



SPONGE PARK FRAMEWORK FOR RESILIENT OPEN SPACES

Manual and Capacity building to transform open space reservations to Sponge parks in Chennai



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Sponge Park Framework for Resilient Open spaces

Manual and capacity building to transform open
space reservation into Sponge Parks in Chennai

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Foreword

Dr Julie Reviere,

Country Director,

Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ), India



Cities in India face significant climate change-related challenges, including extreme weather events such as heatwaves, floods, and cyclones. Rising temperatures and pollution levels exacerbate health issues and threaten water and food security. Additionally, rapid urbanisation and population growth intensify the demand for resources, putting further pressure on already stressed systems. These challenges make sustainable urban planning, improved infrastructure resilience, and robust climate adaptation strategies essential for the future of Indian cities.

Chennai, one of the most vulnerable coastal cities in the Indian state of Tamil Nadu, has been an epicenter of extreme weather events over the last decade. To cope with the negative impact of climate change, the city administration has been developing various mitigation and adaptation measures. The initiatives include, amongst others, the implementation of the so-called 'sponge' approach which aims at designing urban areas to absorb and retain rainwater, reducing flooding and enhancing groundwater recharge. Open spaces are converted into sponge parks to reduce localised flooding and improve groundwater levels. The approach has been piloted in a small number of open spaces. Based on the initial results, the approach will be adjusted and scaled up to keep pace with the rapid urbanisation in the state.

To drive forward the successful implementation of the sponge approach, the city of Chennai is receiving technical support from the Indo-German development cooperation project 'Sustainable Urban Development - Smart Cities II (SUDSC II)'. The project works towards promoting risk-informed, resilient and gender-responsive sustainable urban development. Commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ), the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH implements the project in close cooperation with the Ministry of Housing and Urban Affairs, Government of India. Those joint efforts also contribute to the Green and Sustainable Development Partnership (GSDP) between India and Germany, which declares sustainable urban development as a priority area of bilateral cooperation.

Against this background, GIZ India has partnered with the Greater Chennai Corporation to address current gaps in the implementation of sponge parks. By contributing our individual strengths, we have jointly developed the manual *Sponge Park Framework for Resilient Open Spaces* which aims to reinstate urban resilience and complement city and state efforts to mitigate and adapt to climate change related challenges. The manual closes planning and implementation gaps through the Sustainable Infrastructure Framework. It guides the city administration in the planning, design, implementation, maintenance and enhancement of sponge parks with step-by-step guidelines and checklists.

I would like to thank the Ministry of Housing and Urban Affairs, Government of India, the Municipal Administration and Water Supply Department, Government of Tamil Nadu and the Greater Chennai Corporation for this fruitful cooperation and their continuous support. I am convinced that this manual will play an important role in improving urban resilience and sustainable urban development. Chennai's experience will inspire other Indian cities to adopt a similar approach. With our joint efforts, we are making an important contribution to the Government of India's efforts towards climate-friendly and sustainable urban development and the realisation of the Green and Sustainable Development Partnership between India and Germany. I wish us all the best for future endeavors in this context.

Dr Julie Reviere



Country Director
GIZ India

Message from the Commissioner.

Dr. J. Radhakrishnan IAS,

Additional Chief Secretary to Government / Commissioner
Greater Chennai Corporation



Unplanned and rapid growth of cities is leading to increase in climate induced disasters including floods, storms, heatwaves reducing the cities resilient capacity to address them. Preserving or restoring natural features by adopting nature-based solutions, holistic and integrated strategies to reduce climate risks and innovative ways to address these challenges are imperative for sustainable development of cities.

Chennai has witnessed massive growth in the last two decades exerting tremendous pressure on its existing natural ecosystems and open spaces. The problem is further compounded by unprecedented climate events like extreme cyclones and floods, water scarcity, heat wave, etc. In 2015, Chennai witnessed one of the major floods in its history that damaged habitation causing loss of lives and huge economic losses. Further, climate change projections predict that the city would face extreme storm events and water scarcity, requiring the city to manage and provide innovative solutions to address them.

In response to addressing these challenges, Greater Chennai Corporation (GCC) has embraced the sponge approach for transforming open spaces and existing parks into 'sponge parks' by applying the principles of nature conservation for enhancing resilience to withstand natural hazards by making urban spaces more permeable and preventing floods. On a pilot scale Greater Chennai Corporation (GCC) has undertaken Singara Chennai 2.0 -initiatives for converting parks into sponge parks. GCC is the pioneer in developing sponge parks and proposes to scale up sponge park model exponentially to increase permeable surface to mitigate flooding.

This requires the need for a framework / guideline based on the learnings, best practices from across the globe and develop strategies for institutional strengthening to make Chennai a 'Sponge City'. In collaboration with Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and Sponge Collaborative, this manual has been prepared which will act as a guideline for Greater Chennai Corporation in enhancing the quality of open spaces by adopting nature-based solutions with a gender-responsive approach. I appreciate this collaboration, and congratulate the team in coming up with this manual. I strongly feel that the framework is applicable to urban local bodies across the state. This manual is to be disseminated across the state in complimenting the efforts of the Government of Tamil Nadu in promoting sustainable urban development. We should strive for a multi-stakeholder partnership with businesses, industries, civil society, to scale up such mitigation and adaptation efforts in our vision of making our cities more resilient.



Dr. J. Radhakrishnan IAS

Additional Chief Secretary / Commissioner,
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Executive Summary

Home to more than 12 million people, Chennai is a rapidly industrialising metropolis that has experienced one of the fastest growth rates in India in the last 20 years. Over the past decade, Chennai has also experienced historic flood events, periods of extreme water scarcity, and record heat. Climate change is expected to increase the recurrence and intensity of events like cloudbursts, cyclones, storm surges, and drought. Chennai's urbanisation so far has led to the indiscriminate loss of green cover, encroachment or pollution of water bodies, and overexploitation of the aquifer. This has made Chennai even more vulnerable to climate risks as the concretisation of the city's basins or catchment areas increases runoff from storm events at volumes and speeds that overwhelm the storm water drainage system. Increased imperviousness also remove typical opportunity for natural recharge of the aquifer during rain. Chennai's monsoons are no longer a resource but a threat.

The Sponge City approach seeks to bring back the water balance of urban areas by leveraging nature-based solutions so cities can act like "sponges" during rain events. A Sponge City slows down storm water runoff, makes room for flooding through storage of rainfall, and allows rainwater to recharge the shallow and deep aquifers. Chennai can become a Sponge City by **Protecting** green areas and water bodies that regulate flooding or recharge from urban development or encroachment; **Restoring** degraded water bodies to improve their stormwater storage and aquifer recharge capacity; **Enhancing** coastal, riparian, and wetland ecosystems to withstand extreme flood or storm events; and **Constructing** blue-green infrastructure to replicate the regulating ecosystem services of natural systems in constrained urban areas. Figure i

shows a spatial metropolitan framework for how these actions can collectively transform Chennai into a Sponge City.

Sponge Park Framework for Resilient Open Spaces focuses on how **Chennai's more than 1,100 open space reservations (OSRs)** - government-owned land designated for community recreational purposes- can be transformed into a network of blue-green infrastructure by constructing Sponge Parks.

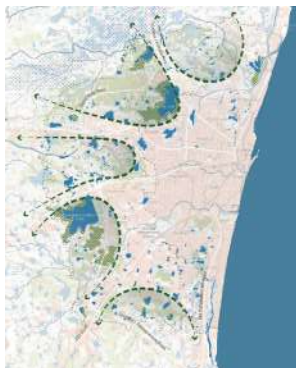
OBJECTIVE / Building Capacity for scaling up Sponge Parks

The Greater Chennai Corporation (GCC) has proactively began the construction of **57 Sponge Parks** as a pilot project in parks and OSRs (Refer to Figure ii). However, the pilot revealed certain institutional and technical gaps and design issues compared to best practices (Refer to Figure iii). This manual addresses those gaps so Spone Parks can be scaled up as a more holistic intervention that becomes a resilient infrastructure network. In order to do so, the study (i) conducted an institutional gap assessment, (ii) developed a spatial prioritisation framework for Sponge Parks in OSRs based on environmental suitability and social need for parks, and (iii) produced this manual to guide GCC decision makers and engineers to implement holistic Sponge Parks.

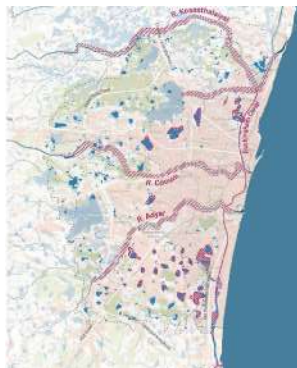
FRAMEWORK / Sustainable Infrastructure Lifecycle

The study utilises the **Sustainable Infrastructure Principles** as defined by GiZ and UNEP to ensure that Sponge Parks are built in a manner that ensures economic needs, social inclusion, environmental resilience, and institutional sustainability in line with Sustainable Development Goals (SDGs) over the entire

Protect : Ecosystems and water bodies from encroachment or pollution



Restore : Ecological functions of degraded or polluted landscape



Enhance : Coastal, riparian and wetland areas to withstand climate change



Construct : BGI in urban open spaces to replicate nature systems

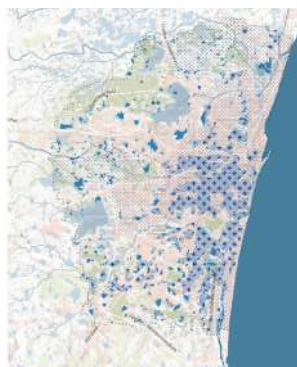


Fig. i. Metropolitan Framework for Sponge City Chennai



Fig. ii. Recharge pit in a constructed Sponge Park by Greater Chennai Municipal Corporation



Fig. iii. Example of Sponge Park constructed in Bangkok by LANDPROCESS

infrastructure lifecycle. The Sustainable Infrastructure Lifecycle is used as a framework to organise the institutional gap assessment and this manual. This is organised in the following way:

Planning Sponge Parks:

A. Strategic Planning, B. Prioritisation

Designing Sponge Parks:

C. Project Planning, D. Concept Design, E. Detailed Design

Implementing Sponge Parks:

F. Finance, G. Procurement, H. Construction

Maintaining Sponge Parks:

I. Operations and Maintenance

Improving Sponge Parks:

J. Monitoring and Repurposing

KEY TAKEAWAYS // STRATEGIC PLANNING FOR SPONGE PARKS

Strategic Planning for Sponge Parks requires evidence-based decision making and community engagement to ensure the upgraded open spaces form a resilient network to mitigate disaster risks while addressing social park needs.

A. Strategic Planning

Currently, the GCC does not have a strategic framework to scale up the Sponge Park pilot due to technical capacity gaps and data gaps. This study focused on all the OSRs and ranked them based on environmental suitability (OSRs on permeable soil and geology in areas with flood or aquifer exploitation risks) and social needs (OSRs in wards with low access to parks, low park area per capita, low greenery and high built-up density as proxies to extreme heat). This is a pre-feasibility product that provides a roadmap for climate adaptation and urban forestry investments across 1,100+ OSRs. (Refer to Figure iv) Representing an area of 515 acres, upgrading all OSRs into Sponge Parks would effectively double the park area per capita in Chennai.

