpecker	LC
				Dinopium benghalense (Black rumped flameback)	LC
				Picus chlorolophus (Lesser yellownape)	LC
		Capitonidae		*Megalaima flavifrons* (Sri Lanka yellow barbet)	LC
				Megalaima rubricapillus (Crimson barbet)	LC
		Pittidae		*Pitta brachyuran* (Indian pitta)	LC
		Alcedinidae		*Alcedo atthis* (Common kingfisher)	LC
				Halcyon smymensis (White throated kingfisher)	LC
		Meropidae		*Merops leschenaultia* (Chestnut headed bee-eater)	LC
				Merops philippinus (Blue tailed bee-eater)	LC
		Cuculidae		*Clamatorjacobinus* (Jacobin cuckoo)	LC
				Cacomantis sonneratii (Banded by cuckoo)	LC
				Eudynamys scolopaceus (Asian koel)	LC
				Centropus sinensis (Greater coucal)	LC
		Psittacidae		*Loriculus beryllinus* (Sri Lanka hanging parrot)	LC
				Psittacula krameri (Rose ringed parakeet)	LC
				Psittacula cyanocephala (Plum headed parakeet)	LC
		Apodidae		*Collocalia unicolour* (Indian swiftlet)	LC
				tachymarptis Melba (Alpine swift)	LC
		Tytonidae		*Ketupa zeylonensis* (Brown fish owl)	LC
				Strix leptogrammica (Brown wood owl)	LC
				Otus bakkamoena (Cooared scops owl)	LC
		Colombidae		*Spilopelia chinensis* (Spotted dove)	LC
				Chalcophaps indica (Emerald dove)	LC
				Treron pompadora (Pompadour green pigeon)	LC
		Ralidae		*Gallirallus striatus* (Slaty breated rail)	LC
				Amauromis phoneicurus (White breasted water hen)	LC
				Pernis ptilorhyncus (Oriental honey buzzard)	LC
Mammals		Felidae		*Prionailurus rubiginosu* (Rusty-spotted cat)	NT
		Cervidae		*Muntiacus muntjak* (Indian muntjac)	LC
		Cercopithecidae		*Trachypithecus vetulus* (Purple-faced langur)	EN
				Macaca sinica (Toque macaque)	EN
Fish		Salmonidae		*Oncorhynchus mykiss* (Rainbow trout)	LC
				Salmo trutta (Brown trout)	LC

Sources: :
Manamendraarachchi and Adikari (2014)
IUCN Redlist
JET

Legend: IUCN 3.1 scale

Dom: Domesticated
Def: Data deficient
NA: Data not available

Table 3.2-2 Survey of Flora in the Project area

Taxa		Significant Species (common name)	Conservation Status (IUCN 3.1)
Family	Species		
Moraceae		*Ficus religiosa* (Bodhi tree)	LC
Putranjivaceae		*Drypete sepiaria* (Weera)	LC
Sapotacceae		*Manilkara hexandra* (Palu)	LC
Rutaceae		*Chloroxylon swietenia* (Ceylon stainwood)	VU
Malvaceae		*Berrya cordifolia* (Trinomalee wood)	VU
Meliaceae		*Azadirachta indica* (Neem wood)	LC
Moraceae		*Artocarpus heterophyllus* (Jackfruit)	LC
Anacardiaceae		*Mangifera indica* (Mango)	LC
Anacardiaceae		*Anchardium occidentale* (Cashew)	LC
Anacardiaceae		*Mangifera zeylanica* (Eth amba)	VU
Arecaceae		*Cocus nucefera* (Coconut)	LC
Lamiaceae		*Tectona grandis* (Teak)	LC
Fabaceae		*Gliricidia sepium*	LC
Fabaceae		*Leucaena leucocephala* (White leadtree)	LC
Ebenaceae		*Diospyros ebenum* (Ceylon ebony)	LC
		Felicium leucocephala	
Lamiaceae		*Vitex altissima*	LC
Rubiaceae		*Canthium dicoccum*	
Ochnaceae		*Ochna obtusata*	LC
Alangiaceae		*Alangium salviifolium*	LC
		Mixeomwlum minurum	
		Drypetes lanceolate	
Celastra		*Gymnosporia emarginata*	
Salviniaceae		*Salvinia molesta* (Kariba weed)	LC
Pontederiaceae		*Eichhrnia crassipes* (Water hyacinth)	LC
Typhaceae		*Typha anguistifolia* (Narrowleaf cattail)	LC
Araceae		*Pistia stratiotes*	LC
Anisophyleaceae		*Anisophyllea cinnamomoides* (Weli piyanna)	VU
Asteraceae		*Vernonia zeylanica* (Ironweed)	LC
Apocynaceae		*Willughbeia cirrhifera*	VU

Source:
Egodawatta and Warnasooriya (2014)
Manamendraarachchi and Adikari (2014)
Munashingha et al., (2009)
Dharmasena, (1993)
Wijerathna and Baladurage
IUCN Redlist
JET

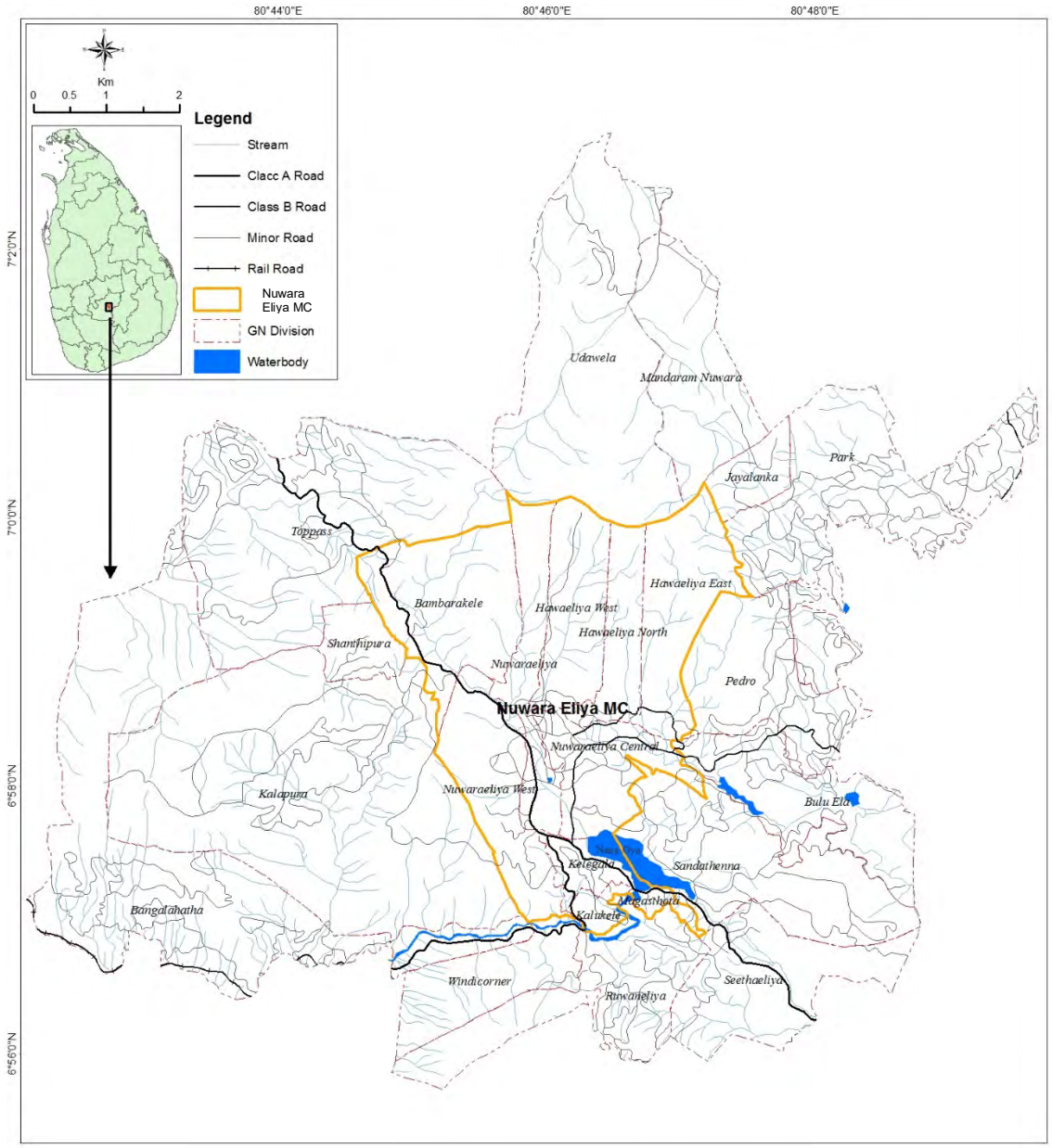
Legend: IUCN 3.1 scale

Dom: Domesticated
Def: Data deficient
NA: Data not available

3.2.9 Socio-Economic Conditions

(1) Administration

Nuwara Eliya MC was established in 1949 to handle all aspects of the development of the city. It comes under Nuwara Eliya Divisional Secretariat Division (DSD), Nuwara Eliya District, Central Province of Sri Lanka. The total area of Nuwara Eliya is 13 km^2, consisting of 10 wards. Nuwara Eliya DSD is 478 km^2 and Nuwara Eliya District 741 km^2, while the Central Province is 5,674 km^2. Details of the administrative area of Nuwara Eliya MC are shown in **Figure 3.2-7**.



Source: Survey Department of Sri Lanka

Figure 3.2-7 Administrative Areas of Nuwara Eliya MC

(2) Population and Demography

According to the Census and Statistics Department of Sri Lanka, the population density of the Nuwara Eliya DSD is 454 per km^2 compared to 421 per km^2 in Nuwara Eliya District, and 465 per km^2 in the Central Province. The population of the Nuwara Eliya Municipality Council was 30,129 in 2012, while the Nuwara Eliya Divisional Secretariat had a population of 212,094. Nuwara Eliya Municipal Council accounts for 14% of the population in the Divisional Secretariat. The population Figures and gender distribution based on the Grama Niladari Division are shown in **Table 3.2-3**.

Table 3.2-3 Population of Nuwara Eliya MC Area

Name of GND	Total	Male		Female	
		No	%	No	%
Hawaeliya East	2,273	1,080	48%	1,193	52%
Bambaralkele	3,143	1,508	48%	1,635	52%
Nuwara Eliya West	2,481	1,353	55%	1,128	45%
Kalapura	3,465	1,726	50%	1,739	50%
Nuwara Eliya	1,290	708	55%	582	45%
Nuwara Eliya Central	4,292	2,016	47%	2,276	53%
Hawaeliya North	2,216	1,044	47%	1,172	53%
Hawaeliya West	2,072	1,014	49%	1,058	51%
Bulu Ela	1,751	846	48%	905	52%
Sandathanna	2,816	1,398	50%	1,418	50%
Kalegala	1,829	857	47%	972	53%
Kalukele	1,093	512	47%	581	53%
Magasthota	1,408	705	50%	703	50%
Total	30,129	14,767	49%	15,362	51%

Source: Census of Population and Housing 2012, Department of Census and Statistics (DCS)

(3) Religion/Ethnicity

The majority of the population of Nuwara Eliya District is either Hindu or Buddhist, with a higher proportion of the former (**Table 3.2-4**).

Table 3.2-4 Population by Religion

Buddhist	Hindu	Islam	Roman Catholic	Other Christian	Other	Nuwara Eliya District Total
276,281	361,073	21,198	32,504	14,837	707	706,600
39.1%	51.1%	3.0%	4.6%	2.1%	0.1%	

Source: Economic and Social Statistics of Sri Lanka -2014, Central Bank of Sri Lanka, April 2014

Indian Tamil and Sinhalese are the dominant ethnic groups (**Table 3.2-5**).

Table 3.2-5 Population by Ethnicity

Sinhala	SL Tamil	Indian Tamil	SL Moor	Other	Nuwara Eliya District Total
279,814	31,797	375,911	16,958	2,120	706,600
39.6%	4.5%	53.2%	2.4%	0.3%	

Source: Economic and Social Statistics of Sri Lanka -2014, Central Bank of Sri Lanka, April 2014

(4) Economy

1) General Conditions

Nuwara Eliya, situated at around 2,000 m above sea level in Central Province, is the centre of tea industry in Sri Lanka. Around the city centre, there are acres of tea plantations and many tea factories. **Table 3.2-6** shows the gross domestic products (GDP) contribution of Central Province which covers Kandy, Matale, and Nuwara Eliya.

Table 3.2-6 GDP by Industry Sector in Central Province (Current Prices)

Unit: Million Sri Lanka Rupee (LKR)

No	Sector	2010		2011		2012		2013	
1	Agriculture	101,741	18.1%	113,969	17.7%	117,963	15.6%	148,885	15.5%
2	Industry	161,227	28.7%	179,054	27.8%	224,035	29.7%	336,117	35.0%
3	Services	299,776	53.3%	351,309	54.5%	433,583	57.4%	474,917	49.5%
	Provincial GDP	562,744	100.0%	644,332	100.0%	755,580	100.0%	959,918	100.0%
	% share of National GDP	10.0		9.8		10.2		11.1	

Source: CBSL Annual Report 2014

Central Province contributes to 10 to 11% of the national GDP. The service industry is the largest sector, contributing to 50 to 60% of the total GDP of the Province.

2) Tourism

Nuwara Eliya is a famous tourist destination in the country, blessed with a cool climate and beautiful sceneries. There are many tourist attractions, such as golf courses, Hakgala botanical garden, Gregory Lake, Victoria Park. **Table 3.2-7**, **Figure 3.2-8** and **Figure 3.2-9** show the tourist arrival number at Hakgala Botanical Garden and Horton Plains National Park, and tourism revenue at these places for 2011-14.

Table 3.2-7 Nuwara Eliya District Tourist Arrival and Revenue

Year	Destination	2011	2012	2013	2014
No. of Foreign Visitors	Hakgala *1	10,092	12,489	14,713	18,071
	Horton Plains *2	29,854	39,123	34,065	69,979
No. of Local Visitors	Hakgala	500,024	587,743	511,873	578,825
	Horton Plain	166,818	184,744	46,511	198,274
Total No. of Visitors	Hakgala	510,116	600,232	526,586	596,896
	Horton Plain	196,672	223,867	80,576	268,253
Year		2011	2012	2013	2014
Revenue: Foreign Visitors (LKR)	Hakgala & Horton Plain	60,675,021	83,836,172	80,077,973	149,769,933
Revenue: Local Visitors (LKR)	Hakgala & Horton Plain	28,152,670	32,247,950	22,838,860	33,567,770
Total Revenue (LKR)	Hakgala & Horton Plain	88,827,691	116,084,122	102,916,833	183,337,703

Source: Annual Statistical Reports- Sri Lanka Tourism Development Authority (Annual Reports of 2011,2012,2013,2014)
Notes: *1; Hakgala Botanical Garden, *2; Horton Plains National Park

Majority of the visitors were local tourist. The number of foreign and local visitors to both places is on the rise. In 2014, there were at least 600,000 foreign and local tourists in Nuwara Eliya. Apart from admission fees, tourists also contribute to revenues of hotels, restaurants, transportations, souvenir shops, and related businesses. Tourism revenues are rapidly increasing and can be quite substantial.

The establishment of a sewerage system will preserve the water environment of the lake and river and contribute to the sustainable growth of the tourism industry and the economy of the area.

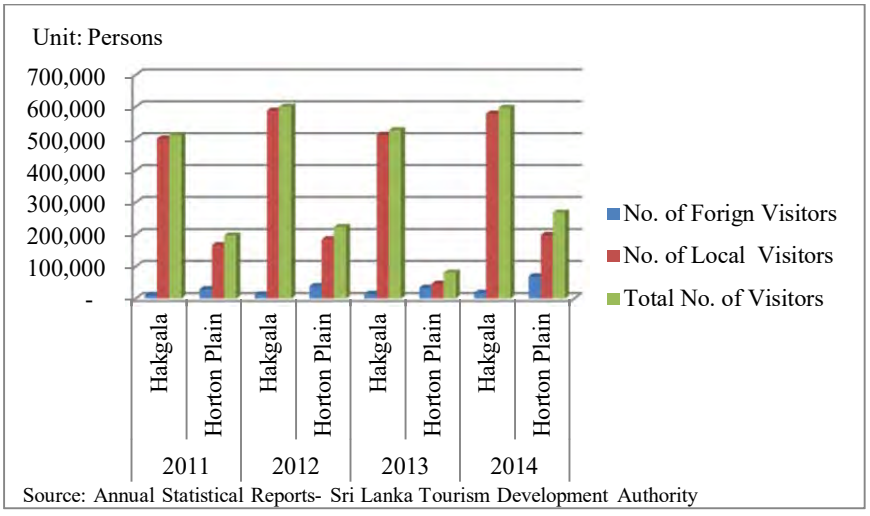


Figure 3.2-8 Nuwara Eliya District Tourist Arrival

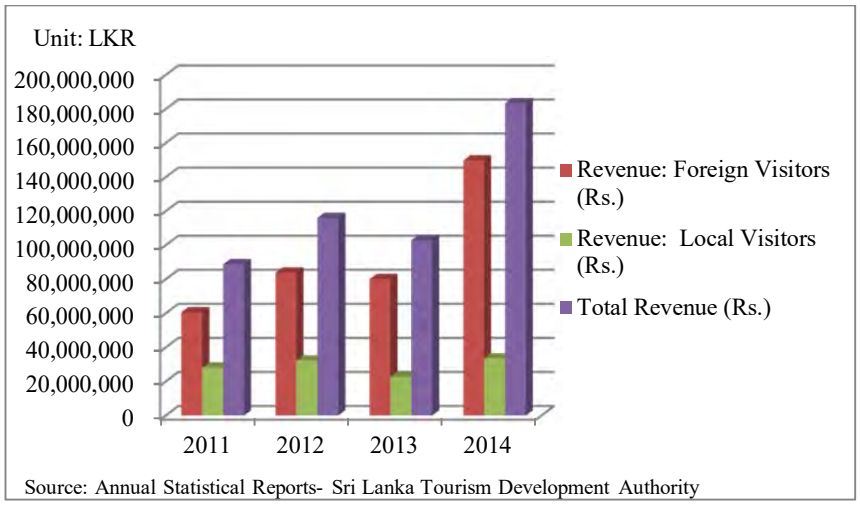


Figure 3.2-9 Nuwara Eliya District Tourism Revenue

3) Household Income

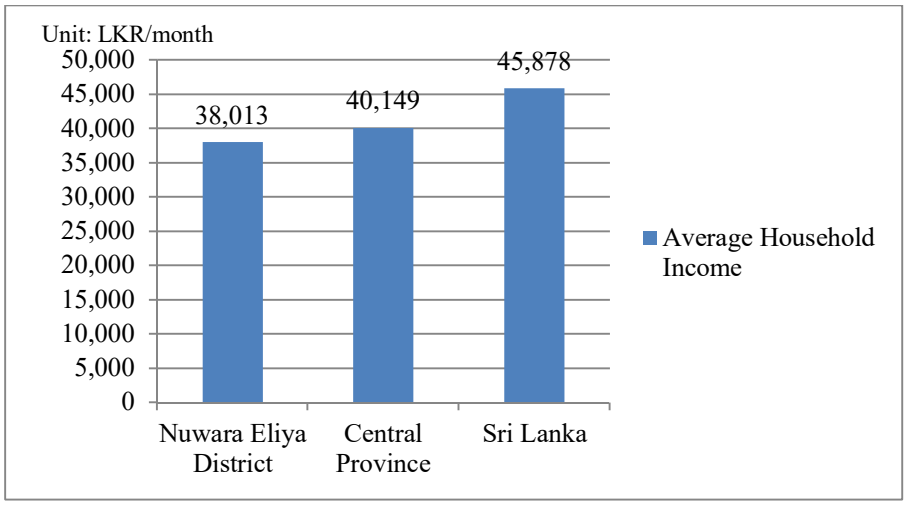
Average household income data are available from "Household Income and Expenditure Survey 2012/2013", some of which are presented in **Table 3.2-8** and **Figure 3.2-10** Average monthly household income in Nuwara Eliya District was 38,013 LKR in 2012/13. Most of the household income came from wage/salaries (42%). Household income in Nuwara Eliya District is 17% lower than the national average and slightly lower than that in Central Province. In Nuwara Eliya, the design of sewage tariff should take into consideration the ability to pay (ATP).

Table 3.2-8 Breakdown of Monthly Household Income for Nuwara Eliya District (2012/13)

Unit: LKR/month

No.	Sector	Nuwara Eliya District	%
1	Average Household Income	38,013	
2	Per capita	9,074	
3	Ave. No. of Income Receivers (persons)	1.9	
4	Wage/Salaries	16,686	42.1%
5	Agricultural Activities	2,647	6.7%
6	Non-Agriculture Activities	4,798	12.1%
7	Other Cash Income	4,678	11.8%
8	Income by Adhoc Gain	5,172	13.1%
9	Non-Monetary Income	4,032	10.2%
10	Income in Kind	1,600	4.0%

Source: Household Income and Expenditure Survey 2012/2013, DCS, Ministry of Policy Planning Economic Affairs



Source: Household Income and Expenditure Survey 2012/2013, DCS, Ministry of Policy Planning Economic Affairs

Figure 3.2-10 Comparison of Monthly Household Income

(5) Land Use

Land use patterns in Nuwara Eliya District and Nuwara Eliya MC are shown in **Table 3.2-9** and **Table 3.2-10** and **Figure 3.2-11**. The area for development is limited. Residential neighbourhoods, forests, conservation areas and tea plantations are occupying about 30, 17, 13 and 10% of the area.

Table 3.2-9 Land Use in Nuwara Eliya District

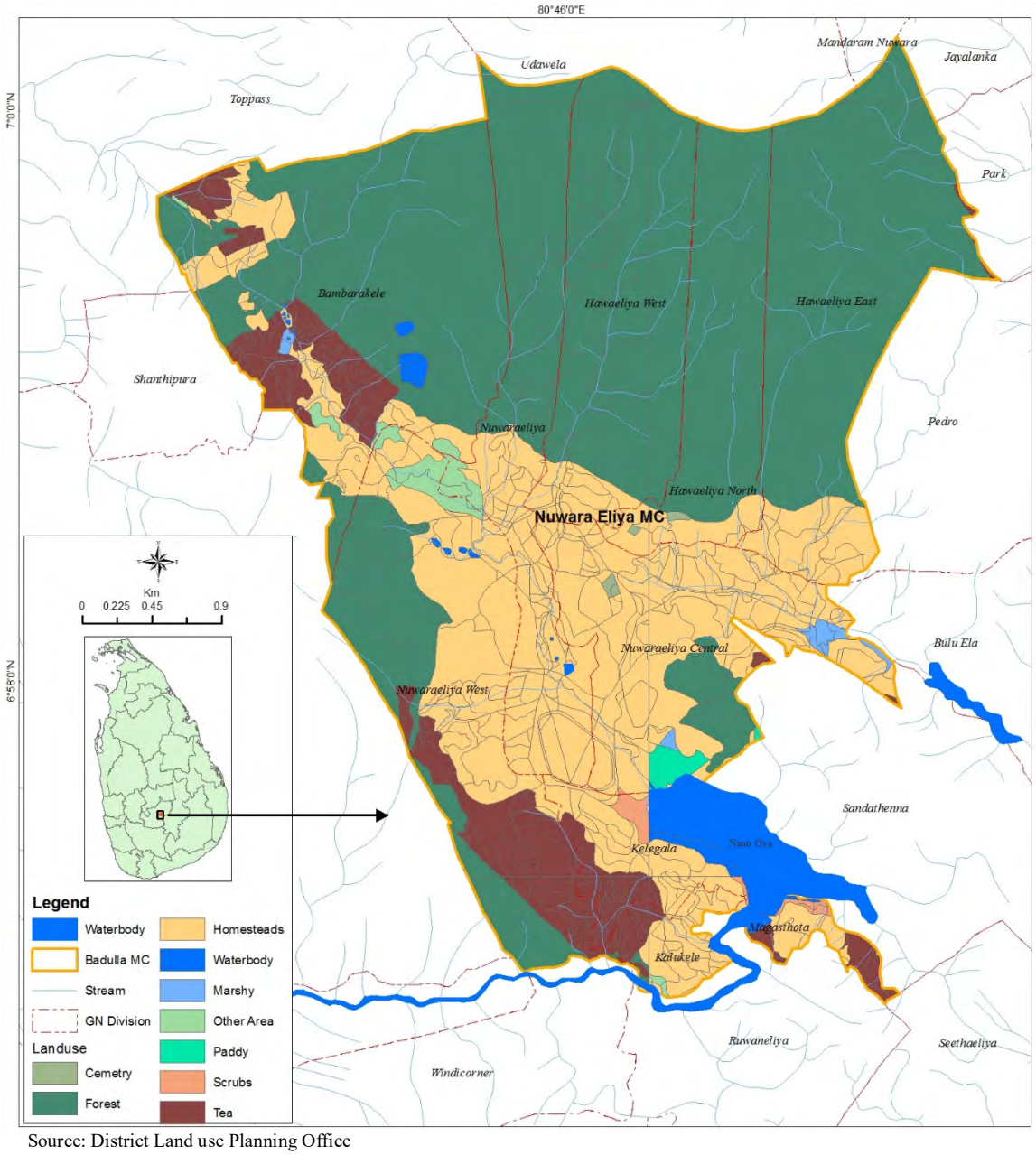
ඉඩම් ස්වභාවය Nature of land	භූමි ප්‍රමාණය (හෙක්ටයාර්) Area (Hec)	ප්‍රතිශතය Percentage (%)
01.අස්වැද්දුන ලද කුඹුරු - Asweddumized paddy land		
1. වාරිමාර්ග - Irrigated	6,073.1	3.5
11.අහස්දියෙන් - Rainfed	76.1	0.0
02.තේ - Tea	40,826.0	23.4
03. රබර් - Rubber	23.0	0.0
04. පොල් - Coconut	8.0	0.0
05. කුරුඳු- Cinnamon	32.0	0.0
06. වෙනත් වගාවන් - Other crops	23,040.4	13.2
07.වනාන්තර- Forests		
1. ඝන වනාන්තර - Dense forests	37,073.5	21.3
11. විවෘත වනාන්තර - Open forests	7,577.8	4.4
111. වගා කරන ලද වනාන්තර - Planted forests	10,404.0	6.0
08.ලදු කැළෑ හා හේන - Grass lands/Chena	16,098.0	9.2
09. වගුරු හා කඩොලාන කැළෑ - Marshes and Mangroves	560.4	0.3
10.ගෙවතු - Home gardens	13,243.7	7.6
11.ජලාශ - Reservoirs	3,500.0	2.0
12.ගොඩනැගිලි- Building	2,639.8	1.5
13වැලි හා ගල් පර - Sand and Mountain	2,044.0	1.2
14. මුඩු බිම් හා අත්හරින ලද ඉඩම් - Abandoned land	4,770.7	2.7
15.වෙනත් (පූජා භූමි, මාර්ග,සුසාන භූමි ආදිය)	6,109.5	3.5
Other (sacred places, roads,cemetery etc)		
එකතුව - Total	174,100.0	100.0

Source: District Land use Planning Office

Table 3.2-10 Land Use in Nuwara Eliya MC

Type of Land Use	Area (ha)
Residential Area	377
Commercial and Institutional Area	139
Agricultural Area	41
Water Area	52
Nature Conservation, Parks & Recreation	165
Tea Estate	142
Forest	231
Others	152
Total	1,299

Source: Land Use 2002- 2017 (Nuwara Eliya MC)



Source: District Land use Planning Office

Figure 3.2-11 Land Use in the Project Area

3.2.10 Present Water Supply

Table 3.2-11 shows the distribution of drinking water facilities by type in Nuwara Eliya MC. The piped water supply system covers about 90% of the households.

