Smart City scheme, CLOSED-LOOP WASTEWATER SYSTEM

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CEGE 0048 – Integrated Design

UCL

Project Background

Smart City Scheme

The smart city scheme (SCS) is an ambitious programme set up by the Mauritius government to attract global investors and provide them with a platform to create intelligent, innovative and sustainable future cities across the Mauritius island [1]. The target for the programme is aimed at fusing Mauritius into a full-fledged international business and financial environment [2]. The smart city scheme focuses on the creation of environmentally friendly working, living and leisure spaces in terms of water recycling, energy regeneration and advanced transportation system [2]. Under the 'smart city scheme', an existing site in the Pamplemousses district needs to be redeveloped to meet the sustainable criteria and scheme target. Therefore, a closed-loop wastewater system is assigned as a more effective way for water management to utilise the water usage within the area.

Site Introduction

- **Location:** Located at west of the Pamplemousses District, covering an area of 230 hectares. The Pamplemousses District is located in the northwest of Mauritius Island.
- **Climate:** The site enjoys a climate type of maritime subtropical with a fairly uniform temperature throughout the year and most of the precipitation occurs between December and April.
- **Ecological system:** The volcanic origin, special topography, isolation from the main continental plates of the island of Mauritius, contribute to the biodiversity of the island and makes the island home to endemic species such as Mauritius grey white-eye, Pink Pigeon, samber etc [3].
- **Ethnicity:** A plural society, present multi-ethnic beliefs and multi-lingual environment. Hinduism, Christianity and Islam as predominant religions and English as the official language. French and Creole are also languages frequently used by the local people [3].
- **Land use and Infrastructure:** The previous use of the area are commercial use and residential use. There is an existing water basin and sufficient infrastructure such as road, electricity cables, water course and irrigation canals. However, lack of a municipal sewer system.

Figure 1: Location Map [4]