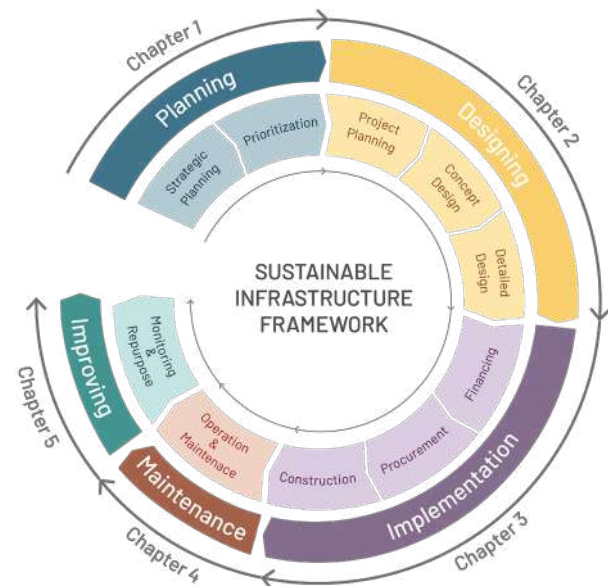


Fig. iv. Sustainable Infrastructure Lifecycle as framework for Manual Chapter organisation

B. Prioritisation

Prioritisation refers to having a systematic way to determine which OSRs can be upgraded to have the most positive environmental and social impact on communities. The study identified 112 Priority OSRs due to their high environmental suitability rankings and location within wards with high park needs. (Refer to Figure v)

GCC is provided with a geodatabase of all OSRs and Wards along with attributes and rankings. Zonal Engineers can use this prioritisation tool with ward representatives to assess the upgrading of which OSRs will benefit the surrounding community and ground truth the city level study with ward level observations about the open space and the stormwater drainage networks.

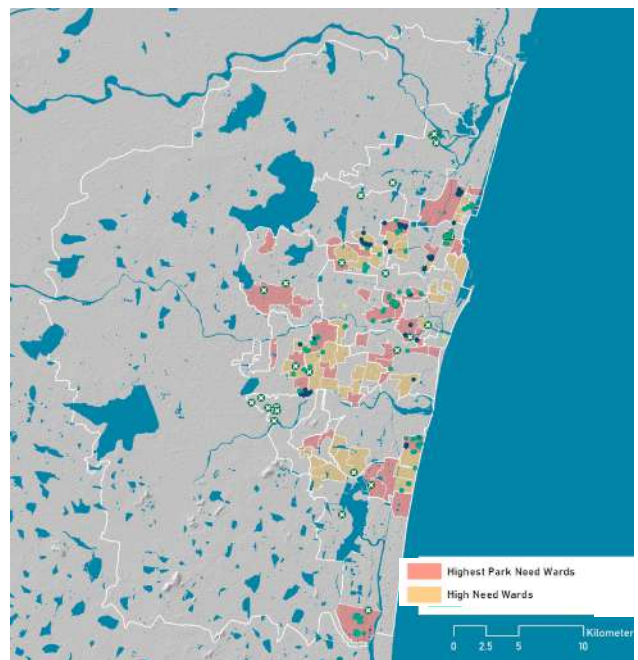
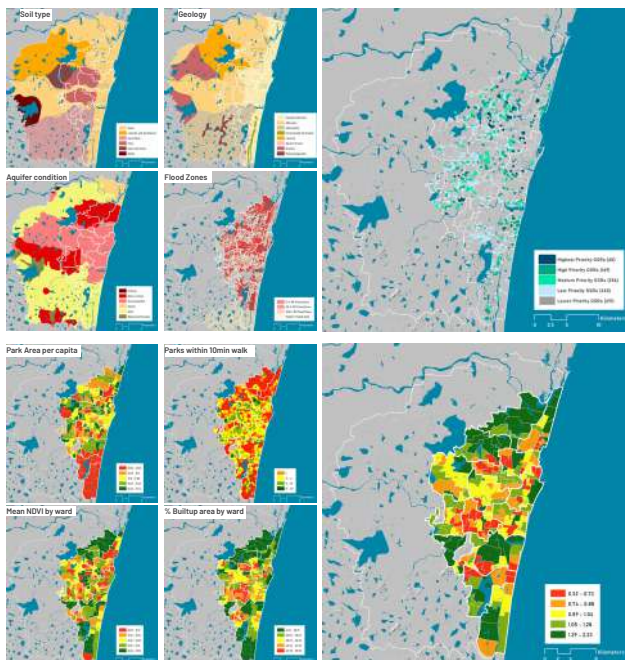


Fig. v. Spatial multicriteria analysis workflow to identify Priority OSRs and Wards

KEY TAKEAWAYS // DESIGNING SPONGE PARKS

Designing holistic Sponge Parks that are climate resilient and socially inclusive requires the thoughtful integration of four **Sponge Park Systems**:

S.1. Soil and Grading: Modifying soil composition, improving soil health, and contouring earthworks to create zones for intensive planting, programmed spaces, and hydrology

S.2. Hydrology and Blue-Green Infrastructure: Ensuring the sequence, sizing, and detailing of BGI components strategically delays, stores, and stores runoff while recharging the aquifer

S.3. Vegetation and Planting: Working with existing vegetation and native species to create a biodiverse, resilient and aesthetic habitat and microclimate that is optimised for maintenance

S.4. Amenities and Facilities: Catering to the needs of local communities by maximising access, fostering inclusion of marginalised groups, ensuring safety of women, and programming the park for a diversity of user groups

The manual also provides detailed guidance on how these systems come together across four **Sponge Park Typologies** based on size of the park: **(S)** Small (<0.2 acres), **(M)** Medium (0.2 - 1 ac), **(L)** Large (1 - 5 ac), **(X)** Special (> 5 ac)

C. Project Planning

At the Project Planning stage, the OSR selected for the Sponge

Park upgrading should be evaluated at the catchment scale with detailed site assessments to determine the feasibility of disaster risk mitigation and the social needs for programming (Refer to Figure vi). Project Planning steps to finalise site selection are organised by Sponge Park Systems

S.1. Soil: Measure infiltration rates to determine recharge potential. Candidate OSR should have high infiltration. Assess soil composition to determine nutrients and contaminants. Candidate OSR should have uncontaminated soil with remedial potential.

S.2. Hydrology: Delineate catchment area and point source pollutant or combined sewer runoff drains. Candidate OSR should not have any industrial pollutants or sewage in contributing drains. Model flood scenarios to determine preliminary sizing of BGI components (Refer to Figure vii). Identify hydrological zones for conveyance, storage and recharge. Candidate OSR should have sufficient space to store runoff from at least a 5 year storm event.

S.3. Vegetation: Study existing vegetation in and around OSR for native and invasive species. Map existing trees and identify forest zone for intensive plantation / urban forestry project. Candidate OSR should show potential to increase biodiversity and greenery.

S.4. Amenities: Audit social amenities available to the local community within 10 minutes walk of the OSR. Identify zones for social facilities. Candidate OSR for parks more than 0.1 ac should provide facilities based on community feedback and audit results.



Fig. vi Community engagement with special audit session for women's needs

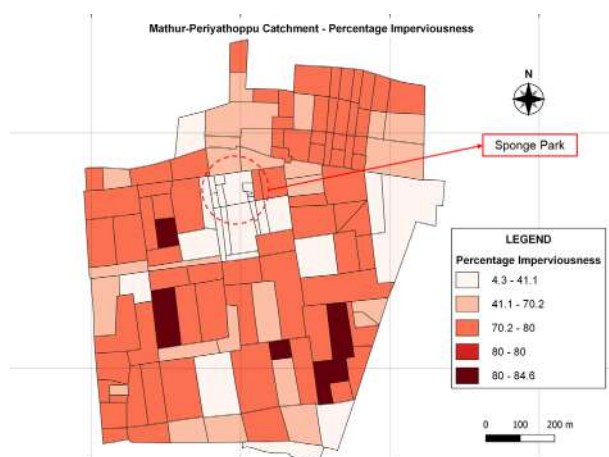


Fig. vii. Catchment level analysis for environmental impact and hydrological flows

D. Concept Design

At the Concept Design Stage, critical decisions are made about how the planned Sponge Park systems come together on site. These decisions have ramifications across the entire infrastructure lifecycle so the manual has provided detailed guidance for each system (Refer to Figure viii) and how it relates to each typology (S, M, L, X).

S.1. Soil and Grading: The manual highlights the importance of soil composition and topography as foundational to good hydrology and thriving vegetation. Soils for Sponge Parks should be improved in the following ways:

Grade the park with clear topographic strategy and appropriate earthworks for stormwater conveyance and storage

Amend compacted soil and improve soil nutrients based on soil composition assessment

Enhance soil nutritional quality in forest zones at higher elevations with organic matter and mulching

Porosity of soil in infiltration zones at lower elevations should be increased with appropriate sand, soil, and gravel mix

S.2. Hydrology and Blue-Green Infrastructure: The manual describes nine BGI toolkits and how they may be positioned in Sponge Parks of all sizes based on the following functions:

Delay runoff conveyance through raingardens or bioswales designed to mimic natural stream flows with bunds as needed

Store stormwater in gently graded recharge pits, detention ponds, sunken courts, and water plazas designed to handle specific storm periods with provisions for overflow

Filter stormwater through vegetated channels, constructed ponds, wetlands, infiltration basins, and wells with filters

Recharge the aquifer with filtered runoff through basins, pits, and wells collected within the park or from extended catchment areas without industrial or sewage pollution

S.3. Vegetation and Planting: The manual presents seven planting mixes with planting layout and species recommendations so Sponge Parks can achieve the following qualities:

Biodiversity through structural diversity, native species, in planting mixes, and intensive forest patches

Resilience to heat through creation of cooler microclimate around trees and strengthening BGI performance

Aesthetics with positive health effects with layered greenery, gardens, pollinator parks, and integration with lighting

Maintainability through species selected, placing trees away from pits/wells, and design provisions for collecting leaf litter

S.4. Amenities and Facilities: The manual positions social infrastructure as a critical level for social inclusion and provides gender-sensitive guidelines that achieve the following goals:

Accessibility for all ages and abilities who benefit from accessible pathways, walkable access and clear circulation

Inclusion of all user groups and genders through diversity of spaces, programming, and nature-based recreation

Safety of women and other genders through safe spaces, clean facilities, maintained spaces, and well-lit parks

Services account for all social, recreational, and health needs

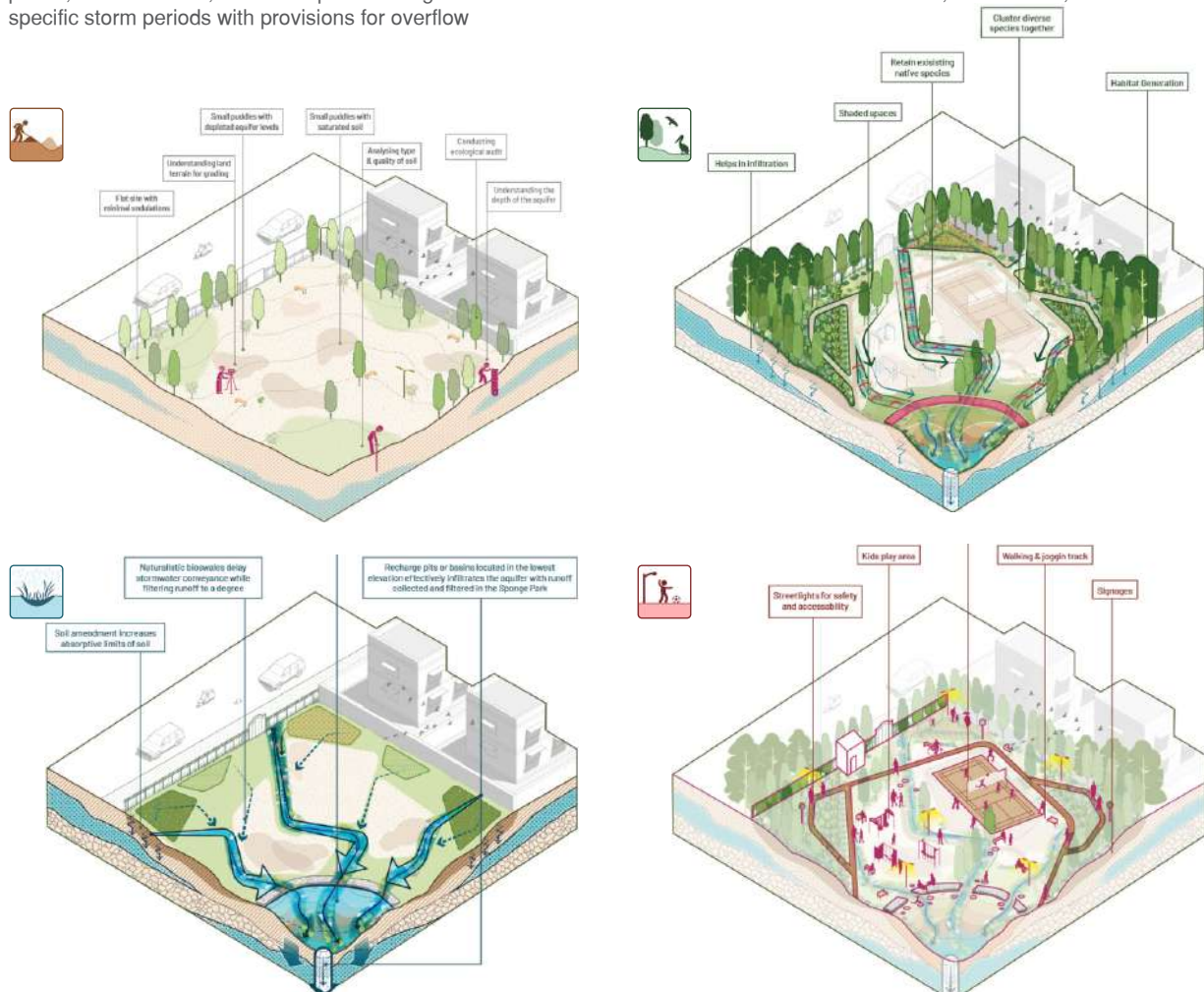


Fig. viii. Visualisation of design guidelines for integrating Sponge Park Systems holistically