Table 3.2-11 Drinking Water Facilities by Type in Nuwara Eliya MC Area

No.	Name of GND	Total	Protected Well Within Premises	Protected Well Out Side Premises	Un Protected Well	Tap Within Unit	Tap Within Premises	Tap Outside Premises	Rural Water Project	Tube Well	Bourses	River , Tank, Stream	Rain Water	Bottle Water	Other
1	Hawaeliya East	580	8	2	17	360	138	15	0	0	0	39	0	0	1
2	Bambaralkele	787	32	10	22	428	117	17	56	14	0	76	0	0	15
3	Nuwara Eliya West	578	8	1	66	301	60	130	1	1	0	10	0	0	0
4	Kalapura	840	35	141	88	58	94	180	198	0	0	46	0	0	0
5	Nuwara Eliya	272	1	4	0	205	45	11	5	0	0	0	0	0	1
6	Nuwara Eliya Central	1017	24	4	7	718	103	16	125	1	0	0	0	0	19
7	Hawaeliya North	542	8	8	2	263	77	15	125	2	0	39	0	0	3
8	Hawaeliya West	490	13	0	1	392	67	14	1	0	0	2	0	0	0
9	Bulu Ela	429	25	4	7	329	52	1	2	0	0	8	0	0	1
10	Sandathanna	683	25	79	73	331	89	58	1	3	0	16	0	0	8
11	Kalegala	453	3	0	0	379	55	16	0	0	0	0	0	0	0
12	Kalukele	289	6	2	0	205	57	5	1	0	0	12	0	0	1
13	Magasthota	377	7	0	0	265	82	19	2	0	0	0	2	0	0
	Total	7,337	195	255	283	4,234	1,036	497	517	21	0	248	2	0	49

Source: Census of Population and Housing 2012, DCS

The main sources of water are:

- wells in the Upper Nanu Oya area
- wells in the Upper Bomburu Ela area
- some surface water sources

Water consumption by customer category is shown in **Table 3.2-12**. About 1.5 million m^3/year of water is consumed.

Table 3.2-12 Water Consumption by Consumer Type

Year / Type of Consumption	2013	2014	2015	2016
Domestic	1,423,062	897,211	890,823	895,799
Commercial and Industrial	436,104	510,590	466,790	519,705
Institutional	50,682	70,337	118,018	74,166
Others	4,480	8,310	13,573	26,600
Total (m^3/year)	1,914,328	1,486,448	1,489,204	1,516,270

Source: Nuwara Eliya MC

3.2.11 Solid Waste

Commercial activities generate the largest amount of solid waste, followed by households (**Table 3.2-13**).

Table 3.2-13 Solid Waste Generation by Sector

Residential	27.2%
Commercial	48.4%
Institutions	13.2%
Industries	11.3%

Source: Nuwara Eliya MC

The solid waste generated in the Nuwara Eliya MC area consists of mainly of paper, grass, wood, and plastics (**Table 3.2-14**).

Table 3.2-14 Types of Solid Waste – Nuwara Eliya MC

Kitchen waste	74.6%
Paper	7.8%
Textiles	1.0%
Grass & wood	4.8%
Soft Plastics	4.2%
Hard Plastics	0.9%
Rubber & leather	0.4%
Metal	0.9%
Glass & bottles	1.7%
Stone & ceramic	0.5%
Other	3.2%

Source: Nuwara Eliya MC

Nuwara Eliya has a well-organized solid waste management system. Waste is collected from curb side and transported to a disposal site, 4 km from the town centre. The disposal site was constructed in 2003 as a JICA pilot project (The Study on Improvement of Solid Waste Management in the Secondary Cities in Sri Lanka).

The disposal area has a leachate treatment facility, septage treatment facility, infectious waste discharge pit, small-scale incinerator for garden waste, and a recovery facility (**Figure 3.2-12**). The area is approximately 2 ha, with a remaining useful life of 10-15 years.

Waste Disposal Area

Leachate Collection and Treatment System

Infectious Waste Disposal Facility

Source: JET

Figure 3.2-12 Moon Plains Semi-Engineered Sanitary Landfill Site

3.3 PROJECT JUSTIFICATION

In its national policy enacted in 2010, Sri Lanka aims to achieve 100% access to adequate sanitation through on-site and off-site sanitation facilities by 2025. NWSDB's service plan sets the objective to achieve 7.0% piped sewer coverage by 2020.

The United Nations sets Sustainable Development Goals (SDGs) as the next development agenda for the Millennium Development Goals (MDGs). The goal related to sanitation and hygiene is to ensure universal access to safely and sustainably managed water and sanitation by 2030, and some of the specific targets include:

- By 2030, achieve access to adequate sanitation and hygiene facilities for all.
- By 2030, improve water quality by halving the proportion of untreated wastewater.

As of 2012, coverage of piped sewerage remains at 2.4% in Sri Lanka. Nuwara Eliya has no STP, and relies only on septic tanks and other on-site facilities, which, do not function adequately in densely-populated urban areas. Increasing levels of BOD and coliform bacteria are detected in Lake Gregory situated at the centre of the city.

Nuwara Eliya MC is a world renowned tourist destination and is recognized as an emerging tourist hub in Sri Lanka, evidenced by the increasing number of international and domestic tourists. In 2014, there were at least 600,000 foreign and local tourists in Nuwara Eliya. Apart from admission fees, tourists also contribute to revenues of hotels, restaurants, transportations, souvenir shops, and related businesses. Tourism revenues are rapidly increasing and can be quite substantial. The increase of tourist population is expected to bring about further deterioration of public water bodies and other touristic resources. Therefore, sewerage development is necessary to protect and improve the water environment. Moreover, Japan has supported solid waste management and water supply projects in the MC. These two projects are expected to produce synergistic effects on environment conservation in Nuwara Eliya. Consequently, Nuwara Eliya MC is considered as a candidate for additional survey for the formulation of sewerage project.

CHAPTER 4 PLANNING BASIS

4.1 OUTLINE

- 2046 is the target year for this additional study. According to the NWSDB design manual, this is when the population and development would reach the saturation point for the service area (4.2).
- The entire service population in 2046 is estimated to be around 19,000. The phasing of sewerage system development will be one stage, with consideration of small scale construction cost (4.3.3).
- Based on actual consumption data, 120 lpcd per capita water consumption is used to determine the design wastewater flow, which is estimated to be 4,640 m^3/day (4.5.2).

4.2 DESIGN PERIOD

To match the target year of 2046, the design period for the collection network, pumping stations, treatment plant, effluent disposal and utilization is 30 years (Source: NWSDB Design Manual D7 Wastewater Collection, Treatment, and Disposal & Re-Use 2012). As such, 2046 is the target year for this additional study, which is also when the population and development is projected to reach the saturation point for the area.

4.3 SEWERAGE CATCHMENT AREA

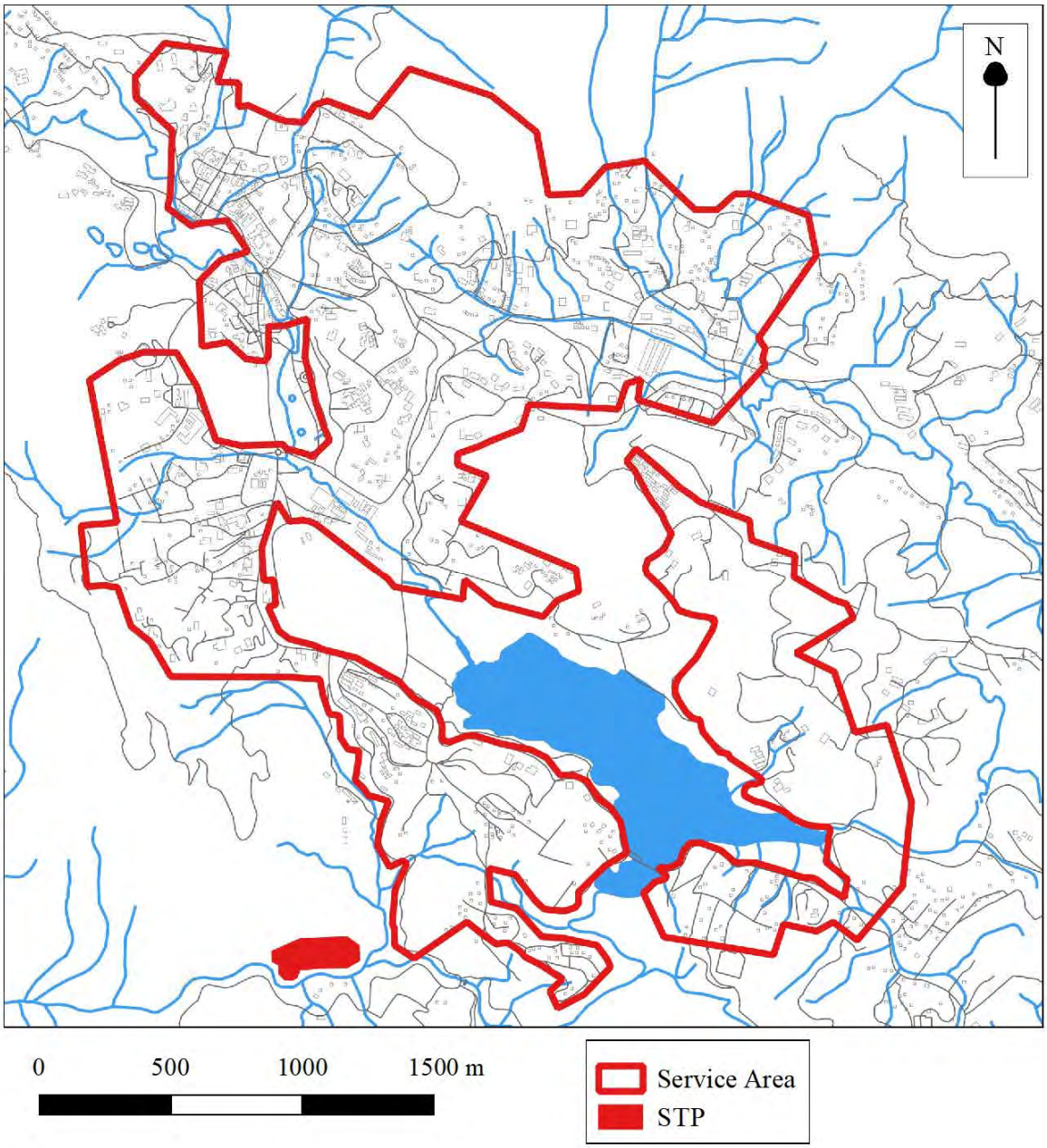
4.3.1 Service Area

The area considered in this additional study covers the wastewater treatment service area decided in the City Sewerage Master Plan (M/P) as shown in **Figure 4.3-1**, and includes:

- developed and populated areas that will be almost fully saturated by 2046
- city centre including large-scale commercial areas, large-scale facilities, such as schools, hotels, housing estate, religious and institutional buildings
- high density residential areas
- areas suitable for applying centralized sewerage system.

4.3.2 Area Prioritization and Project Stages

Development work will be divided in phases, if the entire service area is relatively large and huge magnitude of investment is required. Since the project costs estimated in City Sewerage M/P of Nuwara Eliya is about JPY 9,260 million or LKR 12,000 million, which is relatively small scale, phasing is not considered, and then target area will be the whole service area.



Source: JET

Figure 4.3-1 Whole Service Area of Additional Study

4.4 POPULATION PROJECTION

Population in the target year is one of the most critical factors in determining sewage flow for facility design. This is estimated based on historical population trends obtained from census data.

4.4.1 Census Data

The Department of Census and Statistic has been taking census every 10 years since 1871 (with the exception of 1991), the latest being 2012. This additional study will use the following census documents:

- Census of Population and Housing 2012 - Final Report
- Census of Population and Housing, 2001 (required data provided by the Department in March, 2016 and August, 2017)

Table 4.4-1 presents the population data and **Table 4.4-2** presents population growth for Sri Lanka as a whole, Nuwara Eliya District, and Nuwara Eliya MC, from 1946 to 2012.

Table 4.4-1 Population Data

Year	Sri Lanka	Nuwara Eliya District	Nuwara Eliya MC
1946	6,657,339	-	-
1953	8,097,895	-	-
1963	10,582,064	-	-
1971	12,689,897	-	-
1981	14,846,750	583,716	
2001	18,797,257	703,610	25,388
2012	20,277,597	706,210	23,804

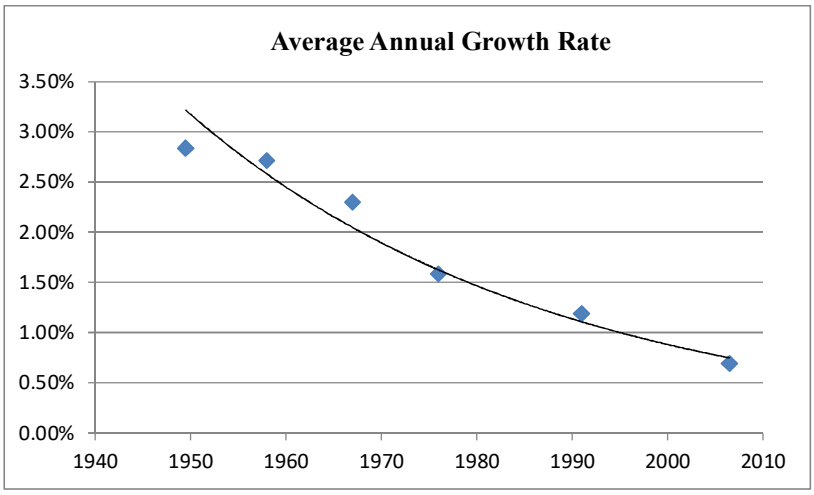
Source: Census results

Table 4.4-2 Average Annual Population Growth

Period	Sri Lanka	Nuwara Eliya District	Nuwara Eliya MC
1946-1953	2.84	-	
1953-1963	2.71	-	
1963-1971	2.30	-	
1971-1981	1.58	-	
1981-2001	1.19	0.94	-
2001-2012	0.69	0.03	-0.58

Source: JET calculated the growth rates based on Census results

Similar to some other developing countries, population growth rate in Sri Lanka is declining as shown in **Figure 4.4-1.** Nuwara Eliya Province also shows lower population growth, but the total population did not go down as in the case of Nuwara Eliya MC in the last decade.



Source: JET calculated the growth rates based on Census results

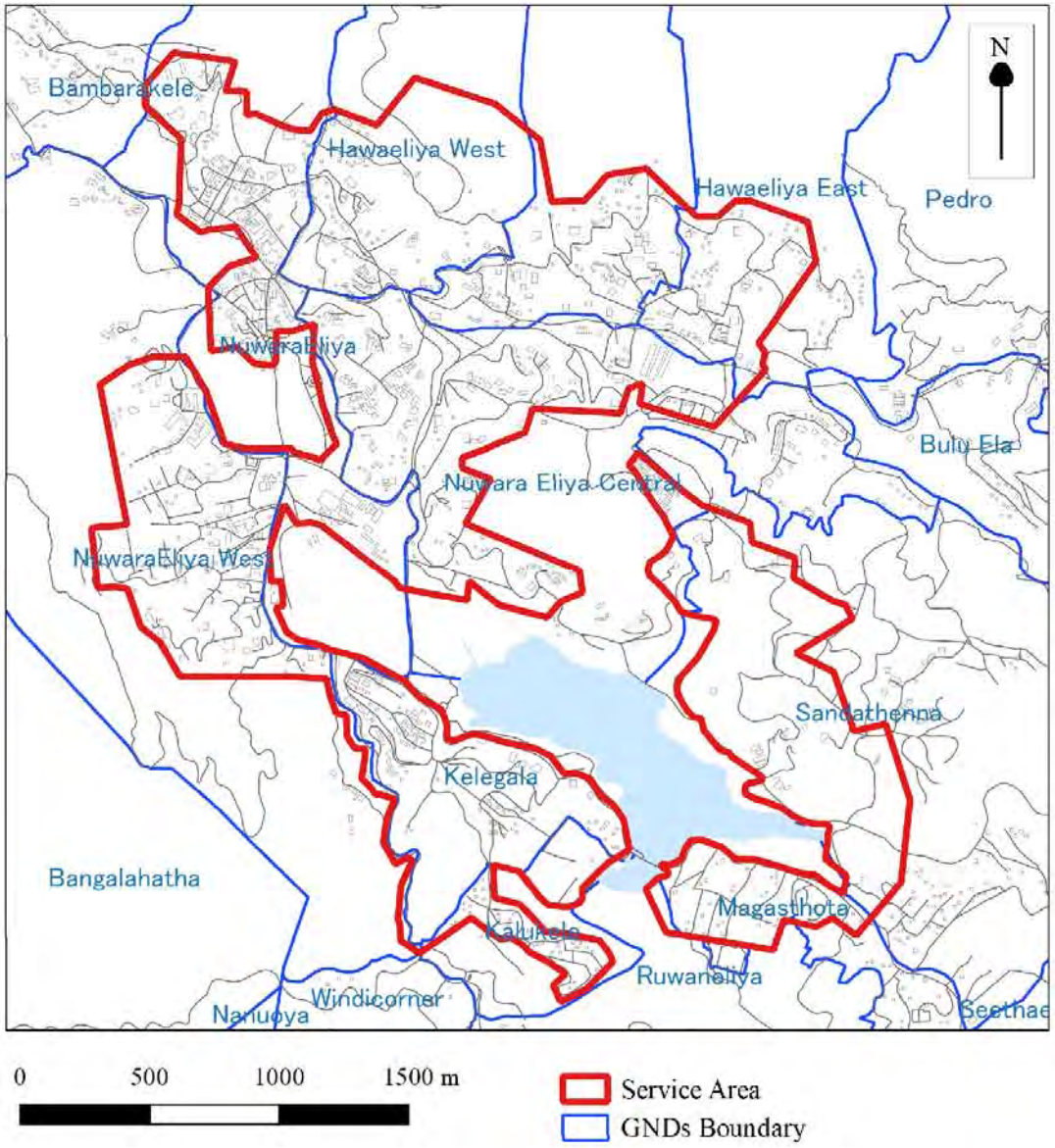
Figure 4.4-1 Average Annual Population Growth in Sri Lanka since 1946

The population of the 10 GNDs fully or partially included in the entire service area is shown in **Table 4.4-3.** The population growth at each GND in the service area. Population of GNDs highlighted in blue shows increase in the last decade, while the rest remain stable or shows some decline.

Table 4.4-3 Population of Census Results of Related GNDs

Nuwara Eliya GND		Population 2001	Population 2012
535H	Havaeliya East	2,327	2,273
535L	NuwaraEliya West	2,540	2,481
535	Nuwara Eliya	1,878	1,290
535D	Nuwara Eliya Central	4,712	4,292
535G	Hawaeliya North	2,686	2,216
535F	Hawaeliya West	1,888	2,072
535C	Kelegala	1,874	1,829
535B	Kalukele	1,131	1,093
535E	Sandathenna	2,803	2,816
535A	Magasthota	1,518	1,408
Total		23,357	21,770

Source: Census results



Source: Survey Department

Figure 4.4-2 GNDs in the Target Area

4.4.2 Population Projection for Sewerage Planning

Population of the GNDs to be covered by the Nuwara Eliya sewerage system is projected to 2046 considering the actual average annual population growth shown in **Figure 4.4-1**, following the manner shown in **Table 4.4-4**:

Table 4.4-4 Estimating GND Population Growth

GNDs	Population Growth	Rationale
with population decrease from 2001 to 2012	0.0%	Population would be stable at year 2012 level.
with population increase from 2001 to 2012	follow the same trend as the District	starting with the rate between 2001 and 2012, growth will slow as the population approaches the saturation value.

Source: JET

The population projections for each GND are shown in **Table 4.4-5**. The details of the projections are presented in **APPENDIX 4-1**. Total service population is estimated to be about 19,000 person.

Table 4.4-5 Population Projection by GND

Nuwara Eliya DSD		Population 2001	Population 2012	Population 2046	Sewerage Service Area	
					% covered	Population in 2046
1.1	Havaeliya East	2,327	2,273	2,273	85	1,932
1.2	NuwaraEliya West	2,540	2,481	2,481	95	2,357
1.3	Nuwara Eliya	1,878	1,290	1,290	100	1,290
1.4	Nuwara Eliya Central	4,712	4,292	4,292	90	3,863
1.5	Hawaeliya North	2,686	2,216	2,216	100	2,216
1.6	Hawaeliya West	1,888	2,072	2,350	100	2,350
1.7	Kelegala	1,874	1,829	1,829	100	1,829
1.8	Kalukele	1,131	1,093	1,093	65	710
	Sub Total 1	-	-	-		16,547
2.1	Nuwara Eliya Central	4,712	4,292	4,292	10	429
2.2	Sandathenna	2,803	2,816	2,834	30	850
2.3	Magasthota	1,518	1,408	1,408	85	1,197
	Sub Total 2	-	-	-		2,476
TOTAL		-	-	-		19,024

Source: JET, based on the census data

4.5 PLANNING BASIS FOR SEWERAGE SYSTEM

4.5.1 Collection System

Separate wastewater collection is proposed for this service area based on the following considerations:

- A separate wastewater collection system is more effective than a combined system for improving the water environment of surrounding water bodies especially during the rainy season.
- "NWSDB Design Manual D7 Wastewater Collection, Treatment, Disposal & Re-Use 2012" recommends the implementation of separate collection systems where possible.
- Other sewerage systems developed and being developed employ separate system in Sri Lanka.

4.5.2 Sewage Flow

(1) Summary

The parameters for sewage flow estimate are shown in **Table 4.5-1**. The values are obtained through discussions with Technical Comittie(TC) and from the NWSDB Design Manual.

Table 4.5-1 Design Basis for Estimation of Sewage Flow

Item	Value	Remarks
Per capita water consumption	120 lpcd	
Return Factor	80%	of water consumption
Non-domestic Flow	75%	of Domestic Flow
Average Dry Weather Flow (ADWF)	Domestic + Non-domestic flow	
Daily maximum dry weather flow	1.25 times	of ADWF
Peak Dry Weather Flow (PDWF)	1.6 times	of ADWF
Infiltration	20%	of ADWF

Planning of Sewer Pipe System: Peak Dry Weather Flow (PDWF) + Infiltration
Planning of Pumping Station: Hourly Maximum Dry Weather Flow + Infiltration
Source: JET

(2) Per Capita Water Consumption

Per capita water consumption is one of the important criteria for determining the capacity of the sewerage system. The 120 lpcd per capita water consumption stated in the City Sewerage M/P is based on the following:

- Actual per capita consumption for the previous 5 years in the service area.
- NWSDB Design Manual's range of 120 to 140 lpcd.
- Coverage of water supply in the service area is saturated and there is no plan to expand the service.

Detail explanation is shown in **APPENDIX 4-2**.

(3) Non-domestic Flow

Water consumption data are collected from Nuwara Eliya MC. The data of the last 3 years (2014-2016) are analysed for estimating non-domestic/domestic flow ratio, as Domestic consumption of the year 2013 is extremely high compare with the following 3 years. Data analysis is presented in **APPENDIX 4-2**.