Design Overview


Figure 3: Wastewater treatment plant design

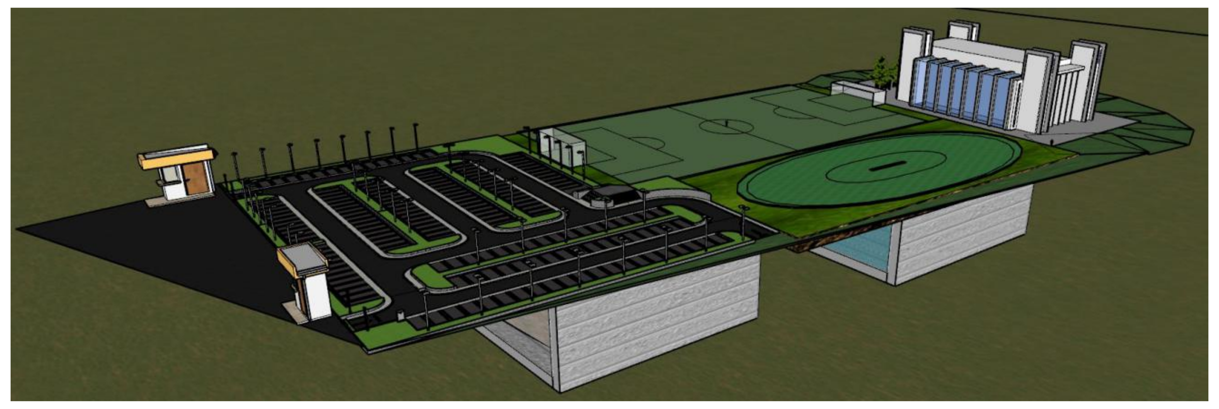
Figure 4: Water storage design

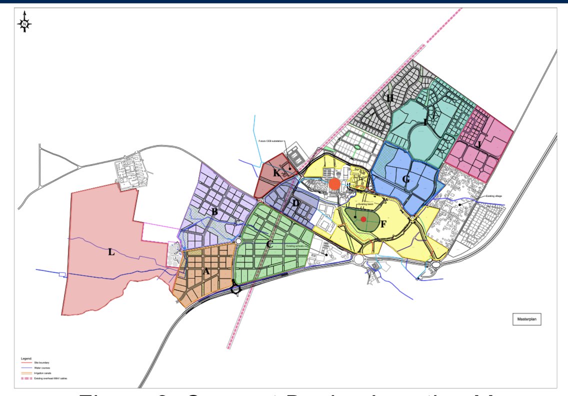
Figure 2: Concept Design Location Map

The concept design for the project which consists of one central plant and one additional storage system. The central wastewater treatment plant will be located at the site of the abandoned sugar factory, while the underground storage system will be constructed at the site of the existing basin near the central plant.

The central factory includes separate components housing different facilities for each step of treatment:

- Primary treatment
- Secondary treatment
- Tertiary treatment
- Additional Treatment: Sludge Treatment

The storage system consists of two chambers that for untreated harvested rainwater and treated clean water respectively. The untreated storm water will be firstly collected in the untreated water tank, pumped to the treatment factory and transported to the treated water storage tank after full treatment. A football pitch and a hockey pitch together with a relative sports/leisure centre will be constructed above the ground. The storage capacity for treated water and untreated stormwater are 6,500 m^3 and 50,000 m^3 respectively.