E. Detailed Design

All design guidelines for Sponge Park systems are cross-referenced with Annexes for more technical readers to understand soil mixes, blue-green infrastructure sizing, planting species, and other details necessary for the creation of drawings and specifications for tender. Illustrations of BGI components as seen in Figure ix convey detailing considerations to technical readers of this manual

KEY TAKEAWAYS // IMPLEMENTING SPONGE PARKS

F. Financing

Chennai is currently financing Sponge Park pilots through a local government program. The manual suggests there are a number of creative **climate adaptation financing** schemes from Central Government and multilateral agencies that can support scaling up Sponge Parks. State and local government **budgetary allocations** in stormwater drainage, drinking water, and disaster risk reduction can also be utilised. Specific town planning regulations that require new townships to retain existing runoff levels can unlock **private sector financing** as developers would have to meet requirements

G. Procuring

The manual is meant to provide enough guidance for GCC to design small (S) Sponge Parks for tendering. The construction of larger parks will require procurement at other stages of the lifecycle with multidisciplinary expertise ranging from landscape architecture to hydrology to civil engineering. The manual recommends **empanalment of consultants, contractors, and vendors** who can deliver on the specifications that Sponge Parks demand.

H. Constructing

Construction practices have to follow detailed specifications enforced by dedicate supervision from qualified professionals. The manual stresses the importance of pollution control (esp. hydrocarbons around infiltration zones), sediment and erosion control, scheduling of activities to optimise the construction of blue-green infrastructure, and proper handling and timing of planting.

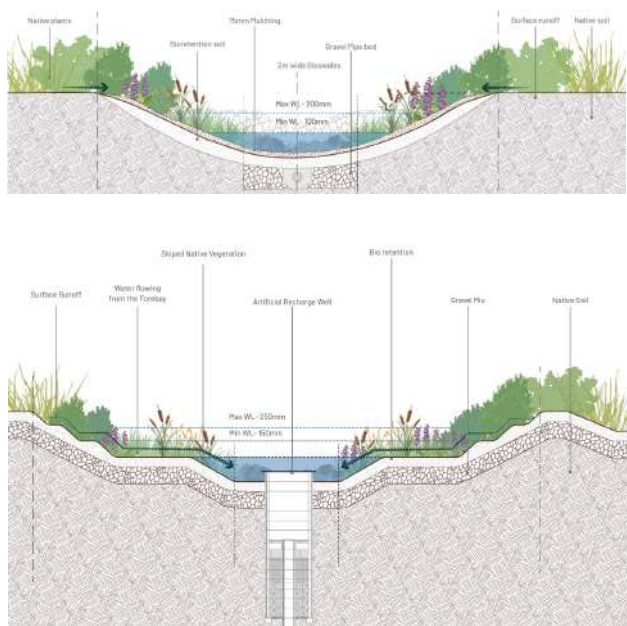


Fig. ix. Detailed drawings of BGI components (Bioswales and Recharge Pit)

KEY TAKEAWAYS // MAINTAINING SPONGE PARKS

I. Operations and Maintenance

Maintaining the soil quality, BGI components, plants, and facilities will ensure the long-term sustainability of Sponge Parks. The manual catalogs important maintenance activities into **Regular and Reactive** weekly or monthly actions with varying intensities depending on the Sponge Park system and season. **Semi-annual and Annual** actions are important to upkeep the performative aspects of the Sponge Park. The seasonal aspect of maintenance regimes is systematically organised within a framework developed by the study as seen in Figure x

KEY TAKEAWAYS // IMPROVING SPONGE PARKS

J. Monitoring and Repurposing

It is important to continuously monitor how Sponge Parks are providing these benefits to build evidence for scaling it up in Chennai, Tamil Nadu, and India at large. The manual recommends monitoring for the following:

Runoff volume to assess whether Sponge Park can withstand flood events as designed or needs to be improved

Aquifer depth and quality to assess improvements due to shallow or deep infiltration. Any detection of contamination should lead to sealing of recharge wells

Temperature to measure ambient cooling impact on users

Biodiversity to ensure plant health improves over time

The Sustainable Infrastructure Lifecycle framework of this manual organises the guidelines for the strategic prioritisation, comprehensive site assessment, integrated design, systematic implementation, and rigorous operations and monitoring of Sponge Parks. By taking these guidelines into account Sponge Parks can become an infrastructural network of open spaces that are gender inclusive, socially vibrant, ecologically rich, and climate resilient.

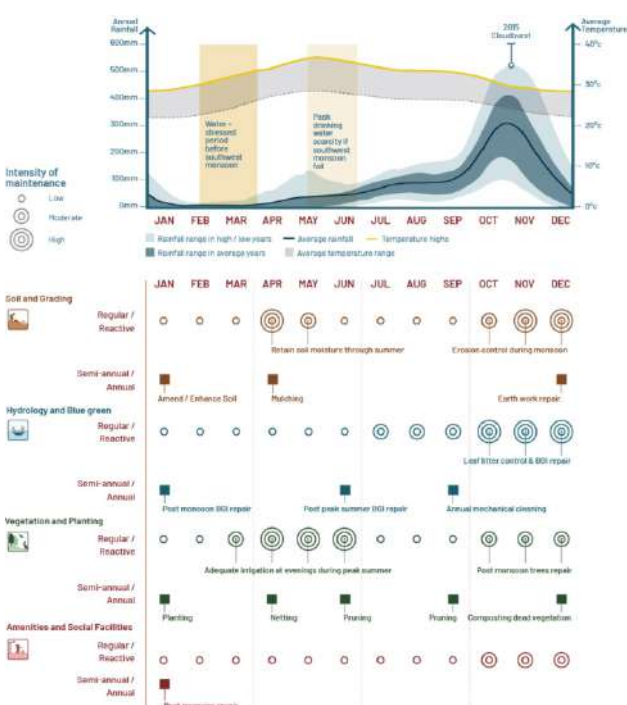


Fig. x. Maintenance Framework for Sponge Park Systems

MODERATE FLOOD
5 year return period

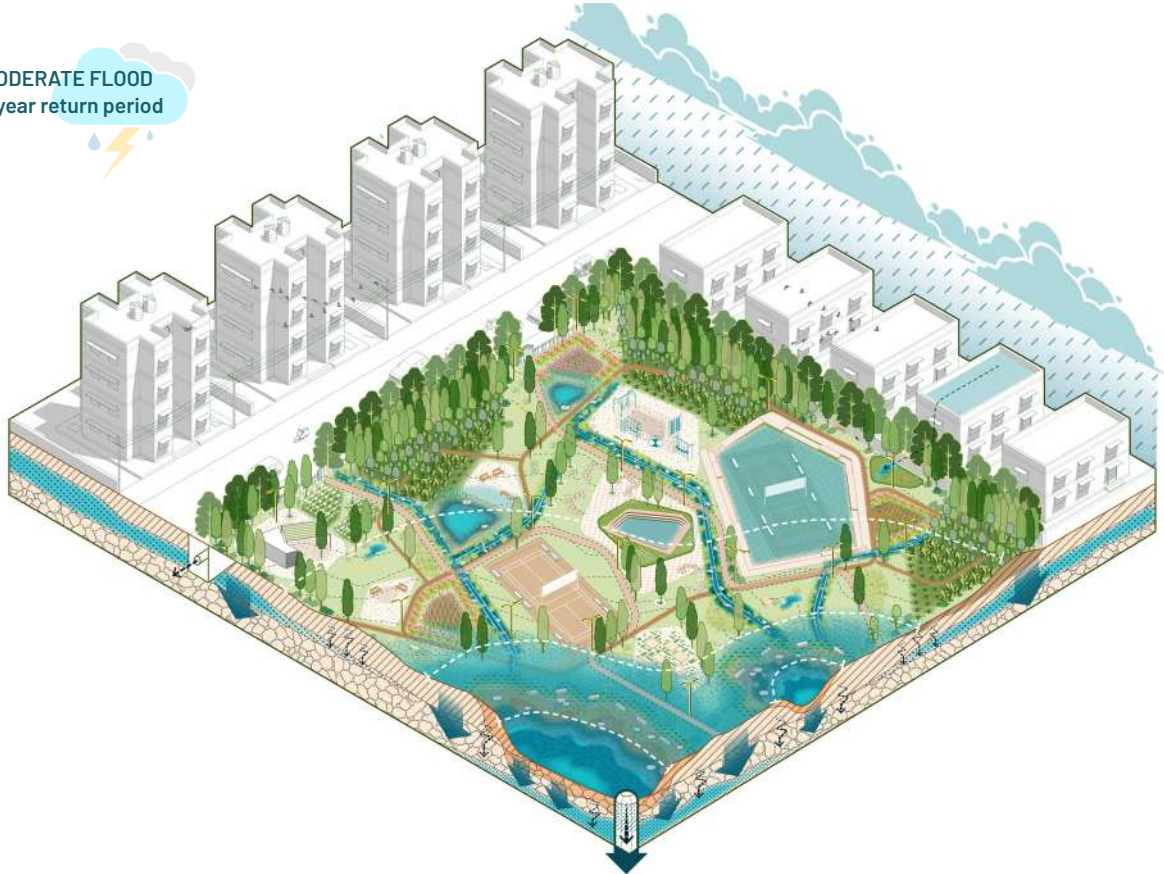


Fig. xi Illustration of Sponge Park with various hydrological zones activated by a 5 year return period storm