The ratio of non-domestic/domestic flow is estimated ranging from 0.61 to 0.75 except for November, 2014, which is something wrong with reason unidentified. Based on the data, 0.75 is employed as no-domestic/domestic flow ratio in the target year. The ratio is the same as the monthly maximum value at the present, as relatively small increase of water supply is expected in the target area in the future with following reasons:

- Average ratio of the last 3 years is 0.673 and target area in land use planned area is relatively saturated.
- Some hotels will be constructed, but the scale and number will be limited in the target area.
- Water supply plan is not existed and is planned to be developed aiming NRW reduction and sifting from water supply to irrigation water for agricultural use
- Expansion of Water supply area is also planned, but increase of water supply in the target area is not included.

(4) Daily Maximum Dry Weather Flow

Seasonal variation is analysed ranging from 1.05 to 1.18 as shown in **APPENDIX 4-2**. However, the data is not enough to discuss and estimate future ratio of Daily Maximum Dry Weather Flow, as available data is only for 3 years.

Rather high ratio of 1.25 is employed as the ratio of Daily Maximum Flow/Daily Average flow relatively as Sri Lanka, since seasonal variation of temperature is relatively big in Nuwara Eliya.

(5) Total Sewage Flow

The estimated sewage flow shown in **Table 4.5-2** is calculated assuming the installation of the sewerage system in the entire service area. The daily maximum flow of 4,640 m^3/day is for the total design capacity of the STP.

Table 4.5-2 Estimated Sewage Flow

	Item	Service Area	Remarks
a	Population	19,024	
b	Water Consumption (l/d/cap)	120	
c	Return Factor (%)	80	
d	Domestic Flow (m^3/d)	1,826	d = a x b x c
e	Non-Domestic Flow (m^3/d)	1,370	e = d x 75%
f	Point source flow (m^3/d)		
g	Infiltration (m^3/d)	639	g = (d + e) x 20%
H	Daily Average Flow (m^3/d)	3,835	h = d + e + f + g
i	Daily Maximum Flow (m^3/d)	4,634	i = (d + e + f) x 1.25 + g For STP design

Source: JET

4.5.3 Sewerage Network

(1) Sewers

The size of each sewer is determined by hydraulic calculations based on the manning equation. The parameters decided through discussions with NWSDB are similar to national standards of other countries, including Japan.

a) Hydraulic Calculation

The Manning formula is adopted for the hydraulic calculation of gravity sewers, and the Hazen William formula is used to calculate friction loss for determining the size of force main pipes.

Manning Formula

$Q = A \times V, \quad V = 1/n \times R^{2/3} \times S^{1/2}$

Where,
Q: Flow (m^3/sec),
V: Velocity of Flow (m/sec),
n: Roughness Coefficient
R: Hydraulic Radius (m)
S: Hydraulic Gradient
A: Cross Section Area (m^2)

Hazen William Formula

$Q = A \times V, \quad V = 0.84935 \times C \times R^{0.63} \times S^{0.54}$

where,
Q: Flow (m^3/sec)
V: Velocity of Flow (m/sec),
C: Flow Velocity Coefficient
R: Hydraulic Radius (m),
S: Hydraulic Gradient
A: Cross Section Area (m^2)

Table 4.5-3 Coefficients for Sewer Design

Type of Pipe	n (Roughness Coefficient)	C (Flow Velocity Coefficient)
Concrete Pipe	0.013	
PVC Pipe	0.013	
HDPE Pipe	0.013	120
GRP Pipe	0.013	
DI Pipe (Ductile Cast Iron Pipe)	0.013	120

Note: The design slopes of gravity sewers are checked based on tractive force required to flush the sand particles expected in sewage flow.
Source: JET

b) Flow Velocity

Minimum Velocity: 0.65 m/s
Maximum Velocity: 3.0 m/s

c) Sewer Capacity

The water depth in the sewer pipes should be as shown in **Table 4.5-4**, based on the technical discussions held on March 2018.

Table 4.5-4 Maximum Water Depth for Each Diameter

Pipe Diameter (mm)	Fullness (h/H)
150	0.5
200	
250	0.55
300	
375	0.6
450	0.65
525	0.7

Pipe Diameter (mm)	Fullness (h/H)
600	0.7
675	
750	0.75
900	
1050	0.8
1200	0.8
1350	

Note: h: Water Depth, H: Internal Diameter of pipe.
Source: NWSDB

d) Minimum Earth Covering

1.2 m

e) Minimum Sewer Diameter

Trunk sewer: 225 mm, Branch sewer: 160 mm

f) Pipe Material

PVC, HDPE and GRP will be used for open cut sections of gravity flow pipes. Reinforced concrete will be used for micro tunnelling sections.

Table 4.5-5 Pipe Material

Type	Diameter	Pipe Material	Remark
Gravity flow pipe	200 mm or less	PVC Pipe	Open cut
	225 to 355 mm	HDPE Pipe	Open cut
	400 mm or above	GRP	Open cut
	450 mm or above	Reinforced Concrete Pipe	Micro Tunnelling
Force main pipe	80 to 400 mm	HDEP	Open cut

Source: JET

(2) Pumping Station

Table 4.5-6 shows the types of pumping stations classified roughly as manhole type pumping station (MTPS) and major pumping station (MPS). Ceylon Electricity Board (CEB) does not require the

installation of a transformer for pumping facilities with an electrical demand of 42 kVA or less. When the electrical demand exceeds 42 kVA and a transformer becomes necessary, an MPS is more suitable and land acquisition is needed to build the pumping station.

An MTPS can be installed under roadways and does not usually require land acquisition, depending on the surrounding environment and location.

Table 4.5-6 Types of Pumping Station

Types of Pumping Station	Site	Electricity
MTPS: Manhole Type Pumping Station	Under Road	Less than 42 kVA
MPS: Major Pumping Station	Property Required	42 kVA and above

Source: JET

(3) Manhole Type Pumping Station(MTPS)

The MTPS is usually used for branch sewers:

- which are over 4.5 m deep, as requested by NWSDB.
- In places where installation of deep sewers by open cut method in narrow lanes can cause the collapse of walls of adjacent houses even though the sewer depth would be less than 4.5m. Kandy sewerage project is facing this private property damage problem.
- In places where micro tunnelling, using driving shaft of 5 x 3 m, is also not feasible such as in narrow lanes, where additional space for construction set up is not available.

Each MTPS requires the installation of space saving power supply units which is set off the ground, similar to those for telecommunication services as shown in **Figure 4.5-1.** These are commonly used in Sri Lanka, and there is no issue with theft or vandalism.

Source: JET

Figure 4.5-1 Power Supply Unit for Manhole-type Pump Stations and Telecommunication Services

4.5.4 Sewage Treatment

(1) Influent and Effluent Standards

The following steps are taken to estimate the influent concentration:

- consultations with NWSDB
- review of domestic wastewater quality of existing wastewater treatment plants including some housing schemes.

The influent wastewater concentration of these plants are summarized in **Table 4.5-7**.

Table 4.5-7 Influent Wastewater Concentration of Existing Plants

Parameter	Unit	Raddolugama ※	Maththegoda ※	Hikkaduwa ※	Moratuwa/ Rathmalana※※	Ja-Ela/ Ekara※※ ※	Kandy ※※※※	Average
pH	-	6.7	6.4	7.0	6.6-8.5	-		6.7
TSS	mg/l	163	90	139	232	-	265	156.0
COD_{cr}	mg/l	609	473	446	274	628	490	485.8
S-COD_{cr}	mg/l	241	241	206	-	-		229.2
BOD_5	mg/l	383	247	240	87	187	290	229
S-BOD_5	mg/l	159	116	149	-	-		141
NO_2+NO_3-N	mg/l	2.3	2.5	5.7	1.0	-		2.9
NH_4-N	mg/l	26	28	24	14	-		23
T-N	mg/l	39	34	33	42	-	70	37
T-P	mg/l	5.9	3.3	2.8	2.8	-	7	3.7

※Average values of the three measurements which were conducted from December 2016 to January 2017(Annex1)
※※Data taken between October 2013 and February 2016
※※※Average of 1-year measurements
※※※※Designed influent quality with returned wastewater
Source :JET

The designed influent qualities of Kandy Project are shown for reference only because the treatment plant was not operated yet.

The allowable discharge limits (shown in **APPENDIX 4-3**) are being amended and a draft is available to the public, although it has not yet been gazetted. The effluent quality from the proposed treatment plant will comply with the amended discharge limits. The allowable limits for organic substances in the amended version are not expected to change much. Limits for heavy metals will be stricter. The amendment introduces an allowable discharge limit for nitrates, set at 10 mg/l as NO_3-N. This new requirement will have a significant impact on the selection of treatment methods.

Design influent and treated effluent qualities are presented in **Table 4.5-8.**

Table 4.5-8 Influent and Effluent Quality

Parameter	Influent wastewater Characteristics	Treated Effluent quality
BOD5	240	<15
COD	600	<100
TSS	160	<15
T-N	45	-
TKN		<150
Ammonia N		<50
NO_3-N		<10
T-P	6	<5[*1]

Note: *1: It means “Dissolved-P”.
Source: CEA

CHAPTER 5 PRELIMINARY PLAN AND DESIGN OF THE SEWERAGE SYSTEMS

5.1 OUTLINE

- Total sewer length in the service area is about 98 km, including the 0.8 km section to be installed by micro-Tunnelling (5.2.1).
- Both open cut and micro-Tunnelling methods have advantages and disadvantages with regards to traffic congestion, construction period, resettlement and public acceptance (5.2.1(2)).
- Actual soil survey will be requested for determine the type of micro-Tunnelling method in future F/S study (5.2.1(2)).
- Nutrient removal type oxidation ditch process is effective in nitrogen removal, is easy to maintain and has low O&M costs (5.3.2).
- Nutrient removal type oxidation ditch, Chlorination disinfection, Screw press sludge dewatering, and Automatic Bar Screen developed in Japan are recommended for this additional study (5.4.1).

5.2 SEWERAGE SYSTEMS

5.2.1 Collection Network

(1) Sewer Layout and Length

Sewer GEMS software is used for modelling the sewer network as requested by NWSDB. It is a multi-platform, sanitary and combined sewer modelling solution.

The design lengths of the sewers are summarized in **Table 5.2-1** and the sewerage development plan for Nuwara Eliya is shown in **Figure 5.2-1**.

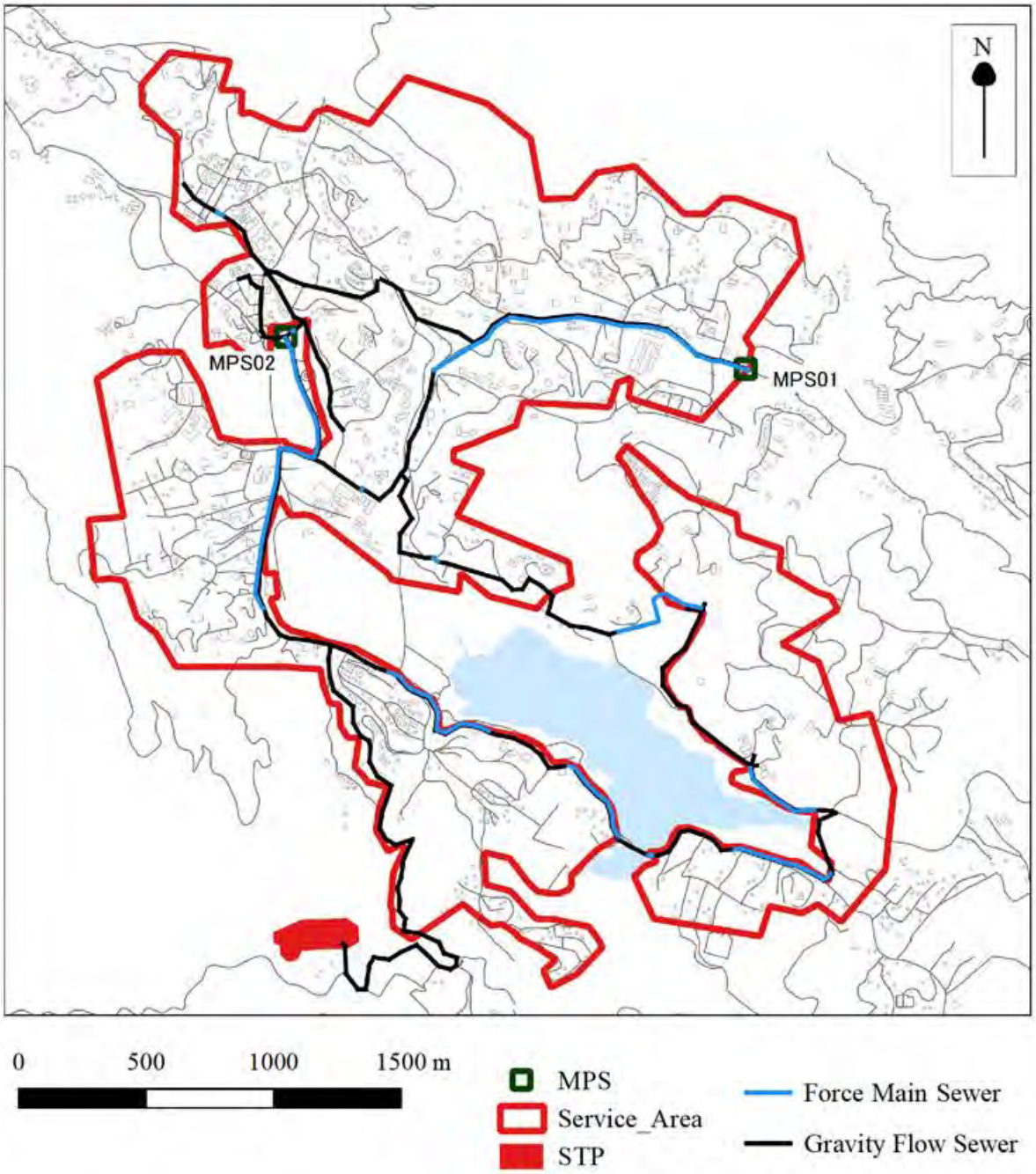
Table 5.2-1 Sewer Length in Service Area

Type	Dia (mm)	Sewer Length (m)
Gravity Sewer	200	79,972
	250	540
	300	680
	400	2,872
	450	123
	sub-total	84,187

Type	Dia (mm)	Sewer Length (m)
Force Main	80	10,248
	100	966
	150	1,386
	250	1,299
	sub-total	13,899

Total Length (m)	98,086

Source: JET



Source: JET

Figure 5.2-1 Main Trunk Sewers Routing

(2) Sewer Construction Method

The total length of sewers is about 98 km, with diameters ranging from 200 to 450 mm. The following installation methods can be used:

- Open cut
- Micro- Tunnelling

Micro-Tunnelling needs construction space at the drive and arrival shafts, but none in between. It has the following advantages compared to the open cut method:

- less obstruction to traffic
- no interruption to land or river traffic at crossings
- requiring less construction space
- shorter construction period for deep or large diameter sewers

Table 5.2-2 summarizes the construction periods, impacts on traffic and resettlement for the two methods. Considering the respective advantages and disadvantages, open cut should be used for shallow and small sewers such as branch sewers, and micro-Tunnelling for deep and large sewers.

Table 5.2-2 Comparison of Open Cut vs Micro-Tunnelling in Service Area

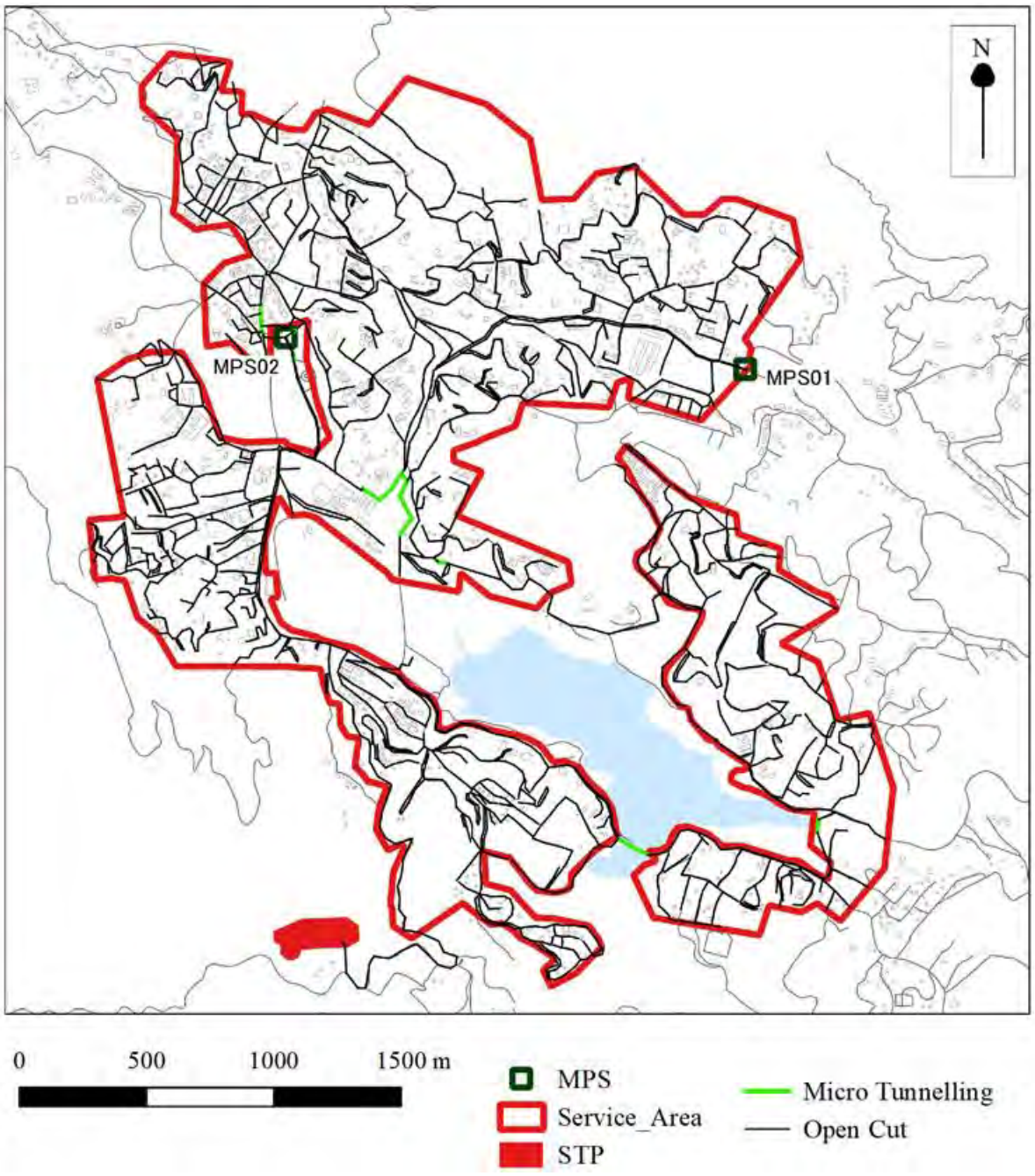
Impacts on	Construction Method	
	Open Cut	Micro-Tunnelling
Traffic	Will cause serious traffic congestion. (especially for deep or large sewers)	No impact. (except around driving/ arrival shafts)
Construction Period	10 to 20 m/day (depending on pipe size and depth)	5 to 10 m/day (depending on pipe size and soil condition)
	Suitable for shallow sewers	Suitable for deep sewers
Resettlement	No resettlement required. Sewer is installed under roads or along the side of roads.	
Nearby Residents	Low	Low
	Need to avoid property damage during construction.	Need to avoid property damage only around shafts during construction.
Construction Cost	Low	High
	80 to 150 thousand USD/m (depending on pipe size and depth)	200 to 250 thousand USD/m (depending on pipe size and soil condition)

Source: JET

The construction method was determined as shown in **Figure 5.2-2**. The sections applying micro-Tunnelling method are summarized as follows:

- The section located in congested road and it is considered to be affected if open-cut method is applied.
- The section exceeding the earth covering depth of 4.5m.

Table 5.2-3 shows the length for each pipe diameter and the method of installation for gravity sewers and force mains.



Source: JET

Figure 5.2-2 Sewer Installation Method

Table 5.2-3 Lengths of Sewer by Diameter and Construction Method

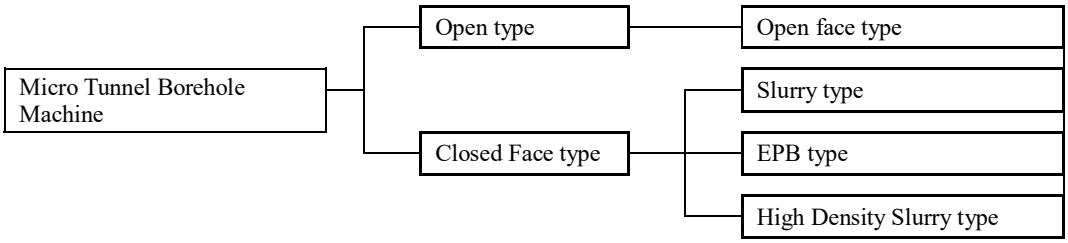
Type	Dia (mm)	Sewer Length (m)		
		Open Cut	Micro Tunnelling	Total
Gravity Sewer	200	79,453	519	79,972
	250	537	3	540
	300	467	213	680
	400	2,848	24	2,872
	450	123		123
	sub-total	83,428	759	84,187
Force Main	80	10,248		10,248
	100	966		966
	150	1,386		1,386
	250	1,299		1,299
	sub-total	13,899		13,899
Total		97,327	759	98,086

Source: JET

(3) Micro Tunnelling Methods

The types of Micro Tunnelling Borehole Machines (MTBM) are summarized in **Figure 5.2-3**. Since it is essential to prevent ingress of water, the Closed Face type is recommended for the construction. Closed Face type is classified into 3 types, which are Slurry type, Earth Pressure Balance (EPB) type and High Density type.

Further detailed soil investigations during the future F/S stage will be necessary to select the best micro tunnelling method.



Source: JET

Figure 5.2-3 Major Pumping Station

(4) Location of MPSs and Its Necessity

Major pumping stations (MPSs) shown in **Figure 5.2-1**. The requirement for each MPS is described in **Table 5.2-4.**

Table 5.2-4 Requirement at Each MPS Site

MPS	Site Condition
MPS-01	To cross the channel by force main and pump the wastewater to a higher elevation (28m lift).
MPS-02	To cross the channel by force main and pump the wastewater from the deep sewer to a higher elevation (8m lift).

Source: JET

(5) Specifications

Specification of the MPSs is shown in **Table 5.2-5**.

Table 5.2-5 Specification of Major Pumping Stations

MPS	Design Flow	Total Pump Head	Unit	Land Requirement
MPS-01	Approximately 0.8 m^3/min	60 m	2+(1)	0.30 ha
MPS-02	Approximately 3.2 m^3/min	30 m	2+(1)	0.30 ha

Notes; (1): one stand-by unit
Source: JET

Candidate sites for the major pumping stations are shown in **APPENDIX 5-1**. Land requirements for the 2 MPSs have been identified in this site survey, but availability has not officially been confirmed. The future F/S study must check the site conditions around 2 MPSs again and confirm the availability.

5.2.2 Manhole Type Pumping Stations

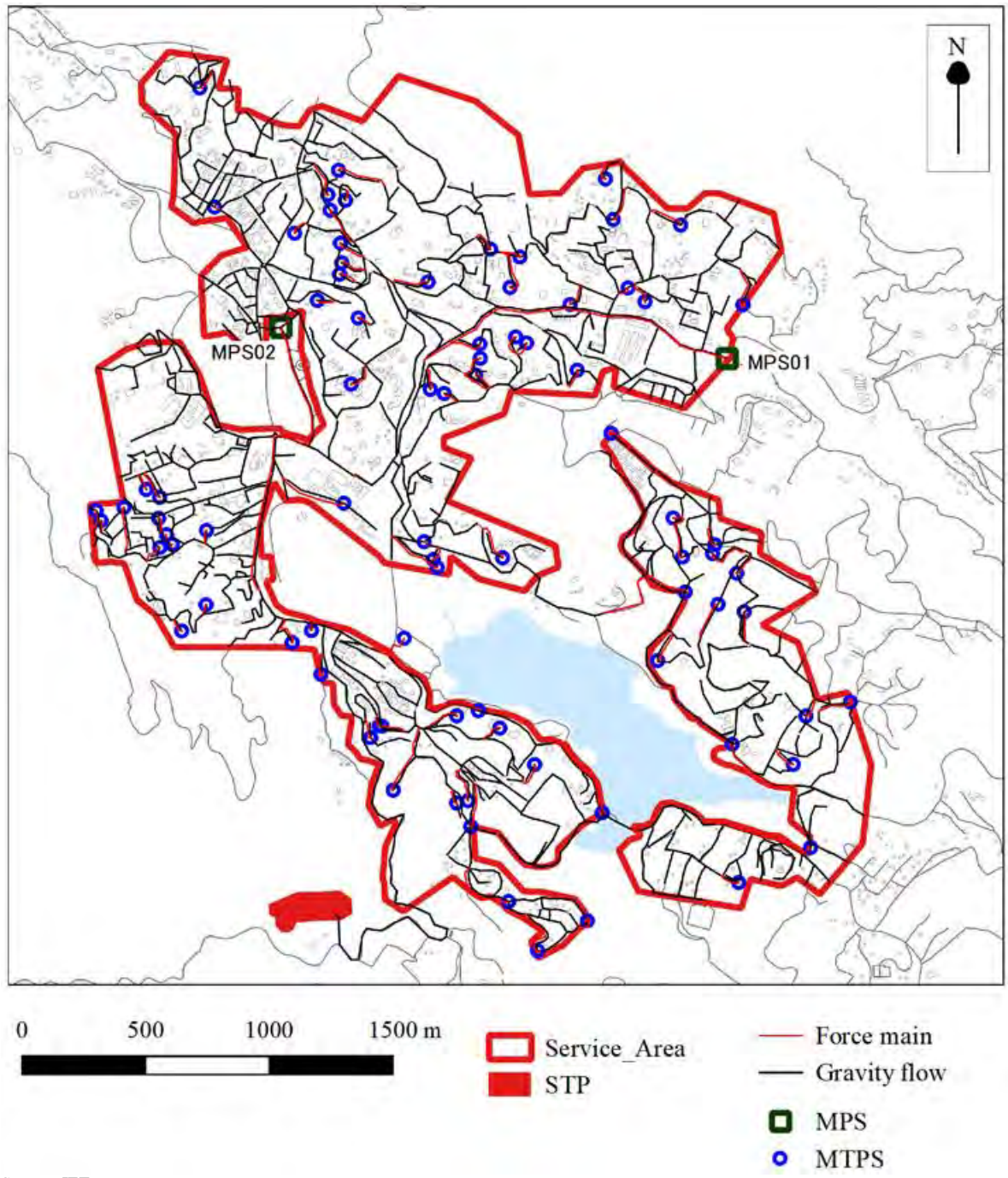
(1) Number and Location of Manhole Type Pumping Stations

Manhole type pumping stations (MTPSs) are installed where branch sewers are more than 4.5 m deep. The number of MTPSs is shown in **Table 5.2-6** and their locations are shown in **Figure 5.2-4**. Most of the MTPSs are installed on the branch sewer network. Therefore the number of MTPSs may appear to be significantly higher than that proposed in the City Sewerage M/P for main trunk sewers.