System Design

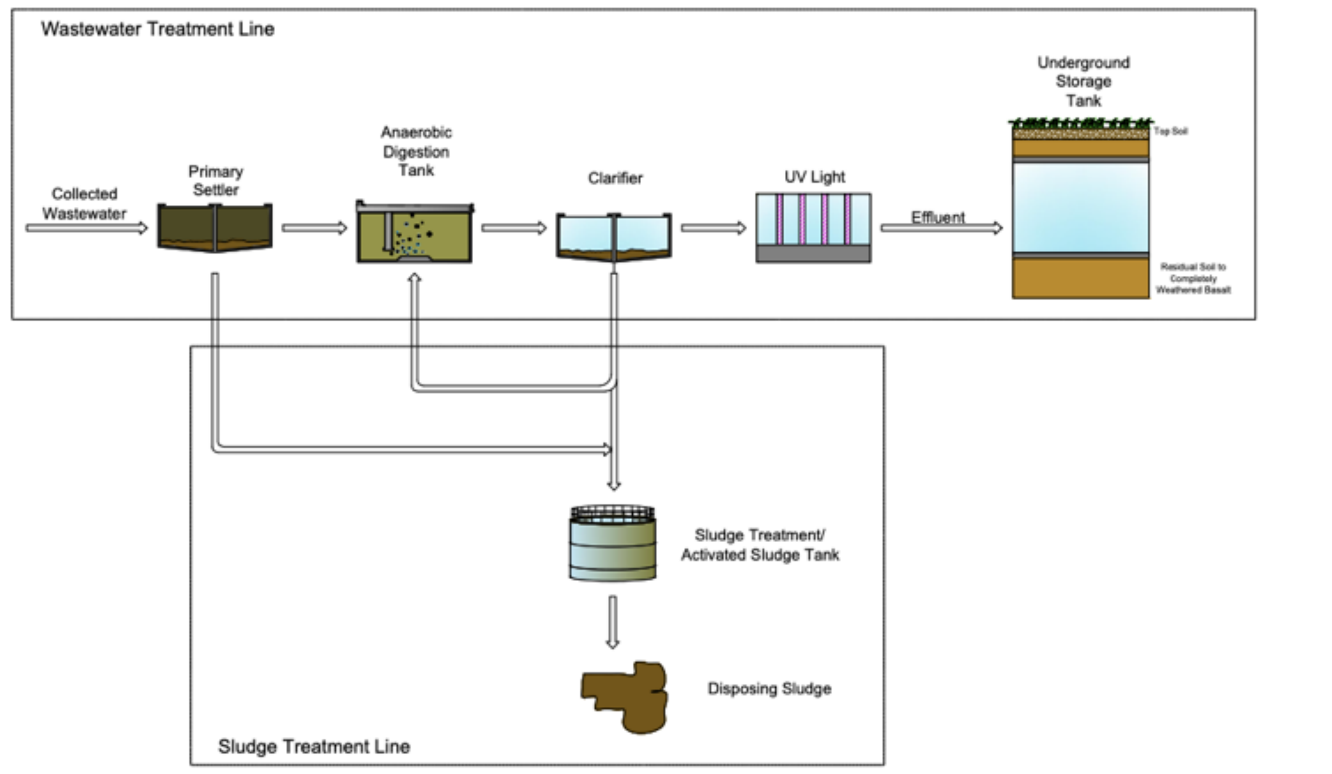

Figure 5: Wastewater Treatment Plant System Flow

The conventional wastewater treatment processes can include physical and biological operations for removing the solids, organic matters and undesired particles in the effluents.

- Primary treatment: Remove the settleable suspended solids (SS) and floating solids, such as plastics, wools, garbage pieces, grease, oil and faecal matters, etc.
- Secondary treatment: Reduce the biochemical oxygen demand (BOD) in the effluent from the previous treatments.
- Tertiary treatment: Ultraviolet light with reasonable costs is used for disinfection as advanced treatment.
- Sludge treatment: The effluent from the former treatments will firstly enter an aeration tank which can be activated by an input of oxygen, so the micro-organisms can be metabolised with biogas. The ultimate sludge waste is disposable and recycled for agricultural use [5].

Community

Community Engagement

Local Labour: Use of local labour wherever possible. This promotes self-sufficiency and increased skill set for future projects.

Local Culture: A predominantly sub-terranean network was most appropriate to their priorities and cultural sensitivity.

Future development: Option to upgrade wastewater facilities for existing nearby villages is a strong positive for wider communities at the edges of the scheme.

Geotechnical Design

There are two primary considerations for geotechnical design, soil conditions and groundwater levels. For soil conditions, moderately weathered basalt is considered difficult to make construction activities. Sheet piles type is recommended to provide two rings of concrete soil mix secant piling around the central plant site. This would be a hard-soft combination allowing soft piles to be worked with at relevant locations. Grouting at the base against sound basalt bedrock will provide a sealant against most seepage. Between the two ring pumps and other plants can be placed providing functionality to the system in an isolated area, the use of compartments within the rings can be explored in construction planning to further the benefits of isolating measures. A depth of 5-6m is predicted to provide desirable outcomes in this case.

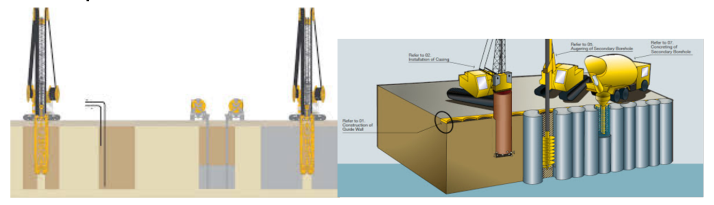
Figure 6: Two-phase Setup for Diaphragm walls