HEAVY FLOOD
25 year return period

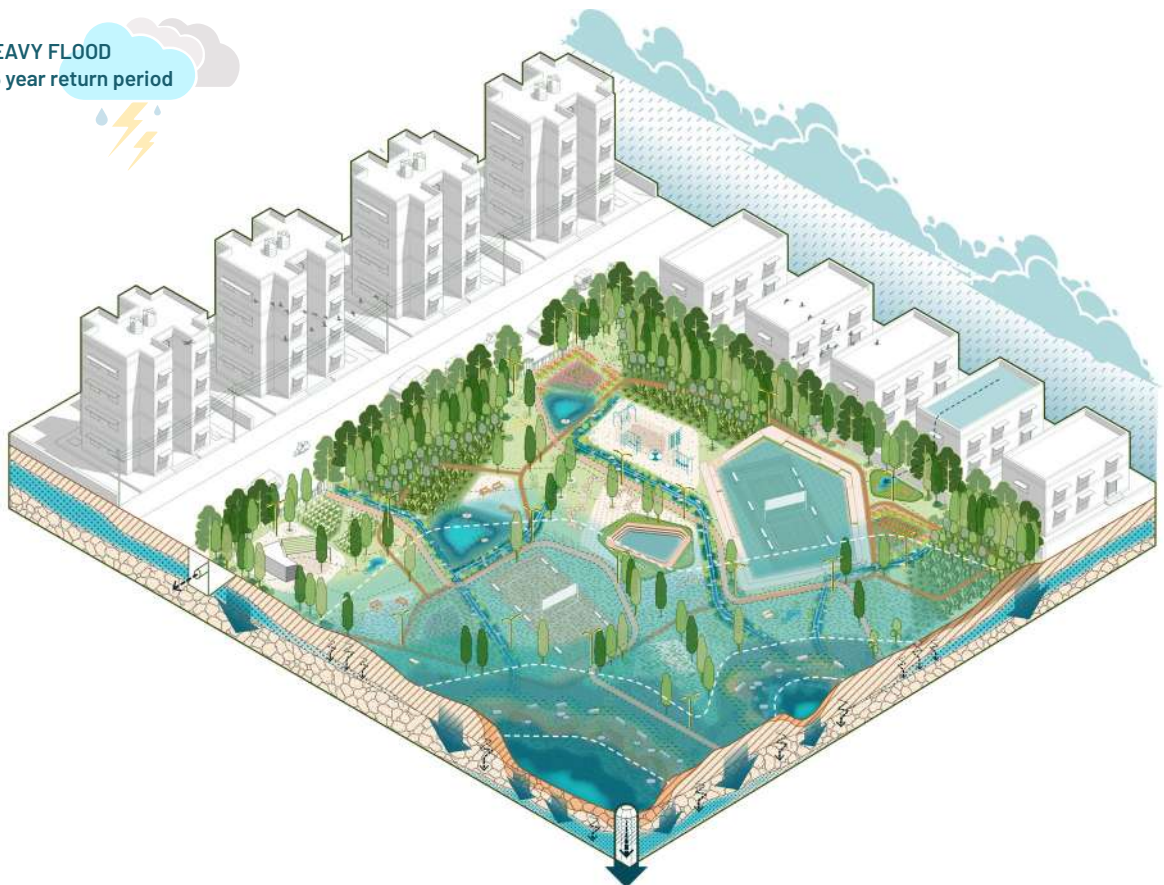


Fig. xii Illustration of Sponge Park designed to handle more extreme storm events by expanding flooded areas and increasing infiltration rates



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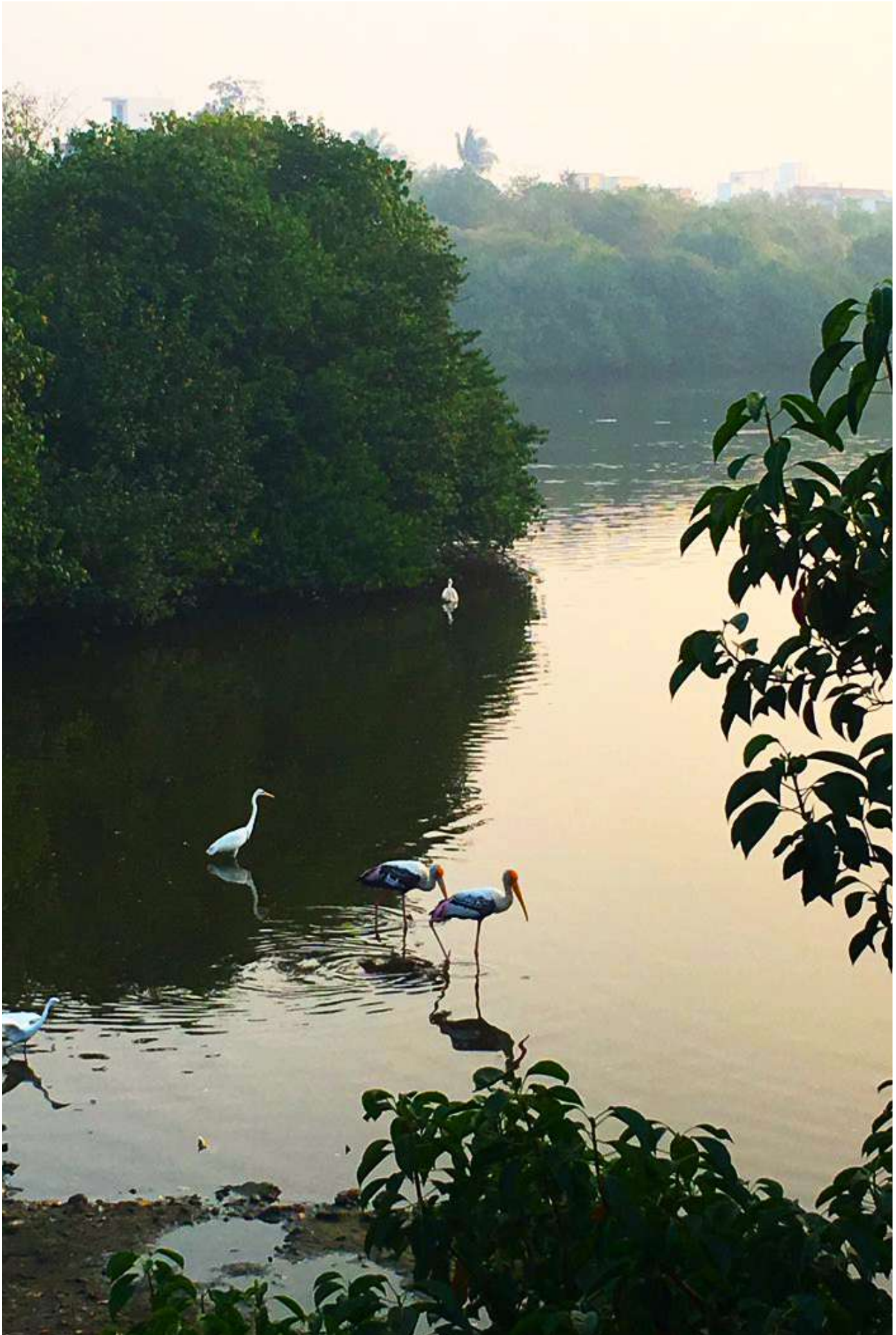


Image Credit - Adayar Eco Park

INTRODUCTION

Project Background

Why Chennai needs to be a Sponge city?

Sponge Parks in Chennai

Sponge Park Manual Framework

Project Background

About the Study

Unplanned and rapid growth of cities is leading to an increase in climate induced disasters including floods, storms, heatwaves reducing the cities resilient capacity to address them. According to the Intergovernmental Panel on Climate Change (IPCC 2022), it is estimated that natural and man-made activities are resulting in emerging risks from climate change, environment deterioration, water scarcity, land constraint and biodiversity loss. Preserving or restoring natural features by adopting nature-based solutions, holistic and integrated strategies to reduce climate risks and innovative ways to address these challenges are imperative for sustainable development of cities. Chennai has witnessed tremendous growth in the last two decades exerting tremendous pressure on its existing natural ecosystems and open spaces transforming large wet and permeable landscape into concrete structures. The problem is further compounded by authorities having to manage unprecedented shocks from extreme rainfall, water scarcity, heat waves crisis.

In 2015, Chennai witnessed one of the major floods in its history that damaged habitation causing loss of lives and huge economic losses. Further, climate change projections predict that the city would face extreme storm events and water scarcity, requiring the city to manage and provide innovative solutions to address them. In response to addressing these challenges Greater Chennai Corporation seeks to promote the "sponge approach" for transforming parks into sponge parks by applying the principles of nature conservation for enhancing resilience to withstand natural hazards by making urban spaces more permeable thereby preventing floods. On a pilot scale Greater Chennai Corporation (GCC) has undertaken Singara Chennai 2.0 initiatives for converting parks into sponge parks that will store flood water. GCC is pioneering in developing sponge parks and in the process of commissioning over 50 parks shortly. GCC proposes to scale up the sponge park model exponentially to increase permeable surface to mitigate flooding. This suggests the need for a framework / guideline based on the learnings, best practices from across the globe and develop strategies for institutional strengthening to make Chennai a "Sponge City".

The **Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH** is implementing the project **"Sustainable Urban Development - Smart Cities II" (SUDSC II)** on behalf of the **German Federal Ministry of Economic Cooperation and Development (BMZ)**. The project supports the **Ministry of Housing and Urban Affairs (MoHUA)** and the partner **State Governments of Karnataka, Kerala, Odisha, Tamil Nadu and Telangana** and partner cities for developing resilient, sustainable approaches and solutions for urban development including infrastructure that consider disaster risk management and the leave-no-one-behind (LNOB) principle. As part of their ongoing initiative, GIZ will extend its technical assistance under the Sustainable Urban Development- Smart Cities II (SUDSC II) project by supporting GCC efforts in mainstreaming and prioritizing sponge parks for enhancing urban resilience and preparing a framework for developing sponge parks as a climate mitigation plan. The SUDSC II projects that operate at national, state and city level, aim at promoting risk-informed, resilient, sustainable approaches and solutions for urban development including infrastructure based on the principles of inclusiveness, integrating disaster risk management, within the context of various programmes and missions of the Government of India. The project intends to address the issues related to sustainable urban development through four outputs: a) Policy support for implementing regulatory planning frameworks for resilient and sustainable urban development b) Capacity Development for strengthening capacities of relevant stakeholders and institutions on resilient and sustainable urban development, c) Innovative.

This project will develop a framework to identify the suitability and prioritization of Sponge Parks to improve climate resilience and gender inclusiveness. Secondly, the project will help the Greater Chennai Corporation to mainstream Sponge Parks through capacity building while producing materials that can inform capacity building in other urban local bodies. The materials will include best practices including water-sensitive urban design (WSUD), sustainable urban drainage systems (SUDs), risk-sensitive land-use planning (RSLUP). The four objectives of the study are summarized below:

1. Assess institutional gaps within GCC on understanding of Sponge City and evaluate current implementation practices of Sponge Parks

The study achieved this through key informant interviews and questionnaires with department heads, zonal engineers, superintendent engineers, assistant executive engineers, and park overseers within the GCC. Our team will visit a number of implemented Sponge Park and review the technical drawings and procurement details to evaluate the process and outcomes.

2. Develop a spatial framework for prioritizing Sponge Parks using pre-existing datasets and providing a Zone-wise summary of prioritized OSRs for Sponge Park upgrading

The study achieved this through a GIS-based spatial multi criteria analysis of pre-existing and obtained datasets that will prioritize open space reserves (OSRs) for upgrading into Sponge Parks based on social and environmental factors. The results of this analysis will identify priority wards in each zone and summarize the prioritization data by zone.

3. Design toolkits and guidelines for planning, designing, finance, procure, implement, and maintain Sponge Parks for typological size and conditions

The study achieved this through the production of a comprehensive guidebook and manual containing graphic toolkits and typological descriptions of how blue-green infrastructure components, landscaping, and social amenities can come together in upgrading small, medium, and large OSRs into Sponge Parks. The manual will provide guidelines for the full infrastructure life cycle of Sponge Parks from strategic planning to construction to decommissioning.

4. Conduct capacity building workshops with GCC Engineers and Department Heads

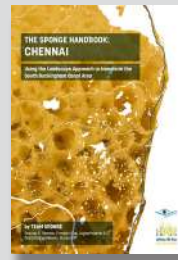
The study concluded with a hands-on capacity building workshop that will present the findings of the project and train GCC engineers and relevant department heads to utilize the manual for prioritizing, transforming, and monitoring OSRs into Sponge Parks with support from technical consultancies and procured contractors as needed.

About Sponge City and Sponge Collaborative

"Sponge City" is an urban planning paradigm based on NbS principles that leverage regional landscapes and blue-green infrastructure (BGI) to manage storm water holistically and build resilience to multi-hazards. A Sponge City benefits from an integrated planning approach that leverages natural and constructed blue-green systems to reduce, delay, and store runoff from storm events to limit flooding and recharge the aquifer where conditions allow (Refer to Figure 1 and 2). Constructed blue-green systems include Sponge Streets that improve streets and Sponge Parks that retrofit existing open spaces for disaster risk mitigation.