Table 5.2-6 Number of Manhole Type Pumping Stations

	Type 1 Less than 2.0 m^3/min	Type 2 Less than 1.0 m^3/min	Type 3 Less than 0.5 m^3/min	Type 4 Less than 0.2 m3/min	Total
Total	1	4	40	40	85

Source: JET



Source: JET

Figure 5.2-4 Location of Manhole Pumps in Each Catchment

(2) MTPS Design and Management

The MTPS design is relatively simple. It consists of a pump underground in the manhole and an above ground electric panel nearby. At the detailed design stage, the internal dimension of the underground unit is determined and a submersible pump suitable for the design flow and required total head is selected.

Many Japanese cities experience fewer problems when non-clogging MTPS is used. After a failure is detected, corrective maintenance should be initiated immediately similar to the practice in Japan. This

involves the mobilization of Management Office (MO) staff for prompt investigation. **Table 5.2-7** shows the one of the maintenance condition in Japanese municipality for reference.

Table 5.2-7 Maintenance Condition for MTPSs in Japanese municipality

Item	Contents
Maintenance type	Outsourcing to the private companies
Walk-around check	1 time / 1 month. Checking by visual judgment.
Regular term maintenance	1 time / 1 year. Cleaning by high-pressure jet, removing the scum by vacuum.
Kind of trouble	There is few machinery trouble for 126 MTPSs. Some specific MTP receiving public toilet get blocked by a nappy. Further instruction for proper use of toilet is necessary.

Source: JET

The simplest and most practical monitoring system can be achieved by installing a signal light on the power supply unit for each MTPS. Nearby residents would call the MO when the pump stops and the signal light comes on. SCADA system can be considered as more MTPSs are installed in detailed design phase.

5.3 SEWAGE TREATMENT PLANT

5.3.1 Treatment Process Design

The treatment plant will accept septage from areas that will not be connected to the sewage collection network for the foreseeable future. Since there is no primary settling tank, the maximum amount of septage that can be accepted should be 0.5% of inflow wastewater volume.

(1) Sewage Treatment Process

Treatment process is assessed qualitatively on removal efficiency, space requirement and ease of O&M.

a) Required Removal Efficiency

The assumed quality of sewage influent and effluent treated by OD are shown in **Table 5.3-1**. The quality of sewage was determined in consultation with NWSDB taking into consideration the sewage quality of Moratuwa/Ratmalana STP, Ja-Ela/Ekala STP and other STPs that are in the neighbourhood of Colombo City. The target effluent quality is set to meet the allowable discharge limits. The dilution ratio of the effluent will vary depending on the flow rate in the stream at the discharge point.

Table 5.3-1 Required Removal Efficiency

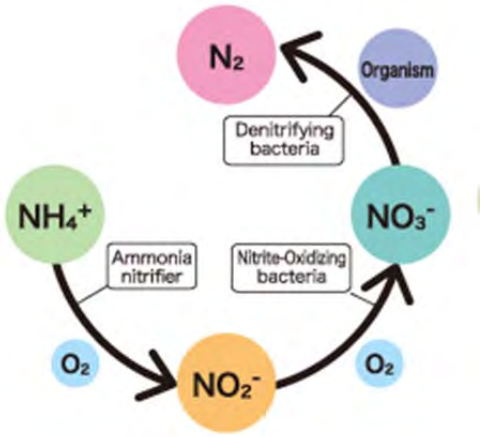
	Influent to the STP (mg/L)	Influent to the reactor*[1] (mg/L)	Discharge limit values for effluent (mg/L)	Required Removal efficiency (%)
BOD5	240	262	30	88.6
COD	600	655	250	61.9
SS	160	188	50	73.4
T-N	45	47	-	-
NH_4+-N	34	35.9	50	(-)
Kj-N	42.7	44.6	150	(-)
NO_3-N	-	(47) *[3]	**10**	**78.8**
T-P	6	7	5*[2]	28.6

Note: *[1]: Includes the side stream load, *[2]: means "Dissolved-P", *[3]: The main part of T-N Nitrogen will be changed to the "NO^3-N" nitrate nitrogen of in aeration process. The maximum nitrogen value of "NO^3-N" may be estimated from the nitrogen value of "T-N".
Source: JET

b) Effluent Quality

The allowable discharge limits (shown in **APPENDIX 4-3**) are being amended and a draft is available to the public, although it has not yet been gazetted. The effluent quality from the proposed treatment plant will comply with the amended discharge limits. The allowable limits for organic substances in the amended version are not expected to change much. Limits for heavy metals will be stricter. The amendment introduces an allowable discharge limit for nitrates, set at 10 mg/l as NO_3-N. This new requirement will have a significant impact on the selection of treatment methods.

Figure 5.3-1 shows the reaction cycle of nitrogen during biological wastewater treatment. Ammonia nitrogen (NH_3-N) and a portion of organic nitrogen is converted to nitrite and nitrate through nitrification carried out by ammonia oxidizing bacteria (AOB) and nitrite oxidizing bacteria (NOB). Nitrate produced by the nitrification process should be reduced through denitrification to less than 10 mg/L to meet the amended allowable discharge limit. Nitrification occurs naturally in small-scale STP which are usually operated with long solids retention time (SRT). High wastewater temperature promotes nitrification. Suppression of nitrification in any biological process is therefore not easy and is not a realistic option. Therefore, the treatment process must have the ability to denitrify. Denitrification is relatively easy to achieve with activated sludge processes but is more difficult for biofilm processes and stabilization ponds.



Source:http://www.zeolite-anammox.com/#!faq/c12z9

Figure 5.3-1 Nitrogen Cycle

c) Required Land

The candidate site for the STP is about 24,000 m^2. All treatment facilities must fit in this space.

d) Treatment Method

The following four treatment processes can remove nitrogen and phosphorus as well as organic matter and are candidates for further evaluation.

- Step-feed biological nutrient removal (BNR)
- A_2O
- Modified Ludzack-Ettinger process
- Nutrient removal type oxidation ditch process

e) Evaluation Results

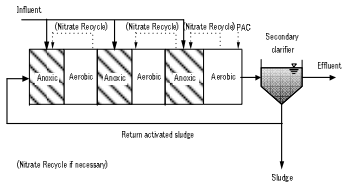
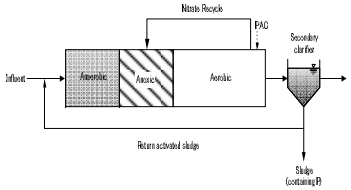
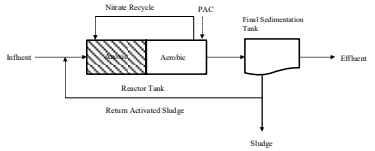
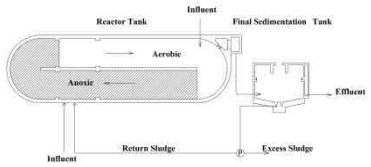
The four treatment processes were evaluated on effluent quality and space requirement for the design

capacity of 4,700 m^3/day. The results are summarized in **Table 5.3-2** .

The Nutrient Removal Type Oxidation Ditch process is selected for the following reasons:

- it can satisfy all required removal efficiency of treated wastewater quality including nitrogen removal.
- it has the most simple equipment with easy maintenance compared to others.
- it has been used successfully in some other cities in Sri Lanka and this experience can be shared for future operation.

Table 5.3-2 Qualitative Evaluation of Four Treatment Methods

Treatment Method	Step-Feed BNR Process	A_2O Process	Modified Ludzack - Ettinger Process	Nutrient Removal Type Oxidation ditch process
Treatment process				
Type of Reaction in Reactor Tank	Biological nitrification-denitrification	Biological nitrification-denitrification	Biological nitrification-denitrification	Biological nitrification-denitrification
	Phosphorous in the excess sludge is removed.	Phosphorous in the excess sludge is removed with high concentration .	Phosphorous in the excess sludge is removed.	Phosphorous in the excess sludge is removed.
Removal Efficiency (Water Quality)	**BOD :92-94%**	**BOD :92%**	**BOD :93-95%**	**BOD :93-96%**
	SS : 90-95%	**SS :93%**	**SS :90-95%**	**SS :92-96%**
	T-N : 83%(3 phase) 78% (2 phase) 67% (1 phase)	T-N :60-70% Depending on circulation ratio	T-N :65-70% Depending on circulation ratio	**T-N :85%**
	T-P :40-60%	**T-P :70-80%**	**T-P :40-60%**	**T-P :40-60%**
	Satisfactory	Not Satisfactory	Not Satisfactory	**Satisfactory**
Required Space ($Q=4,700m^3/day$)	**Enough space**	**Enough space**	**Enough space**	**Enough space**
Operation and Maintenance	More complex equipment compared with Oxidation ditch	More complex equipment compared with Oxidation ditch	More complex equipment compared with Oxidation ditch	**Most simple equipment with easy maintenance**
Evaluation	Fair	Not comply the requirement	Not comply the requirement	Excellent

Source: JET

(2) Disinfection

Treated wastewater is disinfected before discharge to minimize health risks associated with pathogens.

a) Alternatives

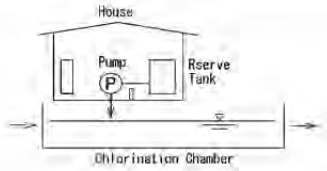
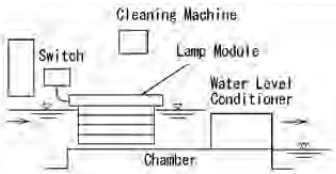
- A: Chlorination
- B: UV Radiation

b) Evaluation of Alternatives

Table 5.3-3 shows the comparison between the two alternatives. Chlorination is the method of choice for the following reasons:

- Although O&M cost is higher, construction cost and equivalent annual cost is lower.

Table 5.3-3 Comparison of Disinfection Methods

Disinfection Methods	Chlorination	UV Radiation
Figure		
Facility	Simple ◎	Little Complex ○
Operation & Maintenance	Making chemical weekly. Confirmation of the concentration by densimeter ○	Exchanging the lamp annual. Confirmation of the lamp by watching equipment. ○
Byproduct	Trihalomethanes (THMs) △	No ◎
Contact Time (Required Area)	15 minutes (Large) ○	5～20 seconds (Small) ◎
Risk of impact for Human (Administrator)	Low danger (Leakage of chlorine gas) ○	Low danger (Expose the lamp directly) ○
Risk of impact for Downstream	Some risks of damage for ecosystem ○	No risks for ecosystem ◎
Construction Cost	Low ◎	High △
O&M Cost	Fair ○	Low ◎
Equivalent Annual Cost	Low ◎	Fair ○
Evaluation	Construction cost and equivalent annual cost is lower than UV radiation Recommendation (○)	

Source: JET

5.3.2 Overall Layout of the Treatment Facilities

(1) STP Site

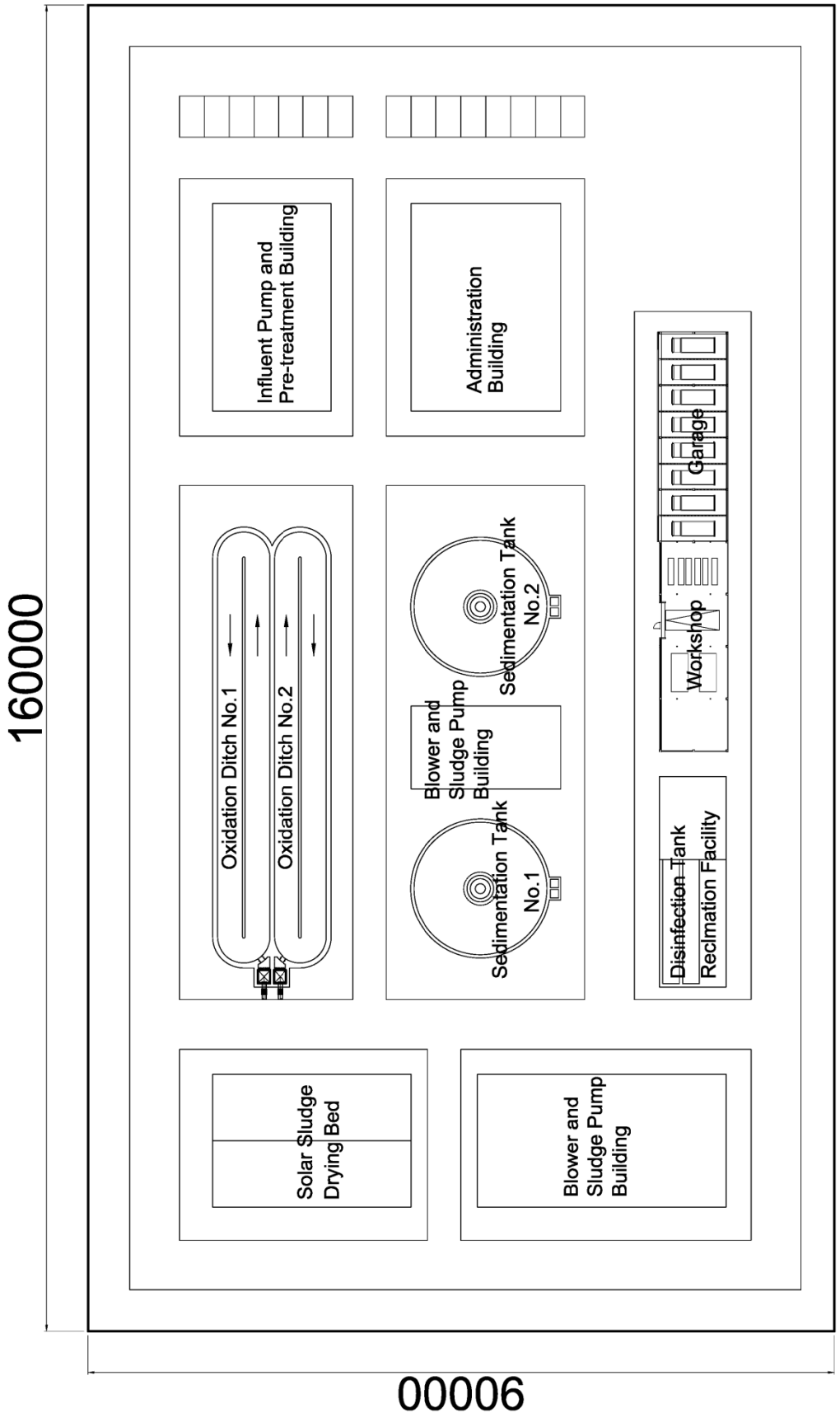
The candidate site is located on the slope of a hill along the Nanu Oya River in the southwest at the outskirt of the city with few nearby residences (refer to photos in **Figure 5.3-2**). The site is publicly owned and Nuwara-Elia MC is starting the process to acquire this land (**APPENDIX 5-2**). The construction of a relatively long access road and bridge over the Nanu Oya River is required.

Source: JET

Figure 5.3-2 Candidate Site (Left: Viewed from South, Right: Viewed from North)

(2) General Layout

The overall layout is shown in **Figure 5.3-3**.



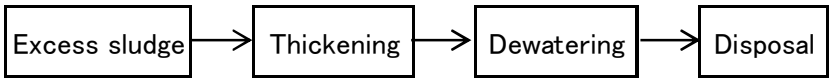
Source: JET

Figure 5.3-3 General Layout of Treatment Facilities

5.3.3 Mechanical Design

(1) Sewage and Sludge Treatment Process Details

A typical sludge treatment process is shown in **Figure 5.3-4**. Excess sludge is thickened then dewatered. Thickening is carried out by gravity. Depending on the type of dewatering machine, thickening is sometimes omitted and excess sludge is dewatered directly. Anaerobic digestion is usually not used since WAS is not easily decomposed anaerobically.



Source: JET

Figure 5.3-4 Flow Schematic for Sludge Treatment

The mass balance and capacity calculations of facilities are shown in **APPENDIX 5-3**.

(2) Mechanical Design

1) Sludge Thickening

Sludge thickening reduces the free water content and the volume of sludge before dewatering.

Since there is no primary settling tank, only waste activated sludge (WAS) is produced from the STP. Traditional gravity thickening that works well for primary sludge is not effective for WAS. Mechanical thickening is more efficient.

However the construction and operation cost of mechanical thickening is much higher than gravity thickening in small scale treatment plant as same as Kandy city.

The gravity thickening is selected for the following reasons:

- most cost-effective
- simple O&M
- there are same experiences for small scale treatment plant in Sri Lanka

2) Sludge Dewatering

a) Alternatives

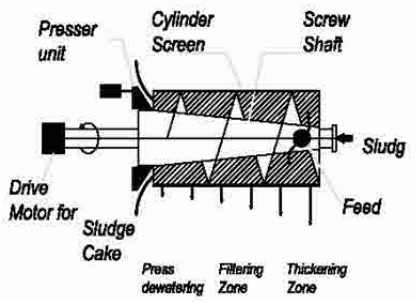
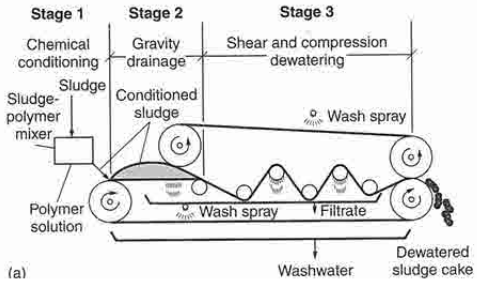
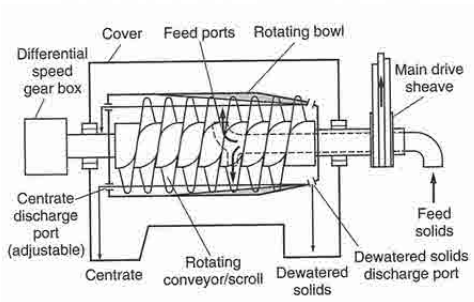
Three types of dewatering machines are evaluated:

- A: Screw press
- B: Belt press
- C: Centrifugal

b) Comparison of Alternatives

Table 5.3-4 shows the comparison of the alternatives for dewatering. Screw press dewatering is selected because of its low O&M cost.

Table 5.3-4 Comparison of Sludge Dewatering Methods

Item \ Alt	Alternative-A: Screw Press Dewatering	Alternative-B: Belt Press Dewatering	Alternative-C: Centrifugal Dewatering
Description			
	Sludge is served between outer tube and screw shaft. Space between the tube and shaft is narrow as it closes to outlet, which presses and dewaters the sludge.	Served sludge is firstly filtrated at gravity dewatering zone. After that, filtrated sludge is dewatered at pressure dewatering zone, in which two filter cloths press the sludge and transfer it outside	Sludge is served to a bawl which rotates at high velocity. Sludge is dewatered by the strong centrifugal force generated by rotation, which is from 1,500G to 3,000G.
Performance	Water content of Thickened Sludge: More than 84% Solids Capture Rate: More than 90% Good (2)	Water content of Thickened Sludge: More than 84% Solids Capture Rate: More than 90% Good (2)	Water Content of Thickened Sludge: More than 84% Solids Capture Rate: More than 95% Excellent (3)
Chemical Consumption	Chemical Injection Ratio: Polymer Flocculent not larger than 1.7% Good (2)	Chemical Injection Ratio: Polymer Flocculent not larger than 1.5% Excellent (3)	Chemical Injection Ratio: Polymer Flocculent not larger than 1.5% Excellent (3)
Number of Machine (Required Area)	2 sets of φ400mm (app. 6.5 m3/h) Good (2)	2 sets of width 2m (app. 6.00 m3/h) Good (2)	2 sets of app. 5 m3/h Good (2)
Operation and Maintenance	Automatic operation. Rehabilitation of Screw is necessary at every 8 years Excellent (3)	Automatic operation. Rehabilitation of filter is necessary at every 8 years Excellent (3)	Automatic operation. Rehabilitation of bowl is necessary at every 3 years Good (2)
Odor	Protected by Cover Good (2)	Protected by Cover. However leakage of odor is more than others. Fair (1)	Protected by Cover Good (2)
Noise and Vibration	Lower than Alternative-C. Good (2)	Least of all Excellent (3)	Loud Fair (1)
Construction Cost	Middle Good (3)	Middle Good (1)	Low Excellent (3)
O&M Cost	Low Excellent (2)	Middle Good (2)	High Fair (1)
Equivalent Annual Cost	Low Excellent (3)	Middle Good (2)	Low Excellent (3)
Evaluation	Total Score =21 points Construction cost is more than Alternative-C. However O&M cost and other performance are better than other alternatives. In addition, annual cost is best as same as Alternative-C. **Recommended (○)**	Total score = 19 points	Total score = 20 points

Source: JET

3) Odour Control

Since the STP is located near a residential area, minimizing the source of odour is important.

Odour can come from preliminary treatment and sludge treatment facilities. Since the STP has no primary settling tank, odour control measures are required primarily for sludge treatment facilities.

a) Alternatives

There are many types of odour control systems. the following are commonly used:

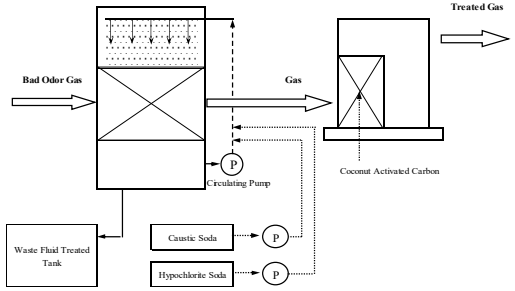
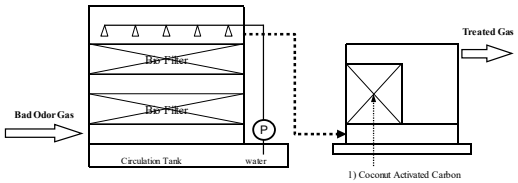
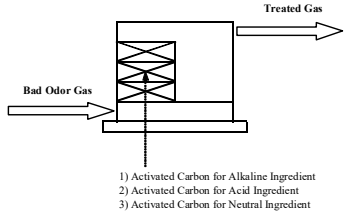
- A: Chemical scrubber
- B: Biological filter treatment
- C: Activated carbon absorption

b) Comparison of Alternatives

As shown in **Table 5.3-5**, biological filter has the following advantages:

- low O&M cost and smallest work volume
- stable odourless operation

Table 5.3-5 Comparison of Odour Control Systems

Item \ Alt	Alternative-A: Chemical Scrubber	Alternative-B: Biological Filter Treatment	Alternative-C: Activated Carbon Absorption
			
	It is a deodorization system, in which chemical washing unit and activated carbon unit are combined. Chemical scrubber removes odorous substance by chemical reaction. Activated carbon adsorbs odorous substances which cannot be chemically removed for safety.	It is a deodorization system, in which biological filter unit and activated carbon unit are combined. Biological filter unit removes odorous substance by bacteria ' s decomposition. Activated carbon adsorbs odorous substances which cannot be biologically removed for safety.	It is a deodorization system where odorous compounds are removed by activated carbon and chemicals attached to surface of the activated carbon. Odorous substances are removed by both physical absorption and chemical reaction.
Performance	It can remove main odorous substances. Coconut activated carbon can be adapted.	It can remove main odorous substances. However some removal efficencies of bad odor are less than Alternative-A.	It can remove main odorous substances if apply activated carbon with chemicals. In case to apply coconut activated carbon only, the removable substances are limited (Evaluation result is changed to "Fair").
	Excellent (3)	Good (2)	Excellent (3)
Required Space	It requires larger space than Alternative-B, because larger number of accessory machines is necessary.	It requires larger space than Alternative-C.	It is the most compact system.
	Fair (1)	Good (2)	Excellent (3)
Maintenance	It is most complex and difficult because of many accessory machines such as various kinds of pumps and controlling equipment, and that storage, handling and dispose of chemicals are necessary.	It is simpler than Alternative-A. The biological condition will be changed by density of odor and the low density condition will cause low performance of odor treatment system.	It is most simple. However, activated carbon should be changed frequently, which costs much.
	Frequency of change of activated carbon	Frequency of change of activated carbon	Frequency of change of activated carbon
	High odor condition: Every year	High odor condition: Every year	High odor condition: Every six months
	Low odor condition: Every two years	Low odor condition: Every two years	Low odor condition: Every year
	Fair (1)	Good (2)	Fair (1)
Operation	It is easy to operate automatically.	It is easy to operate automatically.	It is easy to operate automatically.
	Good (2)	Good (2)	Good (2)
Construction Cost	Middle	High	Low
	Good (2)	Fair (1)	Excellent (3)
O&M Cost	Middle	Low	High
	(Electricity + Chemicals + Coconut Activated Carbon)	(Electricity + Coconut Activated Carbon)	(Electricity + Activated Carbon with Chemical)
	Good (2)	Excellent (3)	Fair (1)
Equivalent Annual Cost	Low	Middle	High
	Excellent (3)	Good (2)	Fair (1)
Evaluation	Total score =14 points	Total score = 14 points The construction cost is highest in all. However the O&M cost and work volume are smallest in all. It will provide the stable operation with odor less condition.	Total score =14 points
		Recommended (○)	

Source: JET

5.3.4 Electrical Design

(1) Electrical Service Entrance and Power Distribution

The 3.3kV power supply from the Ceylon Electricity Board (CEB) is converted to 400V when it passes through a main transformer. The cost of the transformer stipulated by CEB is included in the ODA project cost.