Project Management

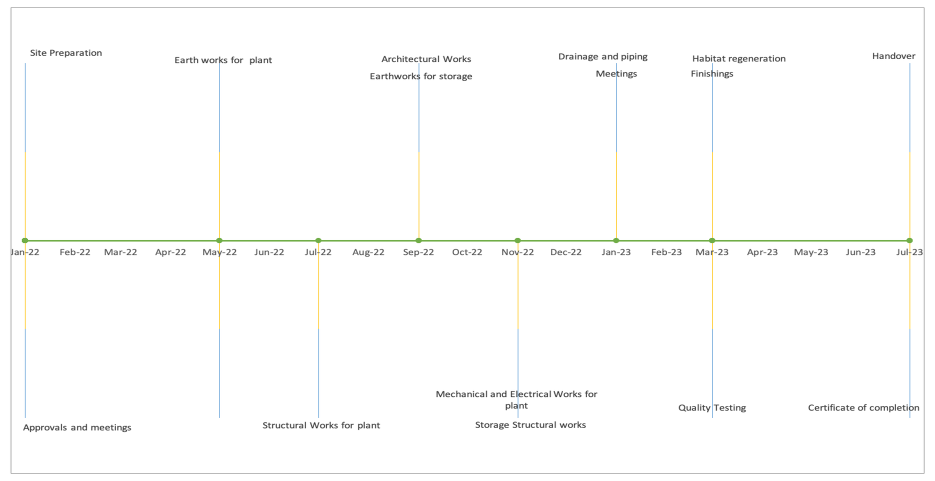
Figure 7: Project Timeline

Project Timeline

The proposed schedule for construction and testing of the treatment plant and storage facility is illustrated above. The plant is expected to be completed and handed over within a year and 6 months. Delays and float times are accounted for in the schedule to account for constraints.

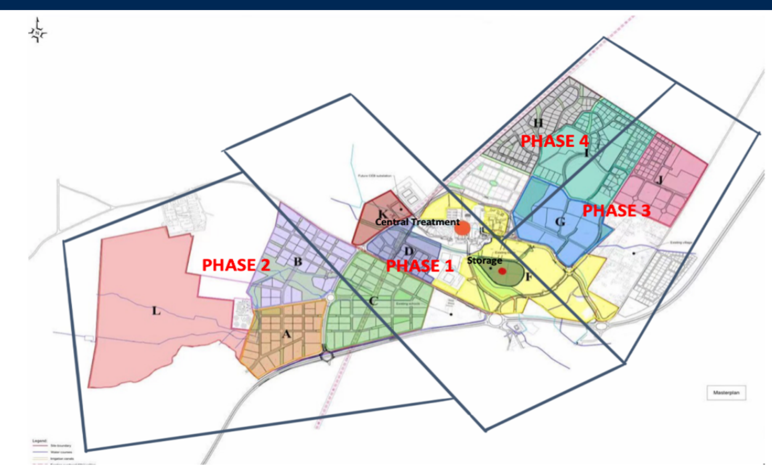

Figure 8: Phasing Plan

Phasing Structure

The smart city is expected to be built and developed in four phases over a 20-year timeline. The accepted design will include a central treatment plant and a storage facility constructed in the initial phase of the project.

Financial Assessment

Factors Affecting Cost

The cost of the wastewater treatment system is dependent on numerous factors, the following of which, were considered to produce the final cost estimate of the plant.

- Design costs
- Quality of influent and effluent
- Quantity of water treated
- Material availability
- Operation costs
- Disposal costs
- Degree of system automation

Table 2: Estimated payback period of the Smart City Scheme

Total Construction Cost	£112,000,000.00
Year	**Cumulative Estimated Earnings (End of Year)**
14	£104,000,000.00
15	£120,000,000.00

Figure 11: Anticipated rent earning

Cost of Plant

The cost estimate of the plant was evaluated, based on published articles for ultraviolet wastewater treatment systems. The figure was found to be slightly higher with an overall total of approximately **£5.52 million**. This includes both design costs as well as contingencies.

Economic Benefits of this Project

- Established branding of the developer,
- Attract international investment,
- Increased social capital by broadening the networks of relationships between people living and working within the city,
- The scheme will generate thousands of new jobs for locals,
- Increased property value for the developer as well as individuals owning nearby land,
- Increase revenue; local cash-flow, boosting the economy,
- Facilitate generation of new local businesses,
- The smart city will enhance the quality of life of both the residents and the surrounding areas.