Sponge Collaborative conducted a detailed feasibility study in Kosasthalaiyar Basin for integrating a BGI network into the fabric of a 170 acre peri-urban neighbourhood in North Chennai. A network of new trees, tree pits, raingardens, and Sponge Parks with retention ponds and infiltration basins was proposed to supplement the stormwater drainage network. Hydrological modelling by IIT Madras showed the BGI network made the neighbourhood more resilient to 25 year return period storms while the drains are only designed to withstand 5 year return period storms. The study also showed that this degree of resilience could be achieved much more cost-effectively with BGI than upgrading drains.

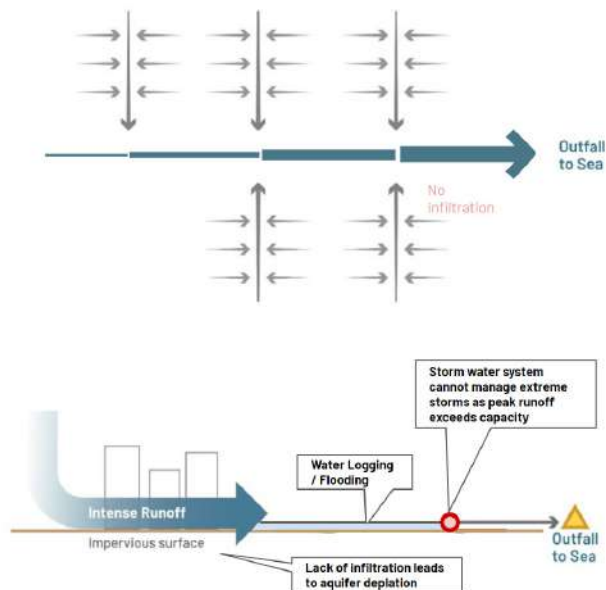
Sponge Collaborative is an interdisciplinary design and planning consulting firm dedicated to mainstreaming nature-based solutions in Sponge Cities, resilient metropolitan regions, ecotourism destinations, and sustainable neighbourhoods or campuses. In 2018, the co-founders published 'Sponge Handbook: Chennai' to contextualise the Sponge City concept to India with GiZ India. The team has been advocating for, designing, and implementing Sponge Cities since then.



Project:
Sponge Handbook:
Chennai (Cities Fit for
Climate Change)

Client:
GiZ India

Grey Infrastructure Approach to flood mitigation



The Sponge city approach to flood and drought mitigation

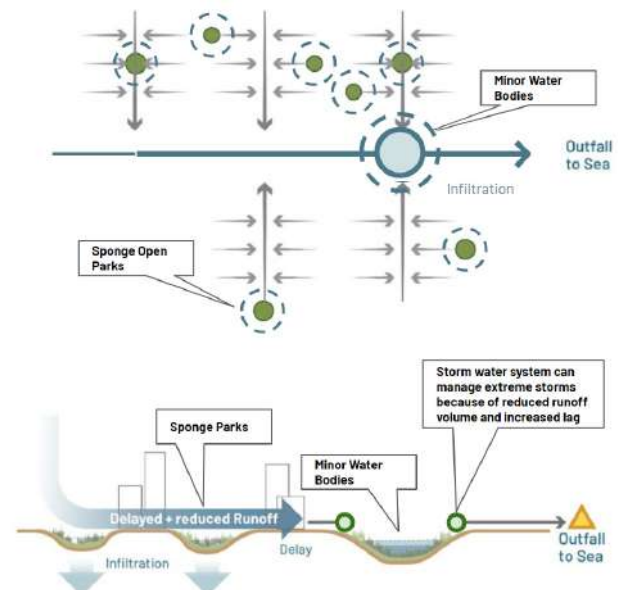


Fig. 1. Sponge Parks can help limit flooding and create opportunities for recharge as an urban blue-green network



Fig. 2 Sponge City examples from Thailand and Singapore with illustration of co-benefits

Why Chennai needs to be a Sponge City ?

Chennai faces the coupled water risks of flooding and drought

On December 3rd 2023, Cyclone Michaung brought unprecedented amounts of rainfall over Chennai causing enormous damage over the course of 36 hours. Streets and homes were flooded for a week or more as the city received between 400 - 500 mm of rainfall. The flooding exceeded the 330 mm of rainfall during the 2015 floods that killed more than 200 people. While the 2023 flood was less lethal, the damage was extensive and exposed the limits of the storm water management strategy that received thousands of crores of investment. Due to climate change extreme storm events are becoming more common in Chennai (Refer to Figure 1). Apart from the two extreme storms of 2015 and 2023, Chennai experienced major floods during the monsoons of 2017 and 2021. Between these major flood events, Chennai also experienced extreme water scarcity in 2019 when drinking water reservoirs had run dry and the city required external water supply to avert Day Zero. As a rapidly growing metropolitan region of more than 12 million people and rising industrialisation, the city's aquifers and water resources will be stressed. Thus, Chennai faces coupled water risks of flooding and drought that cannot be mitigated by traditional grey infrastructure.

Climate change is increasing the severity and recurrence of storm events that greatly exceed the designed capacity of grey storm water network - In the past decade, Chennai flooded multiple times by storm events that greatly exceed the required designed capacity of storm water drains as per the standards set by the Central Public Health and Environmental Engineering Organisation (CPHEEO). As per the CPHEEO manual of 2019, the storm water drains of Tier I cities should be designed to only handle 5 year return period storms. Since building grey infrastructure sized to handle more extreme events is prohibitively expensive, the manual further recommends utilising best management practices (BMPs) like blue-green infrastructure - i.e. designed systems that replicate the hydrological functions of natural greenery by utilising plants, soils, and sub-surface storage systems to delay, store,

and filter storm water runoff. While the intensity of storm events is projected to increase with climate change, total precipitation during monsoons may reduce or be more sporadic. This increases the risk of drought, water scarcity, and depleting aquifers. Sea level rise also threatens aquifers through saline intrusion. Additionally, Chennai is facing record high temperatures in recent summers that is projected to get warmer with climate change (Refer to Fig 3 below for a graphic summary). The increased risk of multi-hazards creates the need for infrastructural solutions that be resilient to multiple hydro-meteorological risks.

Chennai's urban growth is taking place at the expense of landscapes that provided ecosystem services like flood regulation, aquifer recharge, and ambient cooling - Chennai is one of the fastest growing metropolitan regions in India. In the past two decades, the built-up area of Chennai has more than doubled as urban sprawl converted farmlands and forests into concrete and wetlands into peri-urban neighbourhoods. These increases the volume of runoff from storm events due to the loss of green cover or canopy coverage that would have intercepted rainfall or delayed runoff. Figure 4 and 5 illustrates how Velachery Lake in the heart of Chennai lost its water area to planned urban development. This is a representative example of how Chennai lost hundreds of water bodies over time. The loss of lakes, ponds, wetlands, and riparian areas to urban development or encroachment is a loss of natural "Sponge" landscapes which store rainfall, absorb excess runoff, and recharge shallow aquifers. Industrial and municipal effluents pollute ponds and wetlands further compromising their ability to store and filter rainwater.

Unmanaged urbanisation has disrupted the natural hydrological cycle and damaged traditional water management structures and practices more attuned to Chennai's semi-arid monsoon culture. Figure 6 and 7 summarise the negative impact of urbanisation in a graphic manner.

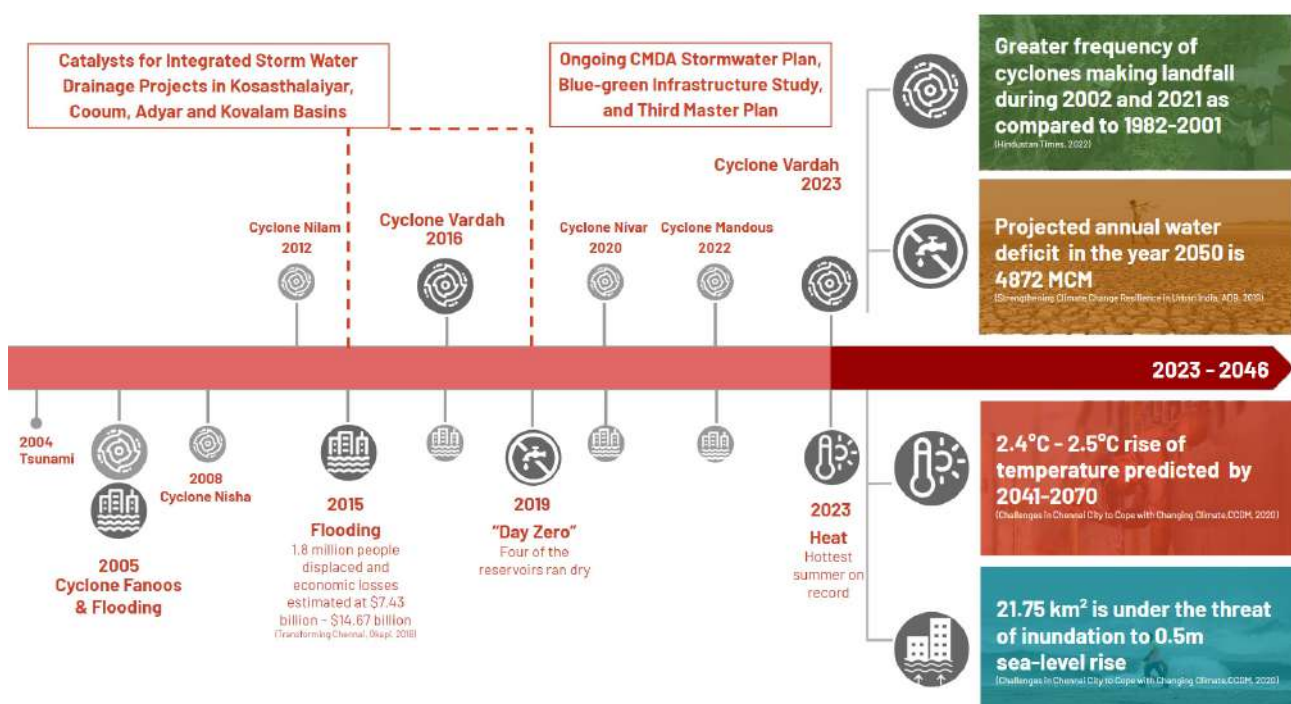


Fig. 3. Disasters in Chennai in the last 20 years and climate change projections

Blue-green Infrastructure offers a cost-effective alternative to build urban resilience to multi-hazards - Blue-green infrastructure is a form of nature-based solution whose benefits and cost-effectiveness at helping cities adapt to climate change is being reported by multiple peer-reviewed studies and international case studies. The high level objective of this study is to mainstream "nature-based solutions" (NbS) as a vehicle to achieve sustainable development goals and build resilience in the rapidly growing urban settlements of Tamil Nadu. NbS is defined by the United Nations Environment Programmes Resolution on Nature-based solutions for Supporting Sustainable as: actions to protect, conserve, restore, sustainable use, and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits. (UNEA-5, 2022). Based on this definition, NbS has tremendous potential to cost-effectively build resilience in urban areas that face multi-hazards and climate risks while improving the quality of life for urban residents.

The advantage of blue-green infrastructure is their ability to mitigate flood and water scarcity risks since they recharge the aquifer with filtered storm water runoff. A detailed feasibility study in the Kosasthalaiyar Basin conducted by Sponge Collaborative with IIT Madras proved that with the right soil conditions, a blue-

green infrastructure network comprising of tree planting, street rain gardens, soil amendments, and the construction of bioinfiltration basins and recharge wells in open spaces cost-effectively supplements the storm water drainage system to handle 25 year return period storms.