Electricity at 400V is distributed from the main transformer to the electrical rooms. There will be one electrical room in each pumping station, sewage treatment facility and sludge treatment facility. Each room has a main control centre.

(2) Emergency Power Generator

Emergency power supply will be needed to maintain the operation of the facilities when long duration power failures occur. The generator must be required to sustain continuous operation of the essential or critical functions and should be located in the administration building for easy access and maintenance.

(3) Instrumentation and Control System

Measuring equipment for monitoring operations include water level gauges, flow meters and water quality meters.

(4) SCADA System

Monitoring and control of treatment plant operations and 2 major pumping stations are carried out by SCADA system which can provide high level supervisory management of processes in multiple sites. The computer server for the SCADA system installed in the monitoring room of the STP will interface with networked data communication units to display conditions of the equipment operation, measurement data, and issue process commands. Programmable logic controllers (PLC) are installed in pumping stations, various locations in the STP, administration, disinfection and sludge treatment buildings. GSM modem provides communication with the 2 major pumping stations.

5.4 APPLICATION OF JAPANESE TECHNOLOGIES

5.4.1 Advanced Technologies Applicable for the Project

The following advanced technologies are recommended to apply for this project:

- Micro-Tunnelling
- Nutrient removal type oxidation ditch process
- Screw press sludge dewatering
- High Efficiency Pump
- Automatic Bar Screen

Japanese technologies have some advantages compared to those of other countries:

(1) Micro-Tunnelling

If a weak soil layer is confirmed at the sewer installation level, the micro tunnelling method using Japanese technology will be advantageous and would be applied in this site.

1) Weak Soil Condition

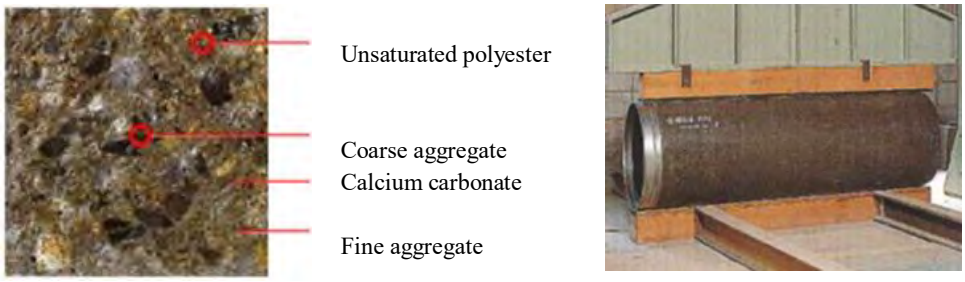
In Japan, micro-Tunnelling is main technology commonly used over long distance and on winding and

congested roads. Japanese companies have developed and accumulated extensive experience in perfecting the accuracy of pipe invert level under weak soil conditions. Automation as well as development of measuring and control equipment contributes to the improvement in curved and long distance jacking. This Japanese know-how can accomplish the task with high construction accuracy for the weak soil conditions.

2) Polymer (Resin) Concrete Jacking Pipe

Concrete corrosion for sewerage facilities is a chemical corrosion through the metabolic reaction of sulfate-reducing and sulfur-oxidizing bacteria on sulphate ions in wastewater and sludge. It is prevalent not only where H_2S gas is produced with turbulent and mixed flow but also where ventilation is not facilitated.

The facilities that are prone to sulfuric acid corrosion are the release ends of pressure force mains in sewer networks. The sewer network in this study area will have many pumping stations, including manhole-type pumping stations. Therefore, anti-corrosion measures must be considered in design phase.



Source: JET

Figure 5.4-1 Polymer Concrete Jacking Pipe

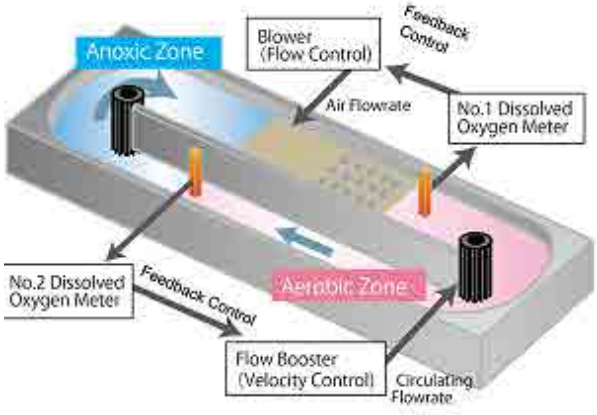
Polymer concrete pipe is moulded with aggregate, filler and reinforcing bar using centrifugal strength and unsaturated polyester. As a binding agent, it is resistant to acid compared to cement concrete. It will give the network a longer service life against sulphate corrosion. Japanese polymer concrete jacking pipes can also withstand high compression force.

(2) Nutrient Removal Type Oxidation Ditch with Dual Dissolved Oxygen (DO) Control System

The nutrient removal type Oxidation Ditch (OD) process is described in many manuals and guidebooks such as "Wastewater Engineering" by Metcalf & Eddy and is used worldwide. However, the control of high efficiency nitrogen removal by the operation of "Biological nitrification-denitrification" zones, requires long channels with long retention times.

Dual Dissolved Oxygen (DO) control for the OD system enables efficient and stable nitrogen removal by controlling aeration and water circulation independently, and producing optimal aerobic and anoxic zones. Therefore the "Nutrient Removal Type Oxidation Ditch with dual (DO) control system" can reduce the energy consumption and provide a suitable level of nitrogen removal with high efficiency.

The dual DO control for OD system was developed in Japan and has received awards for energy saving technology from the "Ministry of Land, Infrastructure,

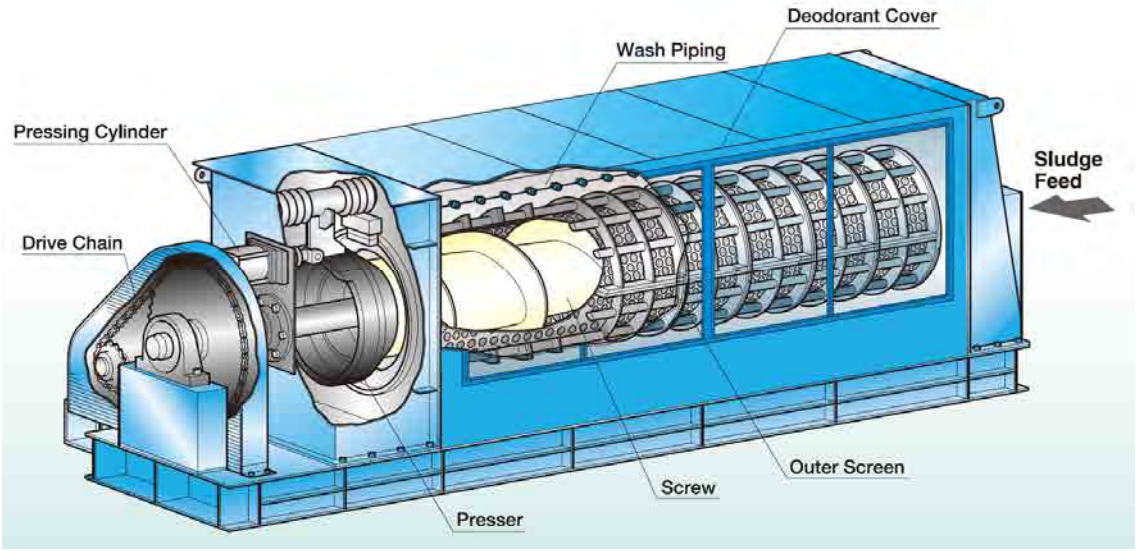


Sources: Maezawa Industries, Inc.

Figure 5.4-2 Image of Dual DO control for OD system

Transportation and Tourism" and the "Japan Society on Water Environment", in 2015. The process has been applied at many sewage treatment plants for energy saving and increasing the capacity of existing Oxidation Ditch treatment plants in Japan.

(3) Screw Press Sludge Dewatering



Sources: ISHIGAKI COMPANY, Ltd.

Figure 5.4-3 Rotary Outer Cylinder Screw Press

Most screw press machines have limited dewatering capacity. Japanese companies offer large capacity or twin-screw machines with rotary outer cylinder screw presses that are more effective in sludge dewatering.

The rotary outer cylinder screw press sludge dewatering machine has compact design and easy maintenance compared to other types of screw press machines. JET recommends this machine because of its lower cost and less space requirement.

(4) High Efficiency Sewage Pump with Flywheel

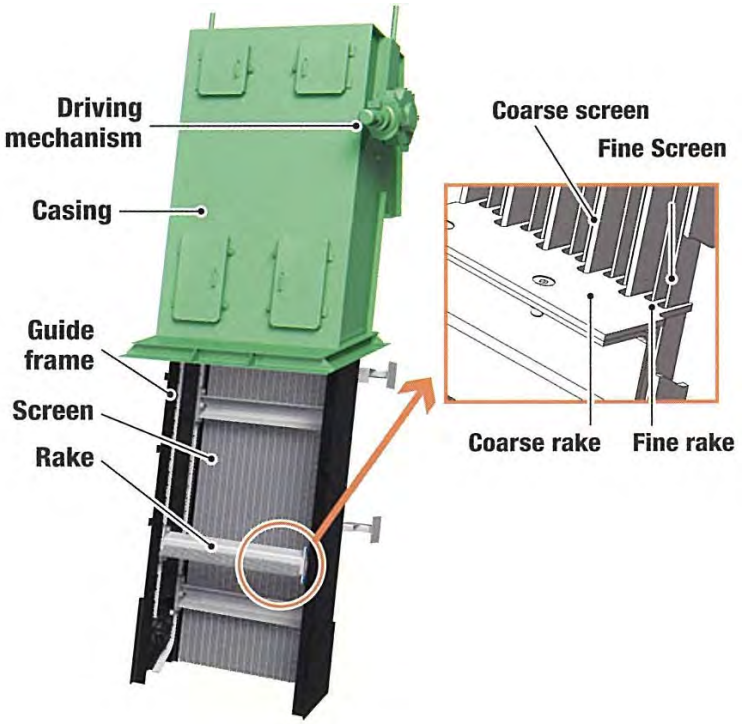
Many Japanese manufactures can supply high performance flywheel submersible sewage pumps. They are required in most Japanese projects to prevent water hammer. The efficiency, quality and reliability of these pumps will affect the O&M cost. Savings on O&M cost with the use of high efficacy pumps can be significant for the large number of pumps required in this project. JET recommends the use of fly-wheel sewage pumps in this project.

(5) Automatic Bar Screen

Most automatic bar screens are either coarse (≥ 50 mm) or fine (≤ 50 mm). Japanese companies can supply dual type screen systems that have the following advantages and disadvantages:

- Advantages: high water flow capacity, lower cost and less space requirement compared to using two sets of screens with different mesh size.
- Disadvantage: higher cost compared to using just one single screen.

JET recommends the dual screen system to lower construction cost and save equipment space.



Sources: Hitach, Ltd.

Figure 5.4-4 Dual Type Automatic Bar Screen

5.4.2 Use of Advanced Japanese Technologies

Table 5.4-1 shows the Japanese technologies recommended for this project because of their high performance, easy maintenance and low operation cost.

Table 5.4-1 Recommended Japanese Technologies

Technology	Advantages
Micro-Tunnelling * Depending on the result of soil investigations in the future F/S study	- Long service life using polymer concrete jacking pipe - Curved and long distance jacking with high construction accuracy for weak soil conditions
Nutrient removal type Oxidation Ditch with dual dissolved oxygen (DO) control system	- Lower operation and maintenance cost - High nitrogen removal efficiency - Good performance with automatic control
Screw press sludge dewatering	- Compact design (large capacity) - Easy maintenance
High efficiency sewage pump with flywheel	- High efficiency - High reliability
Dual Type Automatic Bar Screen	- High water flow capacity - Low cost and require less space (compared to two screens of different mesh size)

Source: JET

CHAPTER 6 IMPLEMENTATION PROGRAM, COST ESTIMATE, AND PROCUREMENT

In this chapter, the implementation program, cost estimate and procurement of this project is estimated under the pre-feasibility study. In addition, the terms and conditions of implementation program, cost estimate and procurement are considered under an assumption that the terms and conditions of STEP for Japanese ODA loan will be applied for this project.

6.1 OUTLINE

- The total project cost is undisclosed.
- The project duration is estimated to be 10 years (including feasibility study and capacity building for O&M of the STP). The project will be completed by September 2028 at the earliest (if the feasibility study will start at October of 2019) (6.4).

Table 6.1-1 Project Cost (March, 2018 price level)

Table 6.1-1 is undisclosed.

6.2 BASIC CONDITIONS AND ASSUMPTIONS

6.2.1 Cost Estimation Policy

Project costs were estimated using JICA's cost estimation tool. NWSDB “Rates 2018” were applied for the unit costs of the general construction works and items, and quotes collected were used for items not listed in “Rates 2018”. The some estimated costs based on the price at 2017 are adjusted by the ratio of cost indexes in construction statistics between January 2018 and January 2019.

6.2.2 Cost Saving Principle

The selection of materials and construction methods is based on economic considerations, construction challenges and capability and experience available locally. **Chapter 5** describes the comparative studies carried out for the selection of major facilities and equipment. Cost analysis aiming to achieve high benefits while minimizing investment is guided by the following principles:

- procurement of general items from Sri Lankan markets
- easily available at lower price
- simple construction methods
- moderate price but high quality
- using high efficiency equipment
- minimizing general cost
- easy and low-cost O&M

6.2.3 Procurement and Construction Policy

The selection of materials and construction methods is based on economic considerations, construction challenges and capability and experience available locally.

Most of the construction materials are available in Sri Lanka. Small size water meters, vehicles and computers are imported but can be purchased locally.

The contractor will import ductile iron and polyethylene pipes, fittings and couplings as well as mechanical and electrical equipment such as pumps, motors, valves, larger flow meters, monitoring and control equipment, and plant machinery and equipment.

(1) Procurement Condition in Sri Lanka

The procurement for water supply projects is normally carried out under unit price contract. International competitive bidding (ICB) is used for contracts involving advanced technologies and local competitive bidding (LCB) for other contracts.

Many local contractors have enough experience and capability to carry out the construction of water supply and sewerage projects involving commonly adopted technologies. NWSDB has procured such work valued at 500 million LKR or more from local contractors.

The latest major sewerage construction projects, such as the Kandy City Wastewater Management Project, Ratmalana/Moratuwa and Ja-ela/Ekala area projects, were carried out under the design-build contract. On the other hand, many construction projects for water supply, such as Kalu Ganga Water Supply Project for Phase 1 stages 2 (Water Sector Development Project II), were carried out under unit price contracts.

All construction packages in this project will be procured by unit price contract under the supervision of the consultants selected to deliver the consulting services. The size of the project renders design-build delivery not appropriate because:

- amendment of design criteria and quantification as a result of changing conditions is difficult and may cause delays;
- the contractor in design-build has to cover many responsibilities, and this will increase the contract price and the need for many clarifications in the bidding process.

However above procurement conditions shall be checked again in feasibility study.

(2) Procurement of Consultant

If this Project is financed under Japanese ODA loan, according to the “Guidelines and HANDBOOK for Procurement” for Japanese ODA loan projects, the borrower shall prepare a short list of the consultants who would be invited to submit proposals. The Guidelines suggests the short list to include normally three to five consultants, who must meet the following criteria:

- have satisfactory overseas experience in detailed design and supervision in the relevant sector,
- have experience working in a developing country,
- preferably have experience with Japanese ODA projects.

6.2.4 Exchange Rate

The exchange rate used is the JICA mission rate at July 2019.

- USD 1 = JPY 108
- USD 1 = LKR 175
- LKR 1 = JPY 0.617

6.2.5 Price Escalation

3.50% price escalation in local currency (LC) and 1.72% in foreign currency (FC) are applied in this

cost estimate.

6.3 PROJECT COMPONENTS AND PACKAGES

The three main components of the Project are:

- Construction and Procurement of Equipment for Nuwara Eliya Sewerage System
- Consulting Services
- Capacity Building in Operation and Maintenance for Advanced Treatment System

Procurement of Construction works are carried out under the "JICA Standard Bidding Document" and "Conditions of Contract for Construction for Building and Engineering Works designed by the Employer" of FIDIC's Red Book MDB 2010.

Procurement of Construction works for LCB are normally carried out under the general terms and conditions developed by the Construction Industry Development Authority (i.e. CIDA Tender Document Guide Lines) which was formerly known as ICTAD in Sri Lanka. However, the NWSDB had developed typical tender documents based on the above guide lines to cater their requirements for local competitive bidding. Hence, in LCB of NWSDB tenders, bidders will have to follow the terms and conditions of their tenders as per the relevant tender documents and giving reference to the CIDA conditions given therein.

If the procurement of all construction works are carried out under the Japanese STEP loan condition, the standard bidding documents (hereinafter SDBs) of all construction works shall be used the latest version issued by JICA for goods and services contracts, under the Japanese ODA Loans and the application rule of bidding is "STEP loan" or "Tied loan" for each package.

6.4 CONSTRUCTION OF FACILITIES

Construction of facilities is undisclosed.

The content and bidding process for each package is summarized in **Table 6.4-1**.

Table 6.4-1 Content and Bidding Method for Each Construction Package

Table 6.4-1 is undisclosed.

ICB contracts with large and complex works will include the setup of a standing dispute board (DB) for Package 1. The dispute board of Packages 1 will be organized by 3-person because of the larger scale and complex deliverables. Dispute board for Package 2 and 3 will be organized by one person.

All contracts will include the security deposit. The major item of security deposit is shown in

Table 6.4-2.

Table 6.4-2 Major Items of Security Deposit for Each Package

	Item	Content
1	Physical Protection Office	Additional Fence for Office,
		Additional Light
2	Site Monitoring and Security	Additional Security Guard,
		Metal Detector,
		Alarm System with Monitoring Camera
3	Traveling Management	Additional Rental Car (4WD)
		Driver
4	Communication	Additional Mobile Phone
		Wifi-system

6.4.1 Consulting Services

Consulting services are undisclosed.

(1) Surveys and Investigations

Surveys and investigations are undisclosed.

(2) Detailed Design

Detailed Design is undisclosed.

(3) Bidding Assistance

Bidding assistance is undisclosed.

(4) Construction Supervision

Construction supervision is undisclosed.

(5) Capacity Building in Each Stage

Capacity building in each stage is undisclosed.

(6) Required Cost for Consulting Services

Required costs for consulting services is undisclosed.

Table 6.4-3 Required Cost for Consulting Services

Table 6.4-3 is undisclosed.

6.5 IMPLEMENTATION

6.5.1 Feasibility Study

This pre-feasibility study lacks sufficient information on the following aspects: topographic and geological investigations, institutional arrangement, environmental and social considerations. Before the start of this project, the Feasibility Study shall be carried out and it will identify a project budget for the government of Sri Lanka and donors including JICA. The required contents for the Feasibility Study are shown in **Table 6.5-1.** The Feasibility Study will take approximately 12 months to complete.

Table 6.5-1 Contents of the Feasibility Study

Items	Contents	Remark
Basic Data (Population, water usage)	Need to be updated.	
Daily Maximum Dry Weather Flow	Only three years of water consumption data was available during the pre-feasibility study. Need to discuss the future rate of daily maximum dry weather flow based on the updated data.	
Point Source	Need to check the facilities that will discharge the large amounts of wastewater to the system. (Future development facilities, army facilities, etc)	
Soil Investigation	No data is available for existing soil conditions. Further soil investigation is needed to support decisions on trenching methods and special technologies such as micro-tunnelling.	
Location of MPSs	Candidate sites have been identified for 2 MPSs, but availability is not officially confirmed. In the F/S study, the site condition around 2 MPSs must be checked again and the availability of land must be confirmed.	Candidate sites are shown in **APPENDIX 5-1.**
House connections	Number of house connections in this service area is estimated to be 4,800 based on the Service population of 19,000. Need to discuss if the house connections should be included in the scope of works.	
Institutional Arrangements	The organization and capacity of the executing agency for this project shall be confirmed and the need for capacity building shall be considered.	
Environmental Impact Assessment	The environmental impact assessment shall be carried out and an environmental monitoring plan shall be prepared.	
Social Considerations	The social impacts of this project shall be considered. The land acquisition plan and resettlement action plan (RAP) shall be prepared if necessary.	

Source: JET

After above, the implementation schedule will be started and it can be divided to six stages:

- A: Consultant Selection
- B: Detailed Design
- C: Bidding
- D: Construction
- E: Operation and Maintenance

The time required for each stage is estimated taking into consideration Sri Lankan and JICA approval procedures, Bidding conditions and methods. Each Bidding process requires the approval of the Cabinet Appointed Consultancy Procurement Committee (CACPC) and concurrence of JICA.

An approval by CACPC is necessary before JICA concurrence.

6.5.2 Consultant Selection

The required processes for consultant selection is shown in **Table 6.5-2**. According to NWSDB opinion the total period of consultant selection will be estimated 16.5 months. This is a few months longer than the term of JICA standard.

Table 6.5-2 Required Consultant Selection Processes

Content	
1	**Selection of consultants**
1-1	Preparation and issuance of Expression of Interest (EOI) and prepare short-list
1-2	Preparation of Request for Proposal (RFP) & Short-list and Approval by Standing Cabinet Appointed Procurement Committee (CACPC)
1-3	JICA Concurrence for RFP & Short-list
1-4	Issuance of RFP to Short-listed Consultants
1-5	Proposal Submission by Consultants
1-6	Evaluation of Technical Proposal, Approval by CACPC
1-7	JICA Concurrence for Evaluation of Technical Proposal
1-8	Opening Financial Proposals, Evaluation, Approval by CACPC
1-9	JICA Concurrence for Evaluation of Proposals
1-10	Contract Negotiation, Approval by CACPC, Approval by Cabinet
1-11	Signing of Contract
1-12	JICA Concurrence for Signed Contract

Source: JET

6.5.3 Detailed Design

About 18 months is required for detailed design. This includes 12 months of topographic and geotechnical surveys, plus 6 months for the design of branch and tertiary sewer lines. The survey findings will have more significant impact on the design of gravity sewer lines and pumping stations compared with water supply systems.

6.5.4 Bidding

28 months is normally required for ICB in the two-envelope procedure with pre-qualification (PQ). If PQ term (8.5 months) overlaps with detailed design, Bidding can be shortened to 19.5 months from the completion of detailed design. The bidding period can be shortened to 18 months if the preparation of bidding documents can be started during detailed design.

Table 6.5-3 Required Processes for Bidding under ICB or STEP rule

Content		
3	**Bidding Stage for International Competitive Bidding (ICB)**	
3-1	Preparation of Prequalification (PQ) Documents, and Approval by CACPC	
3-2	JICA Concurrence for PQ Document (above JPY 1,000 million)	Pre-Qualification (PQ) Procedure (8.5 months)
3-3	Issuance of PQ Documents	
3-4	PQ Submission by Contractor	
3-5	Evaluation of PQ, Approval by CACPC	
3-6	JICA Concurrence for PQ Result	
3-7	Preparation of Bidding Documents	
3-8	Approval of Bidding Documents by CACPC	
3-9	JICA Concurrence for Bidding Documents	
3-10	Bidding period	
3-11	Technical Bid Evaluation and Approval by CACPC	
3-12	JICA Concurrence for Technical Bid Evaluation	Bidding Procedure (19.5 months)
3-13	Price Bid Evaluation and Approval by CACPC	
3-14	JICA Concurrence for Price Bid Evaluation	
3-15	Contract Negotiation	
3-16	Approval by Cabinet	
3-17	Signing of Contract	
3-18	JICA Concurrence for Signed Contract	
3-19	Opening of Letter of Credit and Issuance of Letter of Commitment	

Source: JET

6.5.5 Construction

The minimum periods required for the construction of the major facilities are as follows:

- Trunk sewers, Pump Stations and STP (Package 1) : 36 months
- Branch and tertiary sewers (Package 2): 36 months
- House connections (Package 3): 48 months

To expedite plant operation, the trial phase can be carried out when the influent wastewater reaches 20-30% of the design flow.

All construction works of Package 1 including Trunk sewers, PS and STP can be carried out in three years including mechanical and electrical works with trial operation. Because the sewage treatment plant including a few months trial operation is normally constructed during three years and the required steps of this construction work is not changed by the scale of sewage treatment plants.