Environmental Impact Assessment

Table 1: Environmental Impact Assessment

IMPACT	LEVEL OF RISK	MITIGATION
Contamination of Water Bodies and waste disposal	H	- Dip trays to prevent spills -Safe storage of toxic materials -Nontoxic alternate forms of substances -Correct waste disposal practices
Noise Pollution	M	- Restricting construction times - Use low level machinery - Considering sensitive periods of the year.
Air Pollution	H	- Monitoring of air quality - Reduce traffic congestion to and from site - Minimal dust generation
Habitat and Soil Disturbances	H	- Habitat relocation where necessary - Identify vibration sensitive zones - Extensive soil sampling and borehole data analysis
Impact on vegetation	M	- Restore vegetation after clearance
Visual Impacts	M	- Modern design - Suitable sizing to fit environment

Environmental Impact Assessment (EIA) is carried out to assess the long term and short-term impacts of the project both positive and negative on the environment and its inhabitants as a whole. This is conducted at the early stage of the planning process in order to mitigate the adverse reactions identified and adapt the project to fit into the local environment.

Project Risk

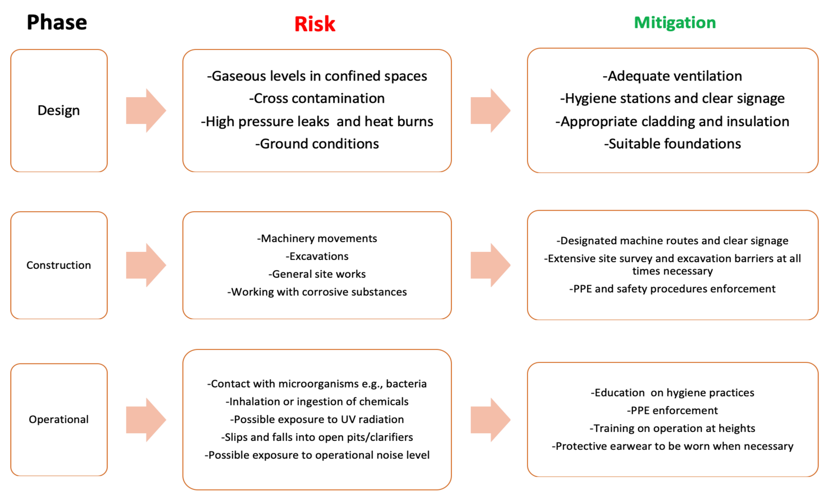

Figure 9: Health and Safety

Health and Safety

Another important aspect of the project is analysing the health and safety of the project. Health and safety is split into design, construction and operational risks.

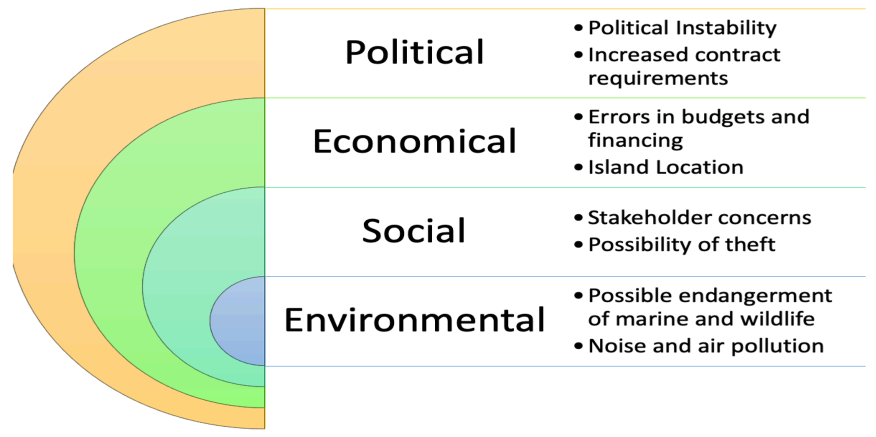

Figure 10: Risk Assessment

General Risk Assessment

Aside from the health and safety risks identified, general project risks need to be accounted for to give a well-rounded assessment of potential risks which could affect the quality, and schedule of the project.

References

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