Faced with increased flood risks, water scarcity and rapid urban expansion, Chennai has a critical need for nature-based solutions in the form of blue-green infrastructure interventions like Sponge Parks. The Greater Chennai Corporation (GCC) has announced plans for hundreds of sponge parks which includes an Integrated Sponge Park in the Kosasthalaiyar Basin designed by Sponge Collaborative. The Chennai Metropolitan Development Authority (CMDA) has also been setting up the foundation for making Chennai a sponge city through the commissioning of consultancies for basin-wide flood assessment and a blue-green infrastructure investment plan.

It is within this content that the study Sponge Park Framework for Resilient Open Spaces - Case Study of Greater Chennai Corporation will build capacity within the GCC for the planning, prioritization, design, financing, procurement, construction, maintenance and monitoring of Sponge Parks through the development of a gap assessment, spatial framework, graphic manual, and workshops.



Fig.4.Velachery lake in 1979



Fig. 5.Velachery lake in 2016

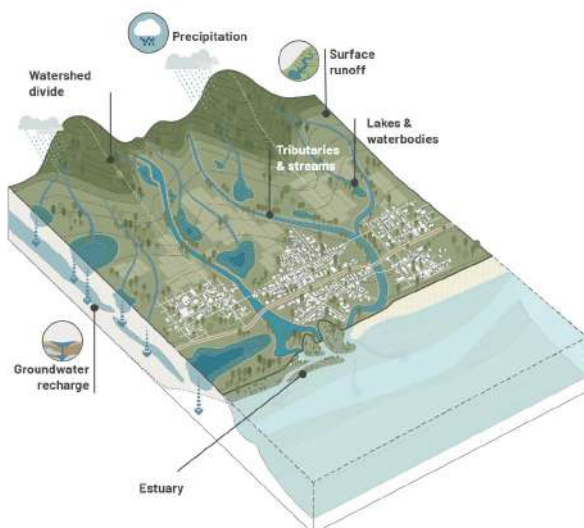


Fig. 6. Basin Hydrological cycle

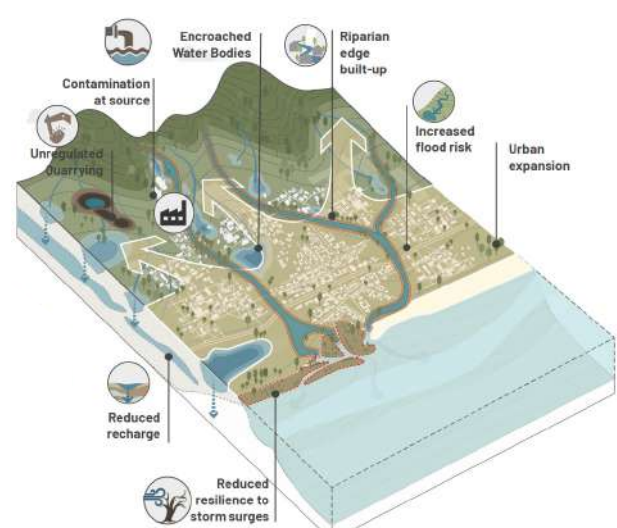


Fig. 7. Modified hydrological cycle due to urbanization

Sponge Parks in Chennai

Sponge parks can play a crucial role in mitigating floods by collecting and storing water during heavy rainfall, thereby recharging groundwater levels and enhancing urban permeability. The Greater Chennai Corporation is actively developing 42 sponge parks before the northeast monsoon season, as part of a larger project comprising 57 parks at a cost of Rs. 7.67 crore. Sponge parks, particularly beneficial in low-lying areas, are being established in north Chennai, with 21 parks currently in development. Additionally, plans for an extensive state-of-the-art sponge park, covering two zones and featuring sports facilities and footpaths, are underway, with detailed project reports nearing completion. Scientific parameters such as infiltration rates are being considered to ensure the effectiveness of this park.

"The capacity of a sponge park depends on the infiltration rate of the soil and the intensity of rain. Excess water is directed to the nearest storm-water drain," said M. Sivaguru Prabakaran, Regional Deputy Commissioner north Chennai. Park locations are selected based on existing parks surrounded by roads to ensure consistent water flow and soil conditions.

An institutional capacity gap assessment conducted in the forms of a **validation workshop (Refer to Annex D)** and **questionnaires (Refer to Annex C)** revealed the lack of a strategic framework to scale up the Sponge Park program, the lack of a scientific basis



Fig. 8 VGP Selva Nagar Sponge park



Fig. 9 Mayor sundar Rao sponge park



Fig. 10 The sponge park getting ready at Perambur Murasoliman Park with a centralised structure for water harvesting

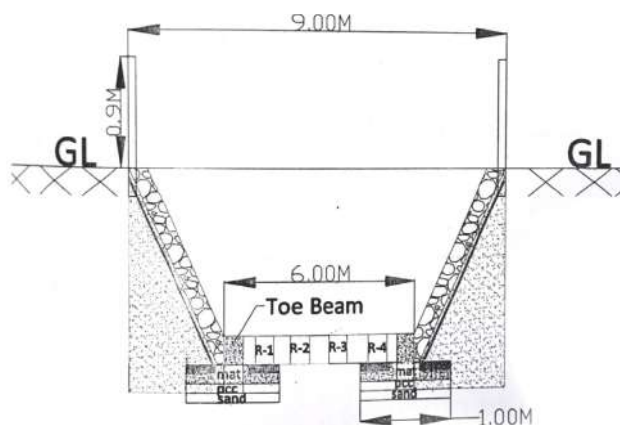


Fig. 11 Technical section of implemented sponge park

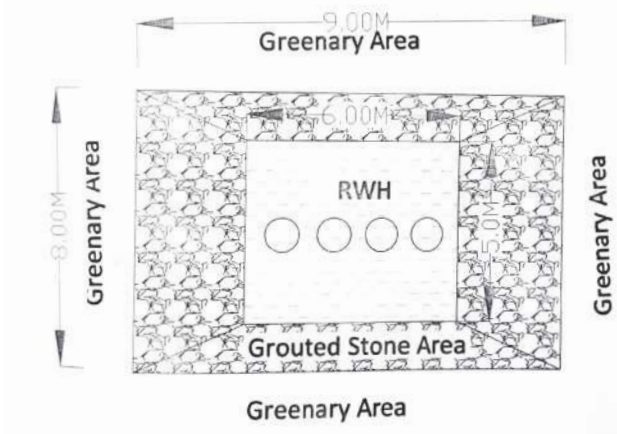


Fig. 12 Technical plan of implemented sponge park

to prioritise open spaces for upgrading into Sponge Parks, the lack of community engagement in site selection and Sponge Park programming, the lack of standardised guidelines for the design of blue-green infrastructure components within Sponge Parks, and the lack of clear manuals for contractors, maintenance personnel, and operational staff. These gaps have led to the implementation of Sponge Parks that have increased the imperviousness of existing parks, disrupted existing amenities or recreational equipments, and carved out public space for an infrastructure that is fenced off to be of any benefit to park users and the community at large..

In contrast, the Integrated Sponge Park pilot in the Mathur MMDA Colony football grounds designed by Sponge Collaborative takes a more holistic approach in weaving together blue-green infrastructure with community needs while also creating the conditions for healthy soils and biodiverse urban ecology. The layout of the social infrastructure in the Mathur MMDA Sponge Park is informed by community engagement (Refer to Figure 10 and 11) to provide diverse programming for all ages and genders. Through strategically grading of the site, opportunities for slow conveyance, storage, and shallow and deep aquifer recharge (Refer to Figure 12 and 13). This manual will provide guidelines for how the GCC can take a similar approach in strategic planning, holistic design, and detailed design (Refer to Figure 14) to build Sponge Parks that are resilient as well as socially inclusive.



Fig. 13 Community interaction for Mathur MMDA Sponge Park



Fig. 14 Community interaction for Mathur MMDA Sponge Park



Fig. 15 Community interaction for Mathur MMDA Sponge Park



Fig. 16 Community interaction for Mathur MMDA Sponge Park

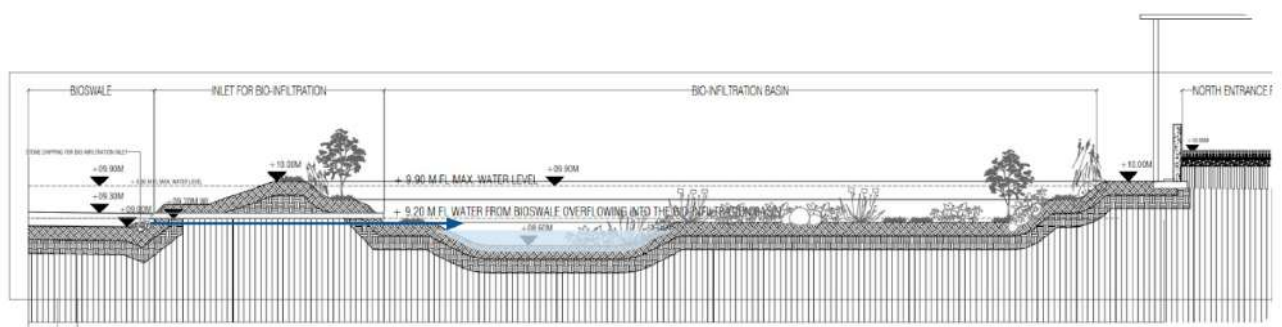


Fig. 17 Example of Technical drawing of the sponge park detail

Sponge Park Manual Framework

Sustainable Infrastructure Life cycle

The manual will be organised as per the Sustainable Infrastructure Lifecycle as part of the Sustainable Infrastructure Principles by GiZ and United Nations Environment Programme from 2018.

1.1. Strategic Planning

Making data-driven decisions based on environmental suitability and social need. Developing a city-level or basin scale framework for Sponge Parks as a network to build urban water resilience.

1.2. Prioritization

Using environmental pre-screening mechanisms, multi-criteria decision criteria, or community engagement to decide which open spaces are prioritized for upgrading to Sponge Parks

2.1 Project Planning

Determining the feasibility, social and environmental impact, and technical requirements of Sponge Park based on hydrological studies, environmental assessments, and geotechnical surveys of open spaces

2.2 Concept Design

Designing, programming, and sizing the grading, hydrology, blue-green infrastructure components, vegetation, and social amenities of Sponge Parks to ensure resilience to extreme events and well being of users

2.3 Detailed Design

Following best practices, guidelines, and specifications to detail concept design intent and issuing clear drawings for financing, tendering, and construction of Sponge Park

3.1 Finance

Costing the implementation and maintenance of Sponge Park accurately and securing funds for procurement through local or sectoral budgets, grants, CSR, and loans with an accounting of benefits

3.2 Procurement

Obtaining goods, works, and consulting services as needed in various stages to plan, assess, design, construct, maintain, or decommission Sponge Parks

3.3 Construction

Following best practices and standard operating procedures to ensure construction of Sponge Parks follow design documentation and built within budget and schedule requirements

4.1 Operations and Maintenance

Sustaining the functions of the Sponge Park as social amenity and resilient infrastructure regular maintenance of blue-green infrastructure by trained staff

5.1. Monitoring and Repurposing

Evaluating the need for upgrading or repurposing through scientific monitoring and determining the end or evolution of the Sponge Park life cycle based on future environmental, social, and hydrological context