The minimum period for Construction works of Package 2 for Branch sewers is estimated by the schedule of open cut works and calculated by follows. The calculated period does not include mobilization and clean-up of construction works.

T3 = 76,856 (m: pipe length) / 10 (m/day/party) / 240 (days/year) / 12 (party) = 2.67 years (3 years)

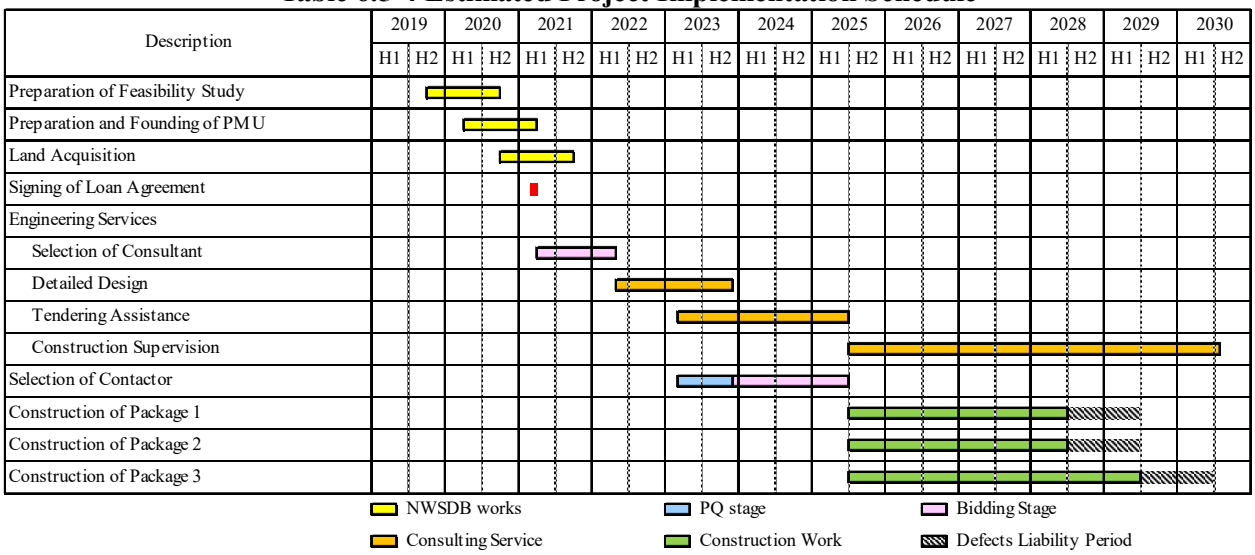
The minimum period for Construction works of Package 2 for House connection is estimated by the schedule of connection works in each household and calculated by follows. It is including the term of clean-up.

T4 = 4,800 (connection) x 3 (day/connection) / 240 (days/year) / 15 (party) = 4.0 years

In above assumptions, the working days per year can be increased more little bit however each number of parties cannot be increased more due to avoid traffic jam and claim from surrounding persons.

Total implementation period is about 10 (112 months) years. The estimated implementation schedule is shown in **Table 6.5-4** and the detailed schedule in **APPENDIX 6-2**.

Table 6.5-4 Estimated Project Implementation Schedule



Source: JET

6.5.6 Action Plan

Many procedures, organizations and agencies are involved in the selection of consultants and contractors, as shown in **Table 6.5-5** and **Table 6.5-6**.

Table 6.5-5 Process for Selection of Consultants and Responsible Organizations

Tasks	Responsible Organization / Section				
	NWSDB	TEC	CACPC	JICA	Cabinet
Preparation of EOI	L	L			
Preparation of RFP & Short-list	L	L			
Approval of RFP & Short-list			C		
JICA Concurrence for RFP & Short-list				C	
Issuance of RFP to Short-listed Consultants	L				
Proposal Submission by Consultants	L	A			
Evaluation of Technical Proposal	L	L			
Approval of Evaluation of Technical Proposal			C		
Concurrence for Evaluation of Technical Proposal				C	
Opening and Evaluation of Financial Proposals	L	L	C		
Concurrence for Evaluation of Proposals				C	
Contract Negotiation	L	L			
Approval of Contract Negotiation by CACPC			C		
Approval of Contract Negotiation by Cabinet					C
Signing of Contract	L				
Concurrence for Signed Contract				C	

Note; "L" means lead or implementing organization, "C" means authority for approval or concurrence, and "A" means advisory agency or organization,
Source: JET

The various organizations involved must carry out their respective responsibilities in a timely fashion if the selection process is to be accomplished smoothly.

Table 6.5-6 Process for Selection of Contractors and Responsible Organizations

Tasks	Responsible Organization / Section					
	NWSDB	TEC	CACPC	JICA	Cabinet	Consultant
Preparation of PQ Documents	L	L				L
Approval of PQ Documents			C			
Concurrence for PQ Document				C		
Issuance of PQ Documents	L					
PQ Submission by Contractor	L	A				A
Evaluation of PQ	L	L				A
Approval of PQ by CACPC			C			
JICA Concurrence for PQ Result				C		
Preparation of Bidding Documents	L	L				L
Approval of Bidding Documents			C			
Concurrence for Bidding Documents				C		
Bidding period	L	A				A
Technical Evaluation	L	L				A
Approval of Technical Evaluation			C			
Concurrence for Technical Evaluation				C		
Price Evaluation	L	L				A
Approval of Price Evaluation			C			
Concurrence for Price Evaluation				C		
Contract Negotiation	L	L	C			A
Approval by Cabinet					C	
Signing of Contract	L					
Concurrence for Signed Contract				C		
Open of letter of credit and issuance of letter of commitment	L	L				

Note; "L" means lead or implementing organization, "C" means authority for approval or concurrence, and "A" means advisory agency or organization,
Source: JET

6.6 COST ESTIMATES

6.6.1 Construction Cost

Construction cost is undisclosed.

Table 6.6-1 Total Construction Cost

Table 6.6-1 is undisclosed.

6.6.2 Operation and Maintenance Costs

The O&M costs for the entire project are estimated based on the required staff complement, electric power consumption, volume of sludge to be disposed, chemicals, repairs and maintenance cost as shown in **Table 6.6-2**. The breakdown of O&M costs is shown in **APPENDIX 6-4.**

Table 6.6-2 Total O&M Costs

Table 6.6-2 is undisclosed.

6.7 FUND REQUIREMENT

Fund requirement is undisclosed.

(1) Consulting Services

Consulting services are undisclosed.

(2) Land Acquisition

Land acquisition is undisclosed.

(3) Import Tax

Import tax is undisclosed.

(4) Value Added Tax (VAT)

Value added tax is undisclosed.

(5) Nation Building Tax (NBT)

Nation building tax is undisclosed.

(6) Physical Contingency

Physical contingency is undisclosed.

(7) Price Contingency

Price contingency is undisclosed.

(8) Interest rate

Interest rate is undisclosed.

(9) Front-End Fee

Front-End fee is undisclosed.

Table 6.7-1 Total Project Costs

Table 6.7-1 is undisclosed**.**

CHAPTER 7 FINANCIAL AND ECONOMIC ANALYSES

7.1 OUTLINE

- Nuwara Eliya MC's financial performance is considered quite good. From the financial view point, Nuwara Eliya MC is said to have the capacity to operate and maintain the wastewater facilities by themselves with considering the past good financial performance of the MC (7.2.1).

- For the past few years, water supply sector of Nuwara Eliya MC has been making surplus (7.2.2).

- The following cost burden principle for sewerage service is recommended to be applied in Sri Lanka:

  - Central government covers 100% of the construction cost, i.e.100% grant for NWSDB or MC
  - Sewerage tariff is calculated to cover O&M costs, and implemented incrementally
  - Small-scale replacement is covered by NWSDB's or the MC's own budget, but large-scale ones should be funded as projects by the central government (7.4.1).

- Proposed sewerage tariff for Nuwara Eliya MC is undisclosed.

- EIRR is undisclosed.

7.2 FINANCIAL CONDITION OF NUWARA ELIYA MUNICIPAL COUNCIL

7.2.1 Financial Condition of Nuwara Eliya Municipal Council

Table 7.2-1, Table 7.2-2 and **Table 7.2-3** shows the summary of financial statements of Nuwara Eliya Municipal Council (MC). In Nuwara Eliya MC, differ from most of the other MCs, they recorded their business transaction in financial statements.

Basically, total expenditures of Nuwara Eliya MC have to be borne by its revenue. An annual surplus or deficit is rolled over to the next year. However, same as the other MCs, Nuwara Eliya MC receives "Reimbursement (MC makes provisional payment of monthly salary of central government staff and the central government settles up the annual amount later.)" of salary of staff who works in the MC but belongs to central government, from central government budget through provincial government. This is included in the "Revenue Grant" account of the **Table 7.2-2**.

Table 7.2-1 Statement of Financial Position of Nuwara Eliya MC

Unit: million LKR

Description	2014	2015	2016
Assets			
Current Assets			
Cash and Cash Equivalent	23.537	57.442	16.121
Investments	8.263	6.617	32.196
Prepayments	2.840	3.542	18.558
Receivables	226.522	203.351	342.349
Stores in hand	17.171	23.468	46.819
Total	**278.333**	**294.420**	**456.043**
Non Current Assets			
Fixed Assets	341.663	405.941	422.876

Total	**341.663**	**405.941**	**422.876**
Total Assets	**619.996**	**700.361**	**878.919**
Equity and Liabilities			
Current Liabilities			
Payables	31.187	80.747	126.715
Receipts in Advance	4.255	5.325	8.631
Deposits	34.204	38.113	30.176
Total	**69.646**	**124.185**	**165.522**
Non Current Liabilities			
Loan Capital	65.352	60.262	54.708
Total	**65.352**	**60.262**	**54.708**
Net Assets/Equity			
Accumulated Fund (Municipal Fund)	137.808	106.319	234.443
Revenue Contribution for Capital	344.341	408.619	422.877
Reserves	2.846	0.976	1.369
Total	**484.995**	**515.914**	**658.689**
Total Equity & Liabilities	**619.993**	**700.361**	**878.919**

Source: 2015 & 2016 Financial Statement, Municipal Council - Nuwara Eliya

Table 7.2-2 Revenue & Expenditure Statement of Nuwara Eliya MC

Unit: million LKR

Description	2014	2015	2016
Revenue			
Rates and Taxes	81.957	79.081	87.652
Rent	87.807	38.733	41.851
Licenses	16.771	17.773	20.957
Fees for Services	16.237	19.879	25.923
Warrant Cost & Fines	0.733	0.881	0.612
Other Revenue	70.016	85.719	127.691
Revenue Grants	100.395	239.688	349.011
Total Revenue	**373.916**	**481.754**	**653.697**
Expenditure			
Recurrent Expenditure			
Personal Emoluments	135.166	234.841	238.080
Travelling Expenditure	2.434	0.701	1.517
Supplies	83.913	62.252	64.927
Maintenance Expenditure	25.686	29.294	17.456
Services	25.183	25.106	29.805
Interest Payments	2.396	5.502	5.038
Transfers	5.928	3.190	1.563
Pensions, Retirement Benefits, and Gratuities & Other Recurrent Expenditure	2.366	1.450	2.701
Total Recurrent Expenditure	**283.072**	**362.336**	**361.087**
Capital Expenditure			
Capital Expenditure	72.141	112.078	179.289
Total Capital Expenditure	**72.141**	**112.078**	**179.289**
Total Recurrent & Capital Expenditure	**355.213**	**474.414**	**540.376**
Excess of Total Revenue over Total Expenditure	**18.703**	**7.340**	**113.321**

Source: 2015 & 2016 Financial Statement, Municipal Council - Nuwara Eliya

Table 7.2-3 Cash Flow Statement of Nuwara Eliya MC

Unit: million LKR

Description	2014	2015	2016
Cash Flow from Operational Activities			
Total Cash Provided from Operations (a)	390.490	503.308	561.086
Total Cash disbursed to Operations (b)	364.804	462.003	558.684
Net Cash Flows From Operational Activities c=(a-b)	**25.686**	**41.305**	**2.402**
Cash Flow from Investment Activities			

Total Cash Provided from Investment Activities (d)	0.000	0.000	0.000
Total Cash disbursed to Investment (e)	4.925	7.403	39.908
Net Cash Flows From Investment Activities i=(g-h)	**-4.925**	**-7.403**	**-39.908**
Cash Flows From Financing Activities f=(d-e)			
Total Cash Provided from Financing Activities (g)	15.196	15.498	16.823
Total Cash disbursed to Financing Activities (h)	14.852	15.530	20.638
Net Cash Flows From Financing Activities i=(g-h)	0.344	-0.032	-3.815
Net Movement in Cash j=c+f+i	**21.105**	**33.870**	**-41.321**
Opening Cash Balance as at January 1st, 2015	2.434	23.539	57.409
Closing Cash Balance as at January 1st, 2015	23.539	57.409	16.088

Source: 2015 & 2016 Financial Statement, Municipal Council - Nuwara Eliya

As shown in the last line of **Table 7.2-2**, Nuwara Eliya MC has recorded annual surplus from 2014 to 2016 after reflecting salary reimbursement. Nuwara Eliya MC has "Accumulated Fund" amounting at LKR 234 million at the end of 2016 (**Table 7.2-1)**. The MC has "Loan Capital" at LKR 55 million and large "Receivables" at LKR 342 million (both in 2016) (**Table 7.2-1)**.

However, the loan amount is not so large and receivable amount does not make serious problem presently. Regarding the cash condition, the MC has a certain amount of positive cash balance at LKR 16 million in 2016 (**Table 7.2-3**).As a result, Nuwara Eliya MC's financial performance is considered quite good.

Table 7.2-4 Trend of Leisure Park Entrance Tickets Revenue of Nuwara Eliya MC

Table 7.2-4 is undisclosed.

From the financial view point, Nuwara Eliya MC is said to have the capacity to operate and maintain the wastewater facilities by themselves with considering the past good financial performance of the MC.

7.2.2 Management and Financial Condition of Water Supply Sector of Nuwara Eliya MC

Management and financial condition of water supply sector of Nuwara Eliya MC is undisclosed.

Table 7.2-5 Management Information of Water Supply Sector in Nuwara Eliya MC

Table 7.2-5 is undisclosed.

Table 7.2-6 is a water tariff table of the MC. In case of tariff revision, Municipal Engineer prepares a draft revision plan. It is discussed and approved by Council (Cabinet in MC level). For average water consumption for household (19 m^3/month), monthly bill is calculated at 84 LKR/month[4]. Water tariff is very low compared to that of NWSDB (480 LKR, for domestic customer in "Other than Samurdhi Recipient and Tenement Garden").

[4] (19m^3/month -5m^3/month) x 6 LKR/m^3 = 84 LKR/month

Table 7.2-6 Water Tariff Table of Nuwara Eliya MC (2012-2018)

Domestic

Water Consumption (m^3/month)	Rate (LKR/m^3)
1-5	0.0
6-20	6.0
21-30	15.0
31-40	25.0
41-50	35.0
Equal and more than 51	50.0

Industrial (Garage) and House Construction

Water Consumption (m^3/month)	Rate (LKR/m^3)
1-40	15.0
41-50	35.0
Equal and more than 51	40.0

Tourism Hotel / Government buildings / Industries

Water Consumption (m^3/month)	Rate (LKR/m^3)
Equal and more than 1	40.0

Business and Construction

Water Consumption (m^3/month)	Rate (LKR/m^3)
Equal and more than 1	30.0

Religious places

50% of Domestic charge

Source: Nuwara Eliya MC

Water supply sector is not financially independent from the MC. MC manages its budget and expenditure to be balanced as an entire MC. The budget plan is formulated for each sector of MC and the annual performance of each sector is clearly shown in notes of financial statements.

Table 7.2-7 is the extract of the notes for the revenue and expenditure statement of the MC in the financial statements. This shows breakdown of water services revenue and recurrent/capital expenditure. Water supply sector of Nuwara Eliya MC made positive balance at LKR 6.6 and 7.5 million in 2015 and 2016. According to the MC, the O&M budget for water supply service is secured enough for the maintenance (excluding depreciation) but not enough for large repair.

Table 7.2-7 Income and Expenditure of Water Supply Sector of Nuwara Eliya MC

Table 7.2-7 is undisclosed.

Table 7.2-8 Trend of Income and Expenditure of Water Supply Sector of Nuwara Eliya MC

Table 7.2-8 is undisclosed.

Figure 7.2-1 is undisclosed.

Figure 7.2-1 Trend of Income & Expenditure of Water Supply Sector of Nuwara Eliya MC

7.3 TARIFF ESTIMATION AND FINANCIAL RECOMMENDATIONS OF THE PROPOSED SEWERAGE PROJECT

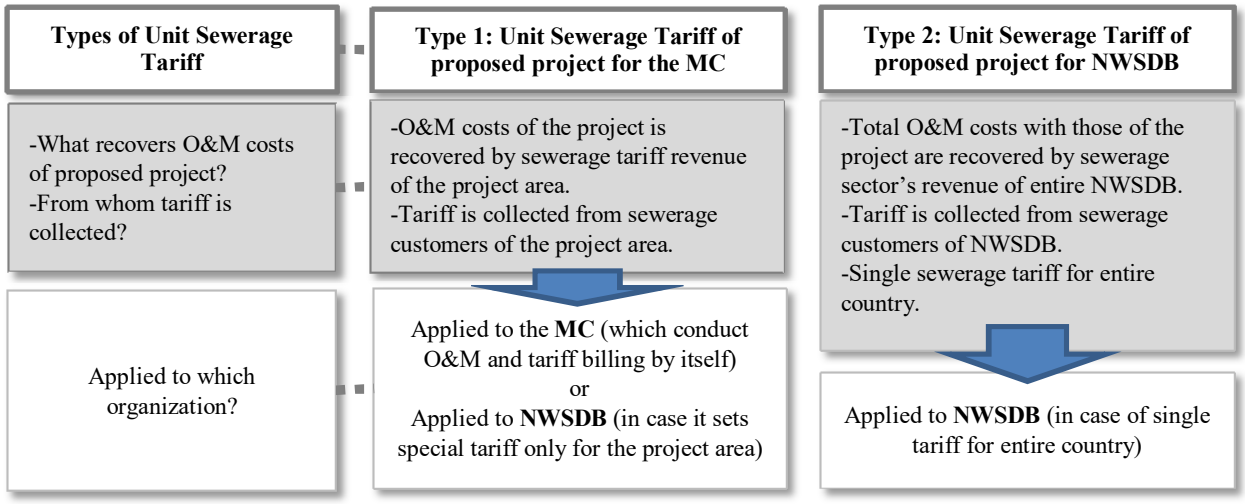
7.3.1 Calculation of Sewerage Tariff to Cover the O&M Costs

Proposed sewerage tariff is calculated in this survey, in order to cover the O&M costs of the constructed facilities. O&M costs include personnel cost, electricity cost, sludge disposal and chemical cost, repair and maintenance cost and so on, excluding depreciation cost, loan repayment and interests.

(1) Two Types of Unit Sewerage Tariff

The final output of this sewerage tariff calculation is the unit sewerage tariff enough to cover the O&M costs of the sewerage facilities for the future.

Two types of unit sewerage tariff are calculated; Type 1 recovers the O&M costs of the project by sewerage tariff revenue in the project area, Type 2 recovers the total O&M costs of the sewerage sector of NWSDB with the proposed project by total revenue of sewerage sector of NWSDB. Type 1 shall be used by; 1) the MC in case that it operates and maintains the constructed facilities, and 2) NWSDB in case that it operates and maintains the constructed facilities and that it applies special tariff limited for the project area. Type 2 shall be used by NWSDB in case that it operates and maintains the constructed facilities and that it applies single tariff for entire country (**Figure 7.3-1**).



Source: JET

Figure 7.3-1 Differences and Target of 2 Types of Unit Sewerage Tariff

(2) Methodology of Sewerage Tariff Calculation

Methodology of sewerage tariff calculation is undisclosed.

(3) Assumptions of Sewerage Tariff Calculation

The following assumptions are used to calculate the proposed sewerage tariff:

- total volume of water consumed by customers is based on the Design Criteria

- price inflation is not reflected in the calculation. Inflation adjustment would be included in the calculation of an actual sewerage tariff.

(4) Relation to Proposed Sewerage Tariff by Strategic Sewerage Master Plan

Relation to proposed sewerage tariff by Strategic Sewerage Master Plan is undisclosed.

Figure 7.3-2 is undisclosed.

Figure 7.3-2 Image of Implementation Schedule of Tariff Raise

7.3.2 Result of Unit Sewerage Tariff Calculation

Result of unit sewerage tariff calculation is undisclosed.

(1) Type 1: MC does the O&M and the billing or NWSDB sets a special tariff for the MC

Table 7.3-1 Calculation of Unit Sewerage Tariff for the Project Nuwara Eliya MC

Table 7.3-1 is undisclosed.

(2) Type 2: NWSDB National Sewerage Tariff

Table 7.3-2 Calculation of Unit Sewerage Tariff for 3rd Raise of NWSDB Nuwara Eliya MC

Table 7.3-2 is undisclosed.

7.3.3 Affordability To Pay, Willingness To Pay, and Proposed Sewerage Tariff

Affordability to pay, willingness to pay, and proposed sewerage tariff are undisclosed.

Figure 7.3-3 is undisclosed.

Figure 7.3-3 Comparison of Future Sewerage Tariff and Affordability to Pay (Type 1)

Figure 7.3-4 is undisclosed.

Figure 7.3-4 Comparison of Future Sewerage Tariff and Affordability to Pay (Type 2)

7.4 FINANCIAL AND ECONOMIC ANALYSIS OF THE PROPOSED SEWERAGE PROJECT

7.4.1 Financial Analysis

(1) Inadequacy of Calculating FIRR for this Project

Inadequacy of calculating FIRR for this project is undisclosed.

7.4.2 Economic Analysis

(1) Methodology and Assumptions

1) Methodology of Economic Analysis

Methodology of economic analysis is undisclosed.

2) Assumptions for Economic Analysis

Assumptions for economic analysis are undisclosed.

Table 7.4-1 Major Conditions and Assumptions of Economic Analysis

Table 7.4-1 is undisclosed.

3) Conversion from Financial Value to Economic Value

Conversion from financial value to economic value is undisclosed.

(2) Economic Benefits of the Project

Economic benefits of the project are undisclosed.

Table 7.4-2 Economic Benefits of the Project

Table 7.4-2 is undisclosed.

1) Saving of Cost for Current Sewage Treatment / Excreta Disposal

Saving of cost for current sewage treatment / excreta disposal is undisclosed.

Table 7.4-3 Benefit of Saving of Cost for Current Sewage Treatment / Excreta Disposal

Table 7.4-3 is undisclosed.

2) Reduction of Health Problems by Water Borne Diseases

Reduction of health problems by water borne diseases is undisclosed.

Table 7.4-4 Benefit of Reducing Water Borne Diseases

Table 7.4-4 is undisclosed.

3) Total Benefit of the Project

Total benefit of the project is undisclosed.

Table 7.4-5 Total Benefit of the Project

Table 7.4-5 is undisclosed.

(3) Economic Costs of the Project

Economic costs of the project are undisclosed.

Table 7.4-6 Total Economic Cost of the Project

Table 7.4-6 is undisclosed.

(4) Economic Evaluation

Economic evaluation is undisclosed.

Table 7.4-7 Cost and Benefit Stream of the Project

Table 7.4-7 is undisclosed.

(5) Sensitivity Analysis

Sensitivity analysis is undisclosed.

Table 7.4-8 Sensitivity Analysis of EIRR of the Project (Cost & Benefit Changes)

Table 7.4-8 is undisclosed.

Figure 7.4-1 is undisclosed.

Figure 7.4-1 Sensitivity Analysis of EIRR of the Project (Cost & Benefit Changes)

CHAPTER 8 MEASURES FOR ANTICIPATED EFFECT OF THE PROJECT

8.1 OUTLINE

- Four effect indicators (volume of sewage treated, population served, sewerage system served rate, and quality of treated effluent) are proposed for the monitoring and evaluation of progress in achieving the intended benefits of the project (8.2).

- The project is expected to achieve its intended targets of each indicator by the year 2029. The indicators should be periodically monitored and summarized to check the effects of the project (8.3).

8.2 EFFECT INDICATORS

Effect indicators are recommended to monitor and evaluate progress in achieving the intended benefits of the Project.

The following indicators are proposed for the project:

volume of sewage treated: measured at the outlet by a flow meter.
population served: calculated by multiplying the of number of house connections by the average family size.
sewerage system service rate: calculated by dividing the area population by population served.
quality of treated effluent: analyed in the laboratory at the STP

8.3 ANTICIPATED TARGET

Targets for the proposed indicators are determined according to the nature of the project and should generally be achieved 2 years after the project becomes operational. The project is expected to achieve its intended targets by the year 2031. Indicators and proposed targets are shown in **Table 8.3-1**.

Table 8.3-1 Indicators and Targets

Indicator	Present (year 2019)	Target (year 2031)
Volume of Sewage Treated (m^3/d)	0	4,700 m^3/day
Population Served (Persons)	0	19,100 persons
Quality of Treated Effluent	BOD_5: － SS : －	BOD_5 ＜15 mg/l SS ＜15 mg/l NO_3-N＜10 mg/l TP ＜ 5 mg/l

Source: JET

8.4 MEASUREMENT PROCEDURE FOR INDICATOR

The volume of sewage treated will be measured automatically at the disinfection facility of the STP. Served population would be estimated from the recorded number of house connections, and percentage of population served would be calculated from the official population data. Quality of treated effluent would be monitored for compliance by the treatment plant operator as required by the discharge permit.