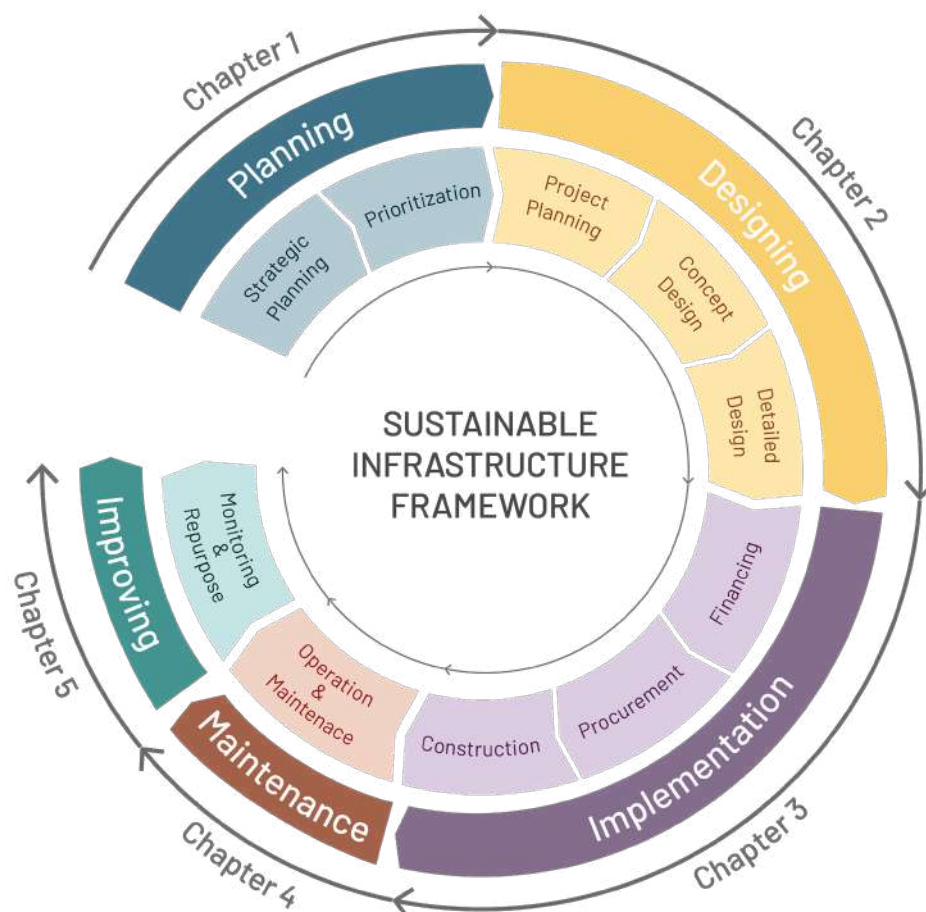


Fig. 18 Sustainable Infrastructure Framework is used to assess capacity and structure the manual for Sponge Parks

How to read the manual ?

CHAPTER 1

Strategic Planning of Sponge Parks



1.1. Strategic Planning : How to understand the need for Sponge Parks at city zone and ward levels.

Pg 28

1.2. Prioritization : How to prioritize investments towards Sponge Parks based on environmental suitability and social needs

Pg 36

- OSR Geo database
- Zonal profiles

CHAPTER 2

Designing Sponge Parks



2.1. Project Planning: How to consider site Characteristics, catchment flows, and community needs to identify design goals and programming for Sponge Parks

Pg 46

2.2. Concept Design: How to integrate Sponge Park systems with each other to meet environmental and social goals

Pg 54

2.3. Detailed Design: How to detail Sponge Park systems and BGI to fulfill hydrological functions and design goals

Pg 78

- Sponge park system with guidelines and annex
- BGI Toolkit and technical annex

CHAPTER 3

Implementing Sponge Parks



3.1. Finance: How to unlock funding for Sponge Parks from intergovernmental, multilateral, and private sources

Pg 112

3.2. Procurement: How to on board technical Expertise for the implementation of Sponge Parks of all sizes

Pg 118

3.3. Construction: How to ensure quality outcome through site management and pollution control in Sponge Parks during construction

Pg 120

- Sponge park typologies

CHAPTER 4

Maintaining Sponge Parks



4.1 Operations and Maintenance: How to maintain Sponge Park systems and schedule operations in response to monsoon cycles and seasonal heat

Pg 130

- Maintenance schedule and activities

CHAPTER 5

Upgrading Sponge Parks



5.1 Upgrading and Repurposing: How to ensure Sponge Parks are climate resilient and fulfilling their Environmental purposes over time

Pg 152

- Repurposing strategies

Audiences of the manual

The manual has been written for various audiences in mind with high level summaries and strategic information in the early chapters with more details in later chapters and technical information in the Annex



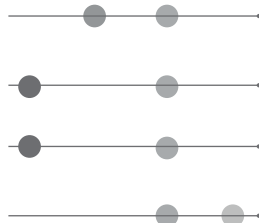
Decision Makers

- Principal Secretary and Commissioners
- Joint commissioner (JC)
- Chief Engineers (CE)
- Regional deputy commissioner (RDC)



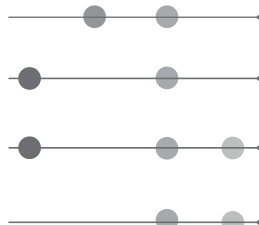
General Readers

- Policy Makers
- Practitioners
- Academics
- Students



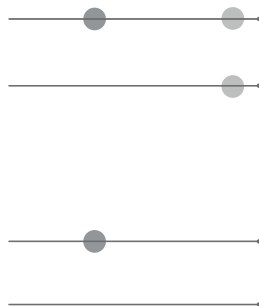
Technical Readers

- Zonal engineers (ZE)
- Assistant executive engineers (AEE)
- Executive engineers (EE)
- Contractors



Implementing agents

- Superintendent Engineer (SE)
- Zonal engineers (ZE)
- Assistant executive engineers (AEE)
- Executive engineers (EE)
- Contractors and Vendors



Executive summary

Introduction

1. Strategic Planning of Sponge Parks

1.1. Strategic Planning

1.2. Prioritization

2. Designing Sponge Parks

2.1. Project Planning

2.2. Concept Design

2.3. Detail Design

3. Implementing Sponge Parks

3.1. Finance

3.2. Procurement

3.3. Construction

4. Maintaining Sponge Parks

4.1. Operation and maintenance

5. Improving Sponge Parks

5.1. Monitoring and repurposing

Annexure

A. Priority OSRs

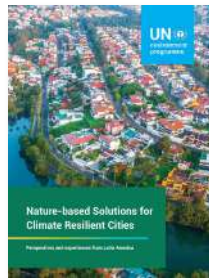
B. Detailed Guides

Resources

The manual brings together information from the best of international and national resources of BGI, BMPs, SUDs, WSUD, climate financing, and other topics. The references seen below have informed the technical sections of the manual and are contextualised for the case of Chennai and India at large.



The sponge Handbook -Chennai



NBS for Climate resilient cities



Rutgers - Green Infrastructure Manual



GSI - Planning & Design Manual



GSI - Stormwater management manual



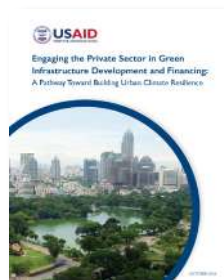
GSI - Landscape Design Guidebook



GSI - Maintenance Manual



GSI - Infrastructure details



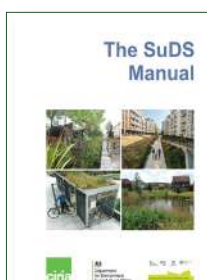
USAID - Guide to engage private sector



Financing climate resilience Manual



Financing Adaptation in India Manual



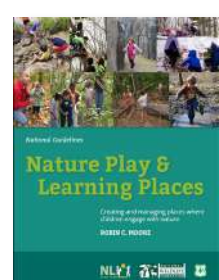
The SuDS Manual



Grow green Manual



Green infrastructure maintenance



National guidelines for Nature play

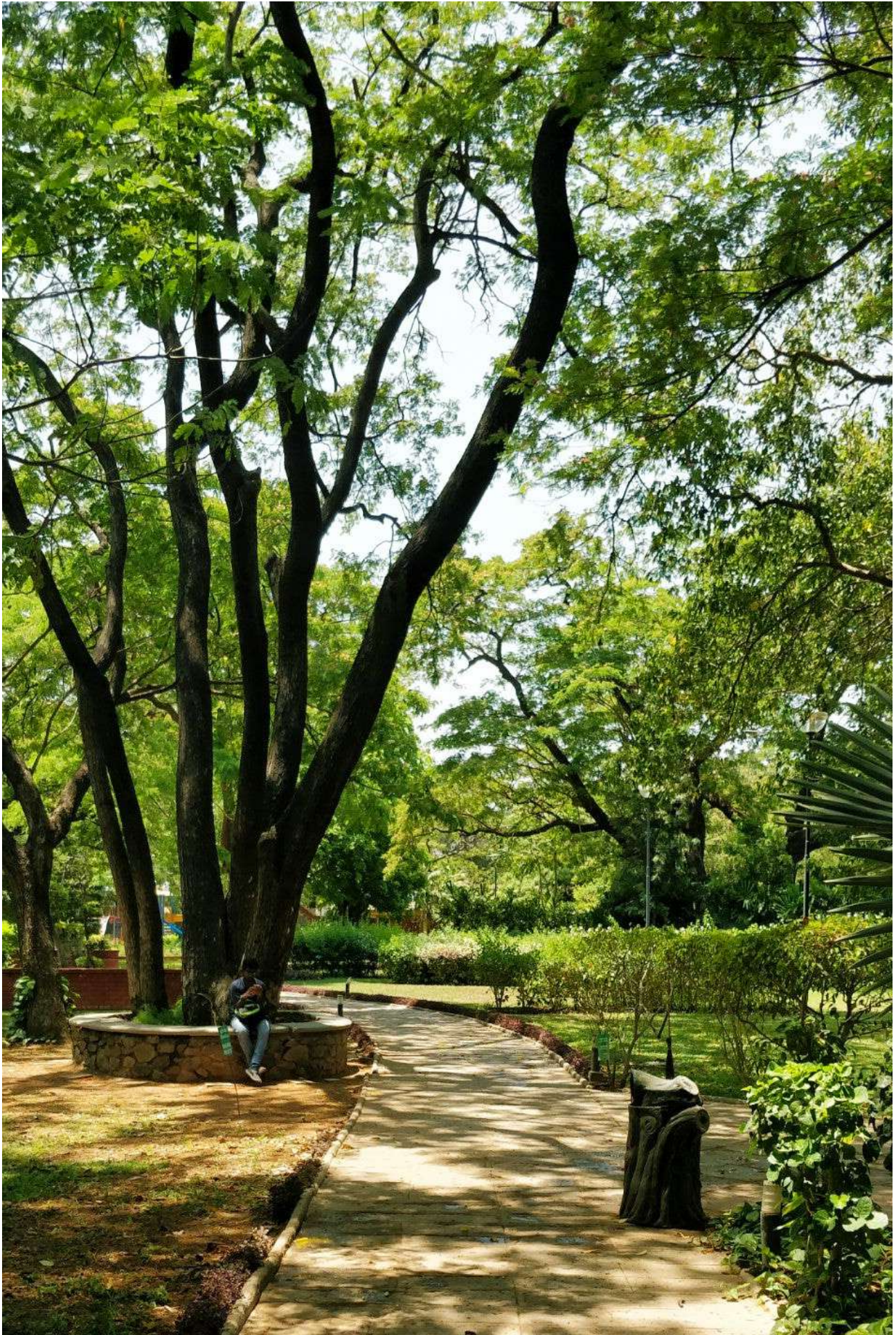


Image Credit - Semmozhi Poongaa Chennai

1 STRATEGIC PLANNING FOR SPONGE PARKS

- 1.1. Spatial Analysis for Strategic Planning of Sponge Parks
- 1.2. Priority OSRs for Sponge Parks

1.1. Spatial Analysis for Strategic Planning of Sponge Parks

The Chennai Metropolitan Area (CMA) spans four basins (Refer to Fig 1.1). Basins are defined by the area that drains into a common river or water body. Chennai can be a Sponge City that is resilient to extreme storm events and water secure when rain water in every basin is delayed, stored, filtered, and recharged into the aquifer. This requires the mainstreaming and implementation of nature-based solutions (NbS) at multiple scales. Chennai will be a Sponge City when it can **Protect**, **Restore**, **Enhance**, and **Construct** NbS at a metropolitan scale. An ecological spatial framework for NbS in Chennai is shown in Fig 1.2 below.