Although water quality improvement would be observed at discharge points of the STPs, this is not a direct measurement of an actual reduction in pollution of the receiving waters. It is recommended that NWSDB periodically monitor water quality in waterbodies, as indicated in **Table 8.4-1**. Accumulated

data before commissioning of the sewerage system will also be needed to demonstrate any improvements resulting from the project.

Table 8.4-1 Recommended Monitoring Method for Water Quality of Rivers

River/Stream Water Quality	Monitoring Locations	Effluent Discharge Point at a STP and monitoring points at rivers (4points) (**Figure 2.2-1**).
	Parameters for Analysis	pH, Turbidity, Temperature, DO, SS, COD, BOD_5, T-N, T-P. Total Coliform, Heavy metal

Source: JET

Regarding the monitoring system of those indicators, the following system is proposed to NWSDB. All indicators are reported to NWSDB Sewerage Section by Project Management Unit once every three month for monitoring the progress and effects of the project (**Table 8.4-2**). Data for calculated indicators are collected by Nuwara Eliya Management Office.

Table 8.4-2 Proposed Monitoring System

Monitoring contents	Monitoring Management Section	Way to monitor
Volume of Sewage Treated (m^3/d)/ Quality of Treated Effluent	Project Management Unit (PMU)	Nuwara Eliya Management Office collects and summarizes data from STP O&M section and reports to PMU once a month.
Population Served (Persons)/ Percentage of the Population Served in the Service Area (%)	Project Management Unit (PMU)	Nuwara Eliya Management Office collects and summarizes the number of house connection in the service area and reports to PMU once a month. PMU calculates served population and percentage of served population based on number of house connection.
River/Stream Water quality	Project Management Unit (PMU)	Nuwara Eliya Management Office collects and summarizes data from laboratory section and report to PMU once a month.

Source: JET

CHAPTER 9 CONCLUSIONS AND RECOMMENDATIONS

9.1 OUTLINE

- The Project will reduce pollution of public water bodies, improve sanitation condition, and subsequently bring about further sustainable economic development. The Project satisfies national priorities for this area and has many positive environmental/social impacts (9.2).

- Some risks on cost increases and delay in the project implementation are expected. Therefore, three recommendations on geotechnical investigation, public awareness, and information sharing with relevant agencies are made for project implantation (9.4).

- It is recommended that sludge from septic tanks be treated in the STP to bring the benefit of the project to people without sewerage services (9.5).

9.2 CONCLUSION

This Project will reduce pollution of public water bodies and improve sanitation/public health conditions and subsequently bring about further sustainable economic development. The Project satisfies national priorities for this area and has many positive environmental/social impacts.

9.3 SUSTAINABILITY

Project benefits can be sustained through: (i) the use of innovative technology appropriate for local conditions; (ii) commitment to capacity building for O&M; and (iii) an appropriate tariff structure. The lessons learned during project design and implementation will be useful for other projects, thereby enhancing the sustainability of the broader initiatives in NWSDB.

9.4 RISKS AND MITIGATION MEASURES

Risks to the successful implementation of the project are identified in **Table 9.4-1**.

Table 9.4-1 Risks and Mitigation Measures

Risks	Mitigation Measures
1 Cost Increases For building foundations, pipe trenching, and micro tunnelling. For building road crossings, under-river crossings of sewers and micro tunnelling.	Analysis of probability and impact
	Sewerage facilities are spread out over the entire project area in the Highland Complex, where there are different soil conditions.
	Mitigation measures:
	Soil tests should be carried out at proper sampling points to confirm the conditions. The scope of work and costs should be discussed with authorities with jurisdictional responsibility. Provisional sums should be included in the cost estimates.
2 Land Acquisition Delay in Project implementation: if the identified land is not acquired before the commencement of the project.	Analysis of probability and impact
	The sewage treatment plant, an access road and three pumping stations are to be built on private land. Construction of the access road may require the resettlement of residents. Land acquisition and resettlement may take time.
	Mitigation measures:
	PMU, Nuwara Eliya MC, NWSDB, UDA, Ministry of Land and Parliamentary Reforms and other relevant agencies must have project sites ready. The budget for land acquisition should be allocated to NWSDB. Awareness meetings for residents surrounding sites should be held for enhancing their understandings of the project to promptly conduct land acquisition and construction.
3 Delivery Quality	Analysis of probability and impact
	It may take time to get permission for the construction of sewers under busy streets.

Risks	Mitigation Measures
Low inflow: at the treatment plant, if sewer construction and house connections are delayed. Poor treated water quality: as a result of equipment and process malfunction because staff do not have adequate training.	Delays in sewer construction and wastewater collection mean targeted treatment operation would not be achieved according to schedule. Insufficient skilled operators may hinder the smooth operation of the treatment plant.
	Mitigation measures:
	Allocate enough time for meetings to explain to relevant agencies in advance, the construction methods (such as micro tunnelling), time required for the work and where sewer lines have to be routed. This would minimize potential delays. Implement capacity building program for O&M staff including technical assistance during construction and at commissioning. Sewerage tariff should be raised to adequately cover the costs of maintenance and equipment replacement.

Source: JET

9.5 RECOMMENDATIONS

The following steps should be taken during subsequent stages of the study or during the design and implementation periods:

(1) Detailed geotechnical investigations should be carried out during the design stage for:
- The STP and pumping station sites to confirm the structural requirements for the foundations.
- Sewer routes to confirm the proper micro Tunnelling methods.
- Pipe trenches to prepare appropriate temporary works and pipe bedding, and to select economical and safe construction methods.
- The tender documents shall specify that the successful bidder is responsible for carrying out an independent investigation of soil conditions.

(2) NWSDB should conduct public awareness activities on the importance of sewage treatment and hold frequent meetings with related organizations to share information on the Project for deepening the understanding of the project's purpose, promoting land acquisition and the resettlement of residents, and accelerating house connection.

(3) NWSDB should share information and coordinate with relevant agencies to avoid potential delays.

(4) NWSDB should accept sludge from septic tanks and treat them in the STP to bring the benefit of the project to people without sewerage services.

(5) NWSDB should add surveys of "Institutional Arrangements for Project Implementation", "Environmental and Social Considerations" and "Abbreviated Resettlement Action Plan" in the future feasibility study, if necessary during the feasibility study stage.

APPENDICES

APPENDIX 2-1 Water Quality Survey Results (2.2.2)

(1) Introduction

The objective of the Survey is to grasp the water quality condition of Nuwara Eliya MC and it was conducted as part of Preparatory Survey on Preparatory Survey on Sri Nuwara Eliya Sewerage Construction Project. The survey consists of two parts, namely Discharge Water Quality and Environmental Water Quality. Four sampling points were selected to satisfy study objectives. The parameters are; Temperature, pH, TSS, TDS, BOD, COD, T-N, T-P, Fecal Coliforms, Total Coliforms, Odour, DO, NH4-N and EC.

(2) Sampling

Samples were manually collected at each location. The samples were stored in appropriate temperature conditions and brought to the laboratory for analysis. While conducting the sampling, following field measurements such as pH, Dissolved Oxygen, Conductivity, Temperature etc. were measured.

(3) Sampling Locations and Schedule

Figure 1. Sampling station location

Table 1. Sampling Station Location Details (Sampling date: 23.04.2018)

Sample Station Ref.	Location	Coordinates	Parameters
Station-N3	Talagala oya at Golf course	06 58 43.9N - 080 45 50.4E	Temperature, pH, TSS, TDS, BOD, COD, T-N, T-P, Fecal Coliforms, Total Coliforms, Odour, DO, NH4-N and EC
Station-N4	Talagala oya at inlet of Lake Gregory	06 58 34.9N - 080 46 18.5E	‘’
Station-N5	Outlet of the Lake Gregory	06 57 11.5N - 080 46 51.5E	‘’
Station-N7	Nanu Oya (At WWTP discharge point)	06 58 26.6N - 080 45 53.2E	‘’

(4) Water Quality Analysis Results

Table 2 gives the water quality analysis results from selected Discharge and Environmental sample sites, respectively.

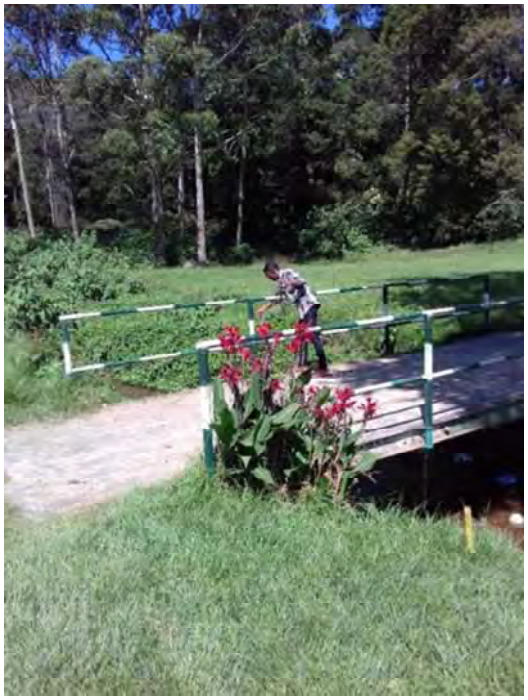
Table 2. Discharge water quality (Sampling date: 23.04.2018)

Sample Station	Temp (°C)	pH	TSS mg/l	TDS mg/l	BOD mg/l	COD mg/l	T-N mg/l	T-P mg/l	Total Coliforms MPN/100ml	Fecal Coliforms MPN/100ml	Odor	DO mg/l	NH_4-N mg/l	EC mS/cm
Station-N3	20	7	2	133	5	13	3.992	0.144	9,200	3,500	Unobjectionable	5.4	<0.01	0.2
Station-N4	19.3	7.2	3	174	10	14	3.896	<0.005	5,400	2,400	Unobjectionable	2.8	3.4	0.27
Station-N5	23.2	8.1	10	151	6	51	2.938	<0.005	270	220	Unobjectionable	5.7	0.9	0.23
Station-N7	24.1	8.1	11	154	6	23	3.611	<0.005	5,400	3,500	Unobjectionable	7.3	0.48	0.24

(5) Conclusion

The results of this study revealed that water quality of the water bodies within the Nuwara Eliya Municipality is under the environment threat caused by public sewage (heavily polluted with sewage and domestic organic waste) discharges to the city drains.
Total Coliforms and Fecal Coliforms levels at the outlet of the Lake Gregory are very low compared to the other 3 flowing water bodies.
A suitable involvement to mitigate degradation and proper management on the water services of the stream network within the Nuwara Eliya Municipality is recommended based on these investigations.

Annexure I - Photographs taken at Water Sampling Locations – Nawaraeliya MC

	
Station ID: Station-N3 **Location:** Talagala oya at Golf course	**Station ID:** Station-N4 **Location:** Talagala oya at inlet of Lake Gregory
	
Station ID: Station-N5 **Location:** Outlet of the Lake Gregory	**Station ID:** Station-N7 **Location:** Nanu Oya (At WWTP discharge point)

APPENDIX 2-2 Laws and Regulations on Environmental Protection (2.2.3)

National Environment (Protection and Quality) Regulation No.1, SLS 776:1987, SLS 721:1985, and SLS 775:1987, regulates effluent according to the discharge locations, such as inland surface water, fields for irrigation, or the ocean. The sewage system is designed following the National Water Drainage Board Design Manual D7, 2012, to meet the relevant effluent regulations. Septic Tanks are designed for SLS745 Part1 and Part2.

The Environment Impact Assessment (EIA) is required for sewerage projects. The legal framework for EIA regulations in Sri Lanka were enacted by the National Environmental (Amendment) Act, No. 56 of 1988 and National Environmental (Amendment) Act, No. 53 of 2000. The guidelines for the EIA process are published in Gazette Notifications. The Central Environmental Authority (CEA) oversees the EIA process and designates state agencies as Project Approving Agencies (PAA).

The first level in the EIA process is the Initial Environmental Examination (IEE). Environmental Impact Assessment at the next level is a more comprehensive exercise where alternatives to the project and mitigation measures are identified.

National Institute of Occupational Safety and Health regulates the safety and health aspects in the construction of any infrastructure project. In the absence of construction safety regulations in the country, contractors follow the SLS OHSAS 18001 Safety System Standards and the Certification Scheme in managing workplace safety.

Table 1. Laws and Regulations on Environmental Protection

Laws/Regulations	Parameters Regulated
Wastewater	
General Standards for Discharge of Effluents into Inland Surface Waters 1. National Environmental (Protection and Quality) Regulations, No. 1 of 2008	Temperature, pH, BOD, SS, oil and grease, toxic matters and heavy metals
Tolerance Limits for Industrial Effluents discharged on Land for Irrigation Purposes 1. SLS 776: 1987	pH, BOD, SS, oil and grease, Cl^-, SAR, toxic matters and heavy metals
Tolerance Limits for Industrial and Domestic Effluents discharged into Marine Coastal Areas 1. SLS 721: 1985 Tolerance Limits for Marine Coastal Waters liable to pollution 2. SLS 775: 1987	Temperature, pH, BOD, COD, SS, NH_3-N, oil and grease, toxic matters and heavy metals
National Water Drainage Board Design Manual D7 Wastewater Collection, Treatment, Disposal & Re-use 1. March 1989 2. February 2012	Sewerage system planning and design such as design period, wastewater flow estimation, sewer design, treatment facility design etc.
Sri Lanka Standards for Septic Tank 1. SLS 745 Part1:2004 for small system 2. SLS 745 Part2:2009 for large system	Septic tank design and maintenance such as flow estimation, design, materials and construction, inspection, commissioning, maintenance
Waste and Wastewater Pollution	
Guidelines for licensing procedure and requirements are listed in No 924/13 dated 23rd May 1996	
General Environmental Protection – Acts and Regulations	
1. National Environmental Act No. 47 of 1980 2. National Environmental (Amendment) Act, No. 56 of 1988 3. National Environmental (Amendment) Act, No. 53 of 2000	Authority, function and obligation of CEA; Policy, management and protection of the environment
Guidelines for Implementing the EIA Process 1. No. 772/22 dated 24th June 1993	"Prescribed Projects" for which EIA are necessary, Project Approving Agencies (PAA) and their responsibilities,

Laws/Regulations	Parameters Regulated
2. No. 850/4 dated 20th Dec. 1994 3. No. 859/14 dated 23rd Feb. 1995 4. No. 1104/22 dated 5th Nov. 1999 5. No. 1108/1 dated 29th Nov. 1999 6. No. 1373/6 dated 29th Dec. 2004 7. No. 1533/16 dated 25th Jan. 2008 8. No. 1534/18 dated 1st Feb. 2008	procedures for compliance with regulations and EIA content and format etc.
1. Coast Conservation Act No. 57 of 1981 2. Coast Conservation (Amendment) Act, No. 49 of 2011	Coastal zone management, permit procedures etc.
Air Pollution	
National Environmental (Ambient Air Quality) Regulations 1. No. 1295/11 dated 30th June 2003 2. No. 1309/20 dated 10th Oct. 2003 3. No. 1557/14 dated 9th July 2008 4. No. 1562/22 dated 15th Aug. 2008 5. No. 1887/20 dated 5th Nov. 2014 6. No. 1895/43 dated 2nd Jan. 2015	sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO) and Particulate Matter (PM_{10}) etc.
Noise Pollution	
National Environmental (Noise Control) Regulations 1. No. 924/12 dated 23rd May 1996 2. No. 973/7 dated 30th April 1997 3. No. 1738/37 dated 29th Dec. 2011	Noise standards in residential, business and industrial areas
Construction	
Occupational Health and Safety Act 1. Health and Safety Policy – Health and Safety at Work Act 1974 2. Occupational Health and Safety at Work, Act 2007 3. National Institute of Occupational Safety and Health Act, No. 38 of 2009 4. Safety System Standards – SLS OHSAS 18001 – Certification Scheme	Occupational Health and Safety Executive to enforce Occupational Health and Safety at Work Act. Occupational Health Safety Management System to Implement Health and Safety at Works as per the Occupational and Safety Policy.
Drinking Water Quality	
Sri Lanka Standards for Drinking Water 1. SLS 614: 1983 2. 1st Revision – SLS 614: 2013	Bacteriological and chemicals of health significance (inorganic constituents, organic constituents) and substances and parameters that may give rise to complaints from consumers.
Tolerance Limits for Inland Surface Waters used as Raw Water for Public Water Supply 1. SLS 722: 1985	Water Quality Standards of Raw Water for Water Supply
National Water Supply and Drainage Board Act 1. NWSDB Law, No. 2 of 1974 2. NWSDB (Amendment) Act, No. 13 of 1992	Regulations on the plan, development activities and management of water supply, sewage and drainage systems etc.

Source: JET

APPENDIX 4-1 Population Projection (4.4.2)

This appendix describes the future population projection to determine the capacities of sewerage facilities.

Future populations by GND are estimated in the following procedure.

- For GNDs in which population has decreased or stagnated from 2001 to 2012, future population is determined as same as the population in 2012.
- For GNDs in which population has increased from 2001 to 2012, future population is determined considering the growth ratio from past years.

Estimated future population by GND is summarized in the following table**.**

Table : Future Population Projection for GNDs showing increasing trend

Area	Population				Average Annual Growth Rate		Year		Projection						
	1981	2001	2007	2012	81 - 01	01 - 12		2012	2015	2020	2025	2030	2035	2040	2046
Sri Lanka	**14,846,274**	**18,797,257**		**20,359,439**	**1.19%**	**0.73%**	**Growth Rate**	**0.64%**	**0.62%**	**0.57%**	**0.52%**	**0.48%**	**0.44%**	**0.41%**	**0.38%**
Central Province															
Nuwara Eliya District	**583,716**	**703,610**		**706,210**	**0.94%**	**0.03%**	**Growth Rate**	**0.02%**	**0.02%**	**0.02%**	**0.02%**	**0.01%**	**0.01%**	**0.01%**	**0.01%**
NuwaraEliya MC						-0.58%	Growth Rate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
		25,388		23,804			Population	23,804	23,804	23,804	23,804	23,804	23,804	23,804	23,804
535H Havaeliya East						-0.21%	Growth Rate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
		2,327		2,273			Population	2,273	2,273	2,273	2,273	2,273	2,273	2,273	2,273
535L NuwaraEliya West						-0.21%	Growth Rate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
		2,540		2,481			Population	2,481	2,481	2,481	2,481	2,481	2,481	2,481	2,481
535 Nuwara Eliya						-3.36%	Growth Rate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
		1,878		1,290			Population	1,290	1,290	1,290	1,290	1,290	1,290	1,290	1,290
535D Nuwara Eliya Central						-0.85%	Growth Rate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
		4,712		4,292			Population	4,292	4,292	4,292	4,292	4,292	4,292	4,292	4,292
535G Hawaeliya North						-1.73%	Growth Rate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
		2,686		2,216			Population	2,216	2,216	2,216	2,216	2,216	2,216	2,216	2,216
535F Hawaeliya West						0.85%	Growth Rate	0.63%	0.59%	0.50%	0.43%	0.37%	0.32%	0.29%	0.26%
		1,888		2,072			Population	2,072	2,109	2,163	2,209	2,250	2,287	2,320	2,350
535C Kelegala						-0.22%	Growth Rate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
		1,874		1,829			Population	1,829	1,829	1,829	1,829	1,829	1,829	1,829	1,829
535B Kalukele						-0.31%	Growth Rate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
		1,131		1,093			Population	1,093	1,093	1,093	1,093	1,093	1,093	1,093	1,093
535E Sandathenna						0.04%	Growth Rate	0.03%	0.03%	0.02%	0.02%	0.02%	0.02%	0.01%	0.01%
		2,803		2,816			Population	2,816	2,818	2,822	2,825	2,828	2,830	2,832	2,834
535A Magasthota						-0.68%	Growth Rate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
		1,518		1,408			Population	1,408	1,408	1,408	1,408	1,408	1,408	1,408	1,408

APPENDIX 4-2 Per Capita Water Consumption and Ratios of Non-Domestic/Domestic Flow and Daily Maximum Flow (4.5.2)

This appendix describes the source data and results of study regarding per capita water consumption and ratios of non-domestic/domestic flow and daily maximum flow. All source data was collected from NWSDB.

(1) Per Capita Water Consumption

Table 1. shows the management information of NWSDB regarding water supply. Household in the Table shows numbers and consumptions of water supply that were paid with normal rate of tariff, since customers of discount rate, such as Domestic, NonVAT, Tenaman Garden, Government Quarters etc. are categorised in others. Per capita consumption can be obtained from the category of Household and **Table 2.** shows the values of last 5years ranging from 120 to 128 litter per capita per day (lpcd).

While, "NWSDB Design Manual D7 Wastewater Collection, Treatment, Disposal & Re-Use 2012" recommends range of per capita water consumption of 120 to 140 lpcd.

Based on the above data and manual, NWSDB employs 120 lpcd as per capita consumption in all Pre-F/S studies and proposals prepared by NWSDB, and variation of sewage amount is made by ratios of Non-domestic water flow and daily maximum flow depending on the nature of the objective area.

Table 1. Management Information of NWSDB

No.	Items	2013	2014	2015	2016	2017
1	No. of Customers					
1-1	Household	1,469,386	1,589,341	1,718,851	1,869,697	1,982,275
1-2	Commercial	98,723	106,807	116,259	126,290	136,398
1-3	Industrial	851	873	993	1,069	1,148
1-4	Governmental	9,429	8,267	8,585	8,975	9,366
1-5	Others	128,166	126,710	109,033	87,509	89,985
	Total	1,706,555	1,831,998	1,953,721	2,093,540	2,219,172
2	Billed amount of water (m^3/year)					
2-1	Household	257,700,650	282,463,510	306,473,041	350,264,520	361,242,538
2-2	Commercial	35,372,555	39,208,012	40,844,503	45,923,051	48,704,653
2-3	Industrial	2,409,438	2,332,241	2,745,566	3,259,537	3,158,229
2-4	Governmental	18,137,052	16,879,093	15,497,313	15,681,870	14,801,789
2-5	Others	70,351,389	74,908,815	76,943,091	79,287,285	81,168,439
	Total billed amount of water	383,971,084	415,791,671	442,503,514	494,416,263	509,075,648

Source: NWSDB

Table 2. Estimate of Per Capita Consumption

Items	2013	2014	2015	2016	2017
No. of Customers					
Household (No.)	1,469,386	1,589,341	1,718,851	1,869,697	1,982,275
Billed amount of water (m^3/year)	257,700,650	282,463,510	306,473,041	350,264,520	361,242,538
Per capita consumption (lpcd)	120	122	122	128	125

Source: JET, Estimate with 4 persons of household size

(2) Non-Domestic/Domestic Flow Ratio

Existing data of domestic and non-domestic consumption from 2014 are shown in **Table 3**. The Table shows the ratio of non-domestic/domestic ranges from 0.61 to 0.75 except November, 2014, which is something wrong with reason unidentified.

Table 3. Data of Domestic and Non-Domestic Consumption

(m^3)

2014	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Domestic	87,737	83,663	74,721	79,142	95,055	69,960	76,817	76,782	80,478	75,124	22,964	74,768	897,211
Non Domestic	55,307	54,648	50,299	51,038	61,395	42,390	47,907	49,434	51,226	48,950	27,538	49,105	589,237
Total	143,044	138,311	125,020	130,180	156,450	112,350	124,724	126,216	131,704	124,074	50,502	123,873	1,486,448
Non Domestic /Domestic	0.63	0.65	0.67	0.64	0.65	0.61	0.62	0.64	0.64	0.65	1.20	0.66	0.66

2015	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Domestic	79,708	70,094	77,010	76,616	76,615	76,160	74,370	76,302	74,901	69,071	68,400	71,576	890,823
Non Domestic	49,798	45,017	51,869	52,173	48,339	46,272	53,831	51,169	47,697	47,215	51,330	53,671	598,381
Total	129,506	115,111	128,879	128,789	124,954	122,432	128,201	127,471	122,598	116,286	119,730	125,247	1,489,204
Non Domestic /Domestic	0.62	0.64	0.67	0.68	0.63	0.61	0.72	0.67	0.64	0.68	0.75	0.75	0.67

2016	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Domestic	81,954	79,741	82,741	71,478	68,599	70,690	73,710	76,619	81,274	70,707	68,938	69,348	895,799
Non Domestic	56,934	56,458	59,422	49,048	45,851	47,427	53,685	53,208	53,463	48,731	48,077	48,167	620,471
Total	138,888	136,199	142,163	120,526	114,450	118,117	127,395	129,827	134,737	119,438	117,015	117,515	1,516,270
Non Domestic /Domestic	0.69	0.71	0.72	0.69	0.67	0.67	0.73	0.69	0.66	0.69	0.70	0.69	0.69

Source: Nuwar Eliya MC adjusted by JET

(3) Daily Maximum Flow Ratio

For the confirmation of the daily maximum flow ratio, the monthly consumption data was collected from 2014 to 2016 as shown in Table A4.2-3. The converted daily consumption of each year is shown in **Table 4.** The table shows the each year's peak factor ranging 1.05 to 1.18.

Table 4. Daily Consumption and Peak Factor

Month	Daily consumption (m^3/day)		
	2014	2015	2016
January	4,614	4,178	4,480
February	4,940	4,111	4,697
March	4,033	4,157	4,586
April	4,339	4,293	4,018
May	5,047	4,031	3,692
June	3,745	4,081	3,937
July	4,023	4,136	4,110
August	4,071	4,112	4,188
September	4,390	4,087	4,491
October	4,002	3,751	3,853
November	-	3,991	3,901

Month	Daily consumption (m^3/day)		
	2014	2015	2016
December	3,996	4,040	3,791
Average	4,291	4,081	4,145
Peak Factor	1.18	1.05	1.13

APPENDIX 4-3 Draft Amendment of Tolerance Discharge Limits (4.5.4, 5.3.1)

Schedule III

Tolerance limit values for the discharge of wastewaters or effluents (industrial / domestic) from a prescribed activity into the inland surface waters

No.	*Parameter*	*Unit, type of limit*	*Tolerance limit values for Inland surface waters*
1.	Total suspended solids	mg/1, max.	50
2.	Total dissolved solids	mg/1, max.	1000
3.	pH at ambient temperature	-	6.0 – 8.5
4.	Biochemical oxygen demand (BOD_5 in 5 days at 20^0 C)	mg/1,max.	30
5.	Temperature at the point of discharge	^{0}C, max.	Ambient water temperature ± 5 or 40 whichever is lesser
6.	Oils and greases	mg/1,max.	10
7.	Phenols (as C_6H_5OH)	mg/1,max.	1.0
8.	Chemical oxygen demand (COD)	mg/1,max.	250
9.	Colour (Maximum spectral absorption coefficient)	Wave length range 436 nm, (Yellow range) 525 nm, (Red range) 620 nm, (blue range)	 $7m^{-1}$ $5m^{-1}$ $3m^{-1}$
10.	Dissolved phosphates (as P)	mg/1,max.	5

11.	Total Kjeldhal nitrogen (as N)	mg/1,max.	150
12.	Ammoniacal nitrogen (as N)	mg/1,max.	50
13.	Nitrate (as N)	mg/1,max.	10
14.	Cyanide (as CN)	mg/1,max.	0.05
15.	Total residual chlorine (as Cl_2)	mg/1,max.	0.5
16.	Chlorides (as Cl)	mg/1,max.	400
17.	Fluorides (as F)	mg/1,max.	2.0
18.	Sulphides (as S)	mg/1,max.	0.5
19.	Arsenic, total (as As)	mg/1,max.	0.05
20.	Cadmium, total (as Cd)	mg/1,max.	0.03
21.	Chromium, total (as Cr)	mg/1,max.	0.05
22.	Chromium, hexavalent (as Cr^{6+})	mg/1,max.	0.01
23.	Copper, total (as Cu)	mg/1,max.	0.05
24.	Iron, total (as Fe)	mg/1,max.	3.0
25.	Lead, total (as Pb)	mg/1,max.	0.05
26.	Mercury, total (as Hg)	mg/1,max.	0.001
27.	Nickel, total (as Ni)	mg/1,max.	0.2
28.	Selenium, total(as Se)	mg/1,max.	0.05
29.	Zinc, total (as Zn)	mg/1,max.	2.0
30.	Silver, total (as Ag)	mg/1,max.	0.035
31.	Pesticides (Total)	mg/1,max.	0.005
32.	Surfactants (Total)	mg/l, max.	5.0
33.	Faecal coliform	MPN/100ml, max.	150

34.	Sulphates (as S)	mg/l, max.	250
35.	Radio Active Material: (a) Alpha emitters (b) Beta emitters	 micro curie/ml, max micro curie/ml, max	 10^{-8} 10^{-7}

Note 1: All efforts should be made to remove unpleasant odour as practicable as possible.

Note 2: These limit values are based on the premise that for inland surface water the dilution factor may be at least 1:8. In an event where the dilution factor is found to be less, the limit values in the Schedule should be adjusted on a proportional basis so as to give rise to more stringent limit values.

Note 3: The above mentioned general standards and criteria should cease to apply with regard to a particular industry when industry specific standards and criteria are stipulated for that industry.

APPENDIX 5-1 Candidate location of Major Pump Station in Nuwara Eliya (5.2.1 (5))

MPS01 MPS02

MPS01 MPS02

APPENDIX 5-2 Land Confirmation for STP (5.3.2)

CPC/NE/MC/WW/2016 (JAICA)

நுவரலிய நாகரீக கொமிஸாரிஸ்
நுவரெலியா மாநகர சபை ஆணையாளர்
THE MUNICIPAL COMMISSIONER
NUWARA ELIYA
කාර්යාලය அலுவலகம் Office 052-2222274 / 052-2222275
ෆැක්ස් பெக்ஸ் Fax 052-2222274
නිවස வாசஸ்தலம் Residence 052-2222371
ඊ-මේල් மின் அஞ்சல் E-mail mcne76@yahoo.com
වෙබ් வலை Web www.nuwaraeliya.mc.gov.lk

මගේ අංකය எனது இல. My No. .....
ඔබේ අංකය உமது இல. Your No. .....
නාගරික කාර්යාලය
நகர சபை அலுவலகம்
The Municipal Office
2016.09.30
දිනය .....

நுவரலிய நுவரெலியா Nuwara - Eliya

Team Leader,
The Project for the Strategic Master Plan under
Sewerage Sector in Democratic Socialist of Sri Lanka,
Team Leader Office,
No. 25, Sangabho Mawatha, Borupana Road,
Ratmalana.

Dear Sir,

Confirmation on the Land Availability for the Construction of a sewerage Treatment Plant for Nuwara Eliya MC Area.

This has reference to your letter No. TL-PSMPSS/Muni.Commissioner-Nuwara Eliya/ 0052 and dated 01st September 2016 regarding the above subject.

02. First of all I have to thank you for selecting our city as one of the five important cities for "Strategic Master Plan under Sewerage Sector" and we hopefully waiting for "Detail Feasibility Study".

03. The proposed STP Site for Nuwara Eliya city is located at right bank side of Nanu-oya stream and next to Pedro Tea Plantation area at Black pool, Nanu-oya, and Hatton – Nuwara Eliya main road.

04. We are now almost above 50% of the acquisition procedure for above STP site.

05. Therefore, I can confirm our council can acquire the proposed STP site without any difficulties for sewerage project.

Thank you.
Yours Faithfully,

R.M.K.R.B. Rathnayake,
Municipal Commissioner,
Municipal Council – Nuwara Eliya.

R.M.K.R.B.
Municipal Commissioner
Municipal Council
Nuwara Eliya.

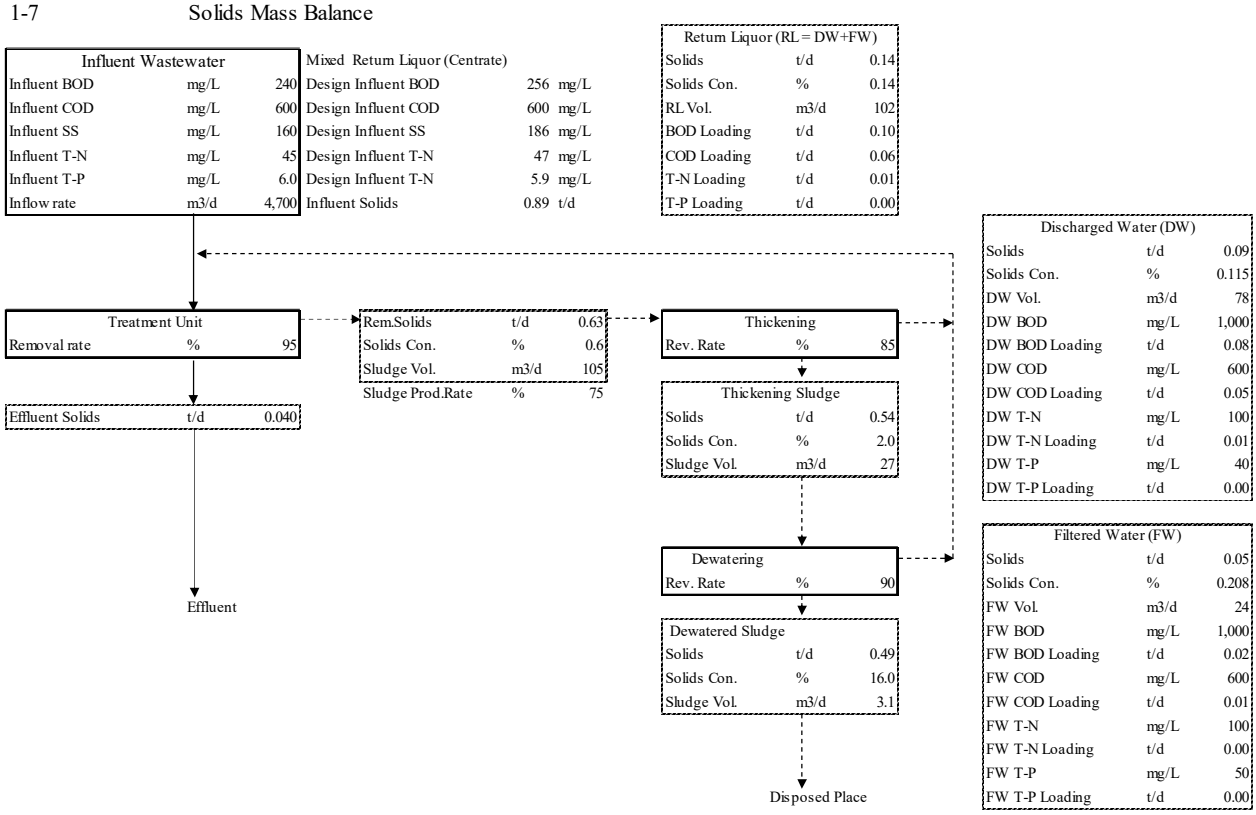
APPENDIX 5-3 Capacity Calculation for Sewage Treatment Plant (5.3.3)

This appendix describes the capacity calculation for STP.

(1) Design Conditions

Item	Calculation
1. Design Parameters	
1-1 Outline of Wastewater Treatment Plant	
(1) Type of Collection System	Separate Sewer System
(2) Wastewater Treatment Process	Oxidation ditch
1-2 Design Flowrate Wastewater	
(1) Average Daily Flowrate	3,900 m^3/d
(2) Maximum Daily Flowrate	4,700 m^3/d
(3) Maximum Hourly Flowrate	10,300 m^3/d
1-3 Influent Quality Wastewater	
(1) BOD	240 mg/L
(2) COD	600 mg/L
(3) SS	160 mg/L
(4) T-N	45 mg/L
(5) T-P	6.0 mg/L
1-4 Design Influent Wastewater Quality (Based on 1-7 MB)	
(1) BOD	256 mg/L → 260 mg/L
(2) COD	600 mg/L → 600 mg/L
(3) SS	186 mg/L → 190 mg/L
(4) T-N	47 mg/L → 50 mg/L
(5) T-P	5.9 mg/L → 6 mg/L
1-5 Removal Efficiency (Total System)	
(1) BOD	95 %
(2) COD	75 %
(3) SS	95 %
(4) T-N	70 %
(5) T-P	60 %
1-6 Effluent Wastewater Quality	
(1) BOD	13 mg/L < 20 mg/L (Effluent Discharge Criteria)
(2) COD	150 mg/L < 250 mg/L (Effluent Discharge Criteria)
(3) SS	10 mg/L < 20 mg/L (Effluent Discharge Criteria)
(4) T-N	15 mg/L < 50 mg/L (Effluent Discharge Criteria)
(5) T-P	2.4 mg/L < 5.0 mg/L (Effluent Discharge Criteria)

1-7 Solids Mass Balance



Sludge Production (Maximum Daily Flowrate)

1-8 Return Liquor (with Influent Wastewater)

Quantity = 102 m^3/day
Quantity (DM)= 4,800 m^3/day

1-9 Waste Activated Sludge

Solids = Maximum Daily Flowrate × Influent SS × $0.95 \times 0.75 \times 10^{-6}$
Solids = 4,800 m3/d × 190 mg/L × 95 %×0.75× 10^-6
= 0.64 ds-t/d
Solid Concentration = 0.6 %

Sludge = Solids ÷ Solids Concentration × 10^2
Sludge = 0.64 t/d ÷ 0.6 % × 10^2
Sludge(OUT) = 107 m^3/d

1-10 Thickening

Solids (IN) = 0.64 ds-t/d

Solids(OUT) = WAS × Recovery Rate × 10^{-2}
Solids (OUT) = 0.64 t/d × 85 % × 10^-2
Recovery Rate = 85 %
= 0.55 ds-t/d

Sludge(OUT) = Solids ÷ Solids Concentration × 10^2
Sludge(OUT) = 0.55 t/d ÷ 2 % × 10^2
Solid Concentration = 2.0 %
Sludge(OUT) = 28 m^3/d

1-11 Dewatering

Solids (IN) = 0.55 ds-t/d

Solids(OUT) = WAS × Recovery Rate × 10^{-2}
Solids (OUT) = 0.55 t/d × 90 % × 10^-2
Recovery Rate = 90 %
= 0.5 ds-t/d

Sludge(OUT) = Solids ÷ Solids Concentration × 10^2
Sludge(OUT) = 0.50 t/d ÷ 16 % × 10^2
Solid Concentration = 16 %
Sludge(OUT) = 3.2 m^3/d

(2) Treatment Process

Item	Calculation
2. Screen and Grit Chamber	
2-1 Screen	
Specification of Screen	
Channel Width	w = 0.800 m
Number of Channels (Screen)	2 channels
2-2 Grit Chamber	
Maximum Hourly Flowrate	10,300 m^3/d
Design overflow rate	1,800 $m^3/m^2/d$
Required Area for settling	A = 10,300 / 1,800 = 5.7 m^2
Channel Width	w = 1.500 m
Channel Depth	h = 1.000 m
Channel Length	L = 3.000 m
Number of Channels (Screen)	N = 2 cannel
Area for settling	A = 9.0 m^2
Volume for settling	V = 9.0 m^3
Retention time	T = 9.0 / 10,300 x 24 x 60 = 1.3 min

3. Oxidation Ditch								
3-1 Reactor Volume								
Design Flowrate								
Maximum Daily Flowrate	=	4,700	m^3/d					
Maximum hourly Flowrate	=	10,300	m^3/d					
Hydraulic Retention Time	=	15	hours					
Req. Volume	=	4,700 m3/d × 15 hrs ÷ 24						
	=	2,938	m^3					
Number of Reactors	=	2	Reactors					
Each Reactor Volume	=	2,938	÷	2	=	1470	m^3	
Water Depth	=	5.0	m					
Width	=	3.0	m					
Req. Total Length	=	1,470 m3 ÷ 5.00 m ÷ 3.00 m						
	=	98	m					
Shape of Reactor		Oval						
Length of oval reactor								
	A =	Width ×Water depth - 0.3 ×0.3×2/2						
	=	3.00 m × 5.00 m − 0.3 × 0.3 × 2 ÷ 2						
	=	14.9	m^2					
	=	(V-π×W×A)/2A+2W						
	=	(1,470 m3 − π × 3.00 m × 14.9 m2) ÷ (2×14.9) + 2 × 3.00m						
	=	50.6	m	→	52	m		
Size of Reactors								
Process		Oxidation ditch						
Width	=	3.0	m					
Water Depth	=	5.0	m					
Number of Reactor	=	4	Reactors					
Volume	=	1,511	m^3/reactor	>	1470	m^3	OK	
3-2 Aerators								
(1) Design Parameters								
Maximum Daily Flowrate	=	4,700	m^3/d					
Influent BOD	=	260	mg/L					
Influent S-BOD	=	130	mg/L					
Influent SS	=	190	mg/L					
Influent Kj-N	=	50	mg/L					
MLSS	=	3,000	mg/L					
Aerobic volume ratio	=	0.5						
HRT	=	15	hrs					

(2) Organic Loading Rate

Organic Loading Rate $= \dfrac{X_I \times Q}{X_A \times V}$

V ; Reactor Volume, m^3
Q ; Maximum Daily Flowrate/Reactor
= 4,700 ÷ 4 = 1,175 m3/d
X_I ; Influent BOD = 260 mg/L
X_A ; MLSS

$= \dfrac{260 \times 1,175}{3,000 \times 1,511} = 0.07$ kg/BOD/d/kgMLSS

(3) ASRT

ASRT $= \dfrac{t_a}{24} \times \dfrac{X_A \times V}{X_W \times Q_W}$

$= \dfrac{t_a}{24} \times \dfrac{X_A \times V}{Q \times X_I \times \alpha}$

ASRT ; Aerobic Sludge Retention Time
X_w ; SS in WAS, mg/L
Q_w ; Volume of WAS, m3
t_a ; Aeration Time in a day
= 12 hours
X_I ; Influent SS = 190 mg/L
α ; Sludge production rate per SS 0.75

ASRT $= \dfrac{12 \times 3,000 \times 1,511}{24 \times 1,175 \times 190 \times 0.75}$
= 13.54 day

Sludge Age (Total Time) $= \dfrac{15 \times 3,000 \times 1,511}{24 \times 1,175 \times 190 \times 0.75} = 16.9$ day

(4) Empirical ASRT

ASRT > 40.7 EXP (-0.101 × T)

T ; Lowest water temperature in monthly average
= 15 Celsius

ASRT = 40.7 exp (-0.101 × 15)
= 8.95 day < 13.54 day OK

(5) Prediction of C-BOD based on ASRT

C-BOD : Carbonaceous BOD

C-BOD = 10.42 × ASRT ^ -0.519
= 10.42 × 13.54 ^ -0.519
= 2.7 mg/L

Assuming BOD/C-BOD is 3.0

BOD = 3 × C-BOD
= 3 × 2.7
= 8.1 mg/L < 30 mg/L

(6) Oxygen requirement for BOD oxidation

OD1 = A × (Removed BOD − Denitrified N × K)

A ; Required O_2/Removed BOD
= 0.6 kg as O_2/kg as BOD

K ; Consumed BOD by Denitrification
= 2.0 kg as BOD/kg as N

Removed BOD = 0.260 × 4,700
= 1,222 kg as BOD/d

Denitrified N ; Assuming all nitrified N is denitrified.

OD1 = 0.6 × (1,222 − 235 × 2.0)
= 451 kg as O_2/d

(7) Oxygen requirement for Internal respiration

OD2 = B × Va × MLVSS

B ; O_2 Volume for internal aspiration
= 0.10 kg as O^2/kg as MLVSS/d

Va ; Aerobic zone volume
= Volume ÷ 2

Assuming MLVSS/MLSS is 0.8

OD2 = 0.1 × 6,044 ÷ 2 × 3.0 × 0.8
= 725 kg as O_2/d

(8) Oxygen requirement for nitrification

OD3 = C × Nitrified N

C ; O_2 consumed by nitrification
= 4.57 kg as O_2/kg as N

Nitrified N ; Amount of nitrified nitrogen
; Influent N − Effluent no nitrified N
− nitrogen of WAS

Influent N ; 0.050 × 4,700
= 235 kg as N/d

Effluent no-N ; Assuming all N is nitrified

Nitrogen of WAS = 0.08 (kg as N/kg as MLSS)
× Qw×Xx

$$Q_W \times X_X = Q_{in}(a \times C_{S-BODin} + b \times C_{ss,in} - c \times X_A \times \tau_A) \times 10^{-3}$$

a ; Rate of Sludge conversion from S-BOD
= 0.5 gMLSS/gS-BOD
*S-BOD : Soluble BOD

$C_{S\text{-}BOD}$; Influent soluble BOD
= 130 mg/L

b ; Rate of Sludge production from SS
= 0.95 gMLSS/gSS

C ; Decay rate = 0.04 1/d

τ_A ; Aeration time = 0.5 d

Qw×Xa = 4,700 ×(0.5 × 130 + 0.95 × 190 — 0.04 × 3,000 × 0.5)× 10^-3
= 872 kg/d

Nitrogen of WAS = 0.08 × 872
= 69.8 kg as N/d

OD3 = 4.57 ×(235 — 0 — 69.8)
= 755 kg as O_2/d

(9) Oxygen requirement in Effluent

OD4 = Oxygen in effluent
= 1.5 × 4,700 × 10^-3
= 7 kg as O_2/d

(10) Actual Oxygen Requirement

AOR = OD_1 + OD_2 + OD_3 + OD_4
= 451 + 725 + 755 + 7
= 1,938 kg as O_2/d

(11) Standard Oxygen Requirement

SOR = $$\frac{AOR \times C_{SW}}{1.024^{(t-20)} \times \alpha \times (\beta \times C_S - C_a)} \times \frac{760}{P}$$

C_{SW} ; Oxygen saturation concentration in clean water at 20 Celsius
= 8.84 mg/L

Ca ; Average DO
= 1.5 mg/L

Cs ; Oxygen saturation concentration in clean water at t Celsius
= 8.39 mg/L
t = 23 Celsius

α ; 0.93

β ; 0.97

P ; 720 (470meter above sea level)

SOR = 2,728 kg as O_2/d

= 2,728 ÷ 12 hr = 227.3 kg as O_2/hr

= 227.3 ÷ 60 min = 3.8 kg as O_2/min

Required Oxygen
= $\frac{2,728}{0.26 \times 4,700}$ = 2.3 kg as O_2/kg as BOD

4. Sedimentation Tank	
4-1 Basin Volume	
Design Flowrate	
Maximum Daily Flowrate	= 4,700 m^3/d
Maximum hourly Flowrate	= 10,300 m^3/d
Design overflow rate (For Peak flow)	= 15 $m^3/m^2/d$
S	= $4.90 \times 10^6 \times T^{0.95} \times X_A^{-1.35} \times [SVI]^{-0.77}$
	T ; Lowest water temperature in monthly = 17 Celsius
	X_A ; 3,000 mg/L
	[SVI] ; Sludge density index = 300
S	= 18.1 $m^3/m^2/d$ > 15 $m^3/m^2/d$
Required Area for settling	= 10,300 ÷ 15 = 687 m^2
No. of basin	= 2 basins
Req. Area for one settling basin	= 687 ÷ 2 = 344 m^2
Diameter of basin	= (4 × 344 ÷ π) ^ 0.5 = 21.0 → 16 m
Effective Area	= 16 ^ 2 ÷ 4 × π × 2 = 402 m^2
Depth of basin	= 3.5 m
Overflow rate	
Maximum Daily Flowrate	= 4,700 m^3/d ÷ 402 m^2 = 11.7 $m^3/m^2/d$
Maximum hourly Flowrate	= 10,300 m^3/d ÷ 402 m^2 = 25.6 $m^3/m^2/d$
Settling Time	= (402 × 3.5 × 24) ÷ 4,700 = 7.2 hrs
Req. Length of weir	= (16 — 1) × π = 47.1 m
Weir Loading rate	= 4,700 ÷ 47.1 ÷ 2 = 49.9 $m^3/m/d$

5. Disinfection

5-1 Basin Volume

Design Flowrate

Maximum Daily Flowrate	=	4,700	m^3/d					
Maximum hourly Flowrate	=	10,300	m^3/d					
Contact Time	=	15	minutes					
Req. Volume	=	10,300	÷	24	÷	60	×	15
	=	107.3	m^3					
Depth	=	2.0	m					
Width	=	2.0	m					
Length	=	30.0	m					
Volume	=	2	×	2	×	30		
	=	120	m^3					

6. Sludge Treatment

6-1 Sludge Thickening

Solids (IN)	=	0.64	t/d
Solid Concentration	=	0.6	%
Sludge(IN)	=	107	m3/d
Solid Loading Rate	=	40	$kg/m^2/d$
Req. Area	=	0.64 × 1,000 ÷ 40	
	=	16	m^2
No. of basin	=	2	basins
Req. Area for one settling basin	=	16 ÷ 2 = 8	m^2
Diameter of basin	=	(4× 8 ÷ π) ^ 0.5	
	=	3.2 → 4.0	m
Effective Area	=	π /4× 4.0 ^ 2 × 2	
	=	25.1	m^2
Depth of basin	=	3.8	m
Overflow rate	=	0.6 t/d ÷ 25 m^2 × 1,000	
	=	25.5	$kg/m^2/d$
Settling Time	=	(25.1 × 3.8 × 24) ÷ 107	
	=	21.4	hrs

6-2 Sludge Dewatering

Solids (IN)	=	0.55	t/d
Solid Concentration	=	2	%
Sludge(IN)	=	28	m3/d
Operation Conditions		7 hrs in one day and 6 days in a week	
Req. dewatering capacity	=	0.55 × 7 ÷ 6 ÷ 7 × 1,000	
	=	92	kg/hour
Solids loading	=	3.1	kg-ds/h/ ϕ 100
Diameter of dewatering	=	400	mm
Number	=	2	
Dewatering capacity	=	(400 / 100)$^{2.2}$ × 3.1 × 2	
	=	130.9	kg/hour

APPENDIX 6-1 TOR for Consulting Service for the NUWARA ELIYA SEWERAGE CONSTRUCTION PROJECT (6.4.1)

Appendix 6-1 is undisclosed.

APPENDIX 6-2 Estimated Project Implementation Schedule (6.5.5)

Appendix 6-2 is undisclosed.

APPENDIX 6-3 Detailed Breakdown of Construction Cost (6.6.1)

Appendix 6-3 is undisclosed.

APPENDIX 6-4 Breakdown of Operation and Maintenance Cost (6.6.2)

Appendix 6-4 is undisclosed.

APPENDIX 6-5 Annual Fund Requirement (6.7)

Appendix 6-5 is undisclosed.

APPENDIX 6-6 Calculation for Share of Japanese Product in Total Construction Cost (6.7)

Appendix 6-6 is undisclosed.

APPENDIX 7-1 Detail of Unit Sewerage Tariff Calculation (7.3.2)

Appendix 7-1 is undisclosed.

APPENDIX 7-2 Social Condition Survey (7.3.3)

Appendix 7-2 is undisclosed.

APPENDIX 7-3 Economic Analysis of the Proposed Sewerage Project (7.4.2)

Appendix 7-3 is undisclosed.