Protect ensures that regional landscapes and water bodies can maintain the hydrological cycle continue to act as natural sponges through conservation and land use planning. **Restore** involves the cleaning up and rejuvenation of water bodies and landscapes that are no longer providing ecosystem services due to pollution or urban development. **Enhance** supplements the ability of riparian and coastal ecosystems to withstand the shocks and stressors or climate change including extreme floods and increasing erosion. **Construct** is the implementation of hybrid or blue-green infrastructure networks that replicate the functions of natural systems within constrained urban areas. While Sponge Parks are a key component of the Construct strategy and the focus of this manual, they cannot withstand extreme flooding unless they are supplemented by the regulating effects of large regional landscapes. The strategic planning of Sponge Parks to ensure a resilient network of open spaces requires a comprehensive understanding of socio-ecological factors and multidisciplinary collaborations.

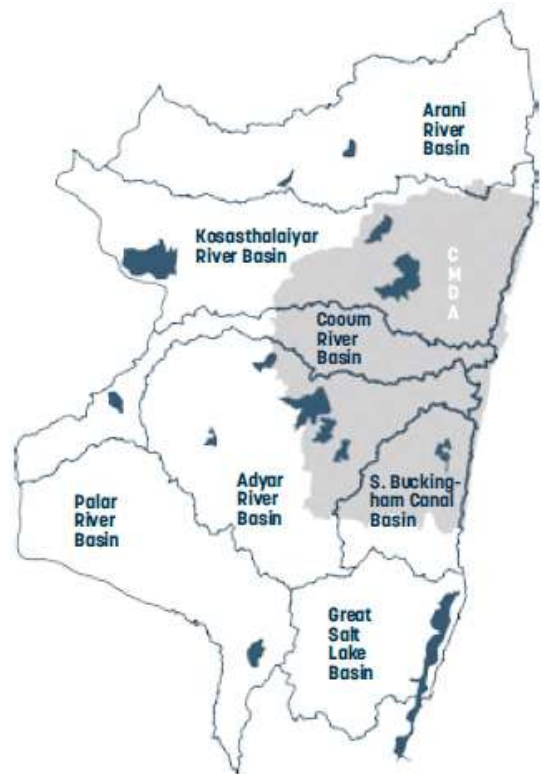
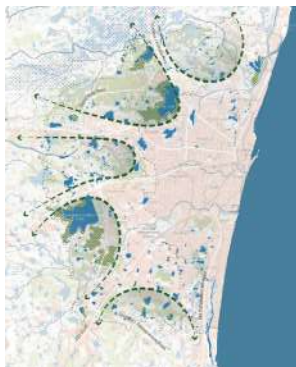
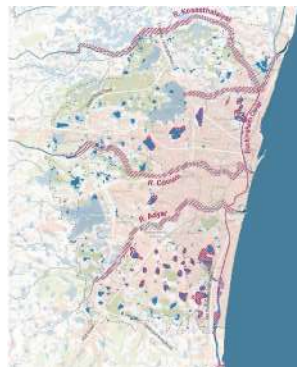


Fig. 1.1 Basins of Chennai Metropolitan Area (CMA)

Protect : Ecosystems and water bodies from encroachment or pollution



Restore : Ecological functions of degraded or polluted landscape



Enhance : Coastal, riparian and wetland areas to withstand climate change



Construct : BGI in urban open spaces to replicate nature systems



Fig. 1.2 Regional scale study

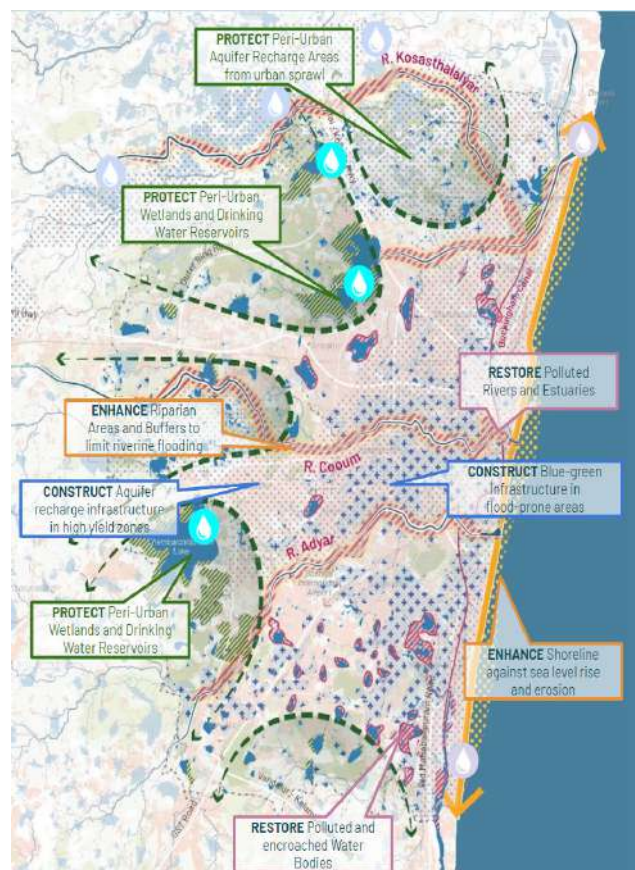


Fig. 1.3 Spatial Ecological Framework for Nature-based Solutions in CMA

The Copenhagen Cloudburst Formula developed innovative solutions through blue-green infrastructure, integrating nature-based strategies with traditional infrastructure in response to a historic storm in 2011 and increased recurrence of cloudbursts due to climate change. The Copenhagen Cloudburst Formula followed a six-step process, emphasizing data analysis, modeling, public involvement, and cost-benefit analysis. This process required months of rigorous analyses and multidisciplinary collaboration that led to the prioritisation of blue-green infrastructure investments as well as a cost-benefit assessment based on cloudburst economics.

To replicate this process for Chennai, requires working with geospatial datasets including high resolution elevation, soil and geology profiles, detailed land cover, aquifer conditions, and probabilistic risk scenarios for pluvial, fluvial, and coastal flooding. Additionally, the political and financial space to conduct a comprehensive assessment for blue-green infrastructure or Sponge City strategy for Chennai needs to be created in order to engage multidisciplinary expertise and community involvement to understand local needs in a holistic manner. This approach will ensure that Sponge Parks effectively build Chennai's resilience.



Fig. 1.4 Steps to identify blue-green solutions as per The Copenhagen Cloudburst Formula



Fig. 1.5 Hydrological analysis of select catchments in Copenhagen

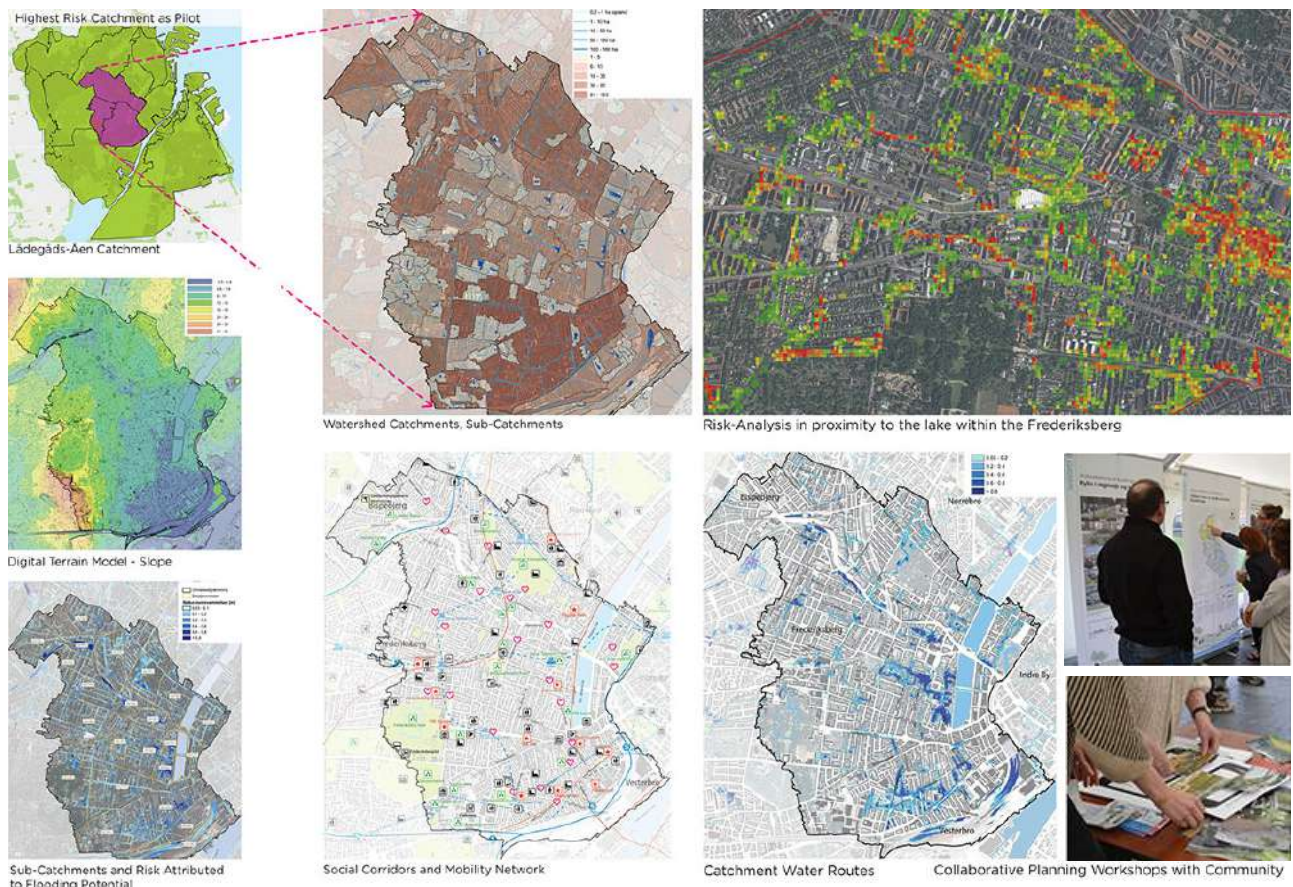


Fig. 1.6 Summary of geospatial analyses and community engagement conducted for Copenhagen Cloudburst Formula

Open Space Reservations (OSRs) in Chennai

Open Space Reservations (OSRs) are land earmarked for open space purposes through 10% allocation of layout area or private townships managed by local governments or private developers. Within the Chennai Metropolitan Area, OSRs are largely under the ownership and stewardship of Greater Chennai Corporation (GCC) or Chennai Metropolitan Development Authority (CMDA).

There are a total of **1,126 OSRs** within the GCC boundary. In total, OSRs add up to 515 acres or 2km² of land. In comparison, all parks within the GCC add up to 400 acres. The transformation

of OSRs into Sponge Parks could more than double Chennai's inadequate park acreage and produce a network of open spaces that make Chennai resilient to flood and drought risk.

Currently, the GCC does not have a strategic framework to scale up the Sponge Park pilot due to technical capacity gaps and data gaps. Strategic Planning for Sponge Parks requires evidence-based decision making and community engagement to ensure the upgraded open spaces form a resilient network to mitigate disaster risks while addressing social park needs.



Fig. 1.7 Small OSR in Chennai



Fig. 1.8 Small OSR in Chennai



Fig. 1.9 Medium OSR in Chennai



Fig. 1.10 Medium OSR in Chennai



Fig. 1.11 Large OSR in Chennai



Fig. 1.12 Large OSR in Chennai

Typology of OSRs

This study focuses on OSRs because they are open spaces with clear ownership by urban local bodies and clear purpose of being earmarked for open spaces. The study began by classifying the OSRs by size since they range from 0.003 acres to 17 acres.

The Typology of OSRs considered Small or S are 0.2 acres or below, Medium or M are between 0.2 - 1 acre, Large or L are between 1 - 5 acres, and Special or X are over 5 acres in size. OSRs in Chennai are widely distributed across all Zones and Wards - particularly in the outer wards of GCC. In terms of typologies the

distribution of OSRs are the following:

- 481 OSRs as S (less than 0.2 ac)
- 538 OSRs as M (between 0.2 - 1 ac)
- 100 OSRs as L (between 1-5 ac)
- 7 OSRs as X (above 5 ac)

Chennai has future plans to expand the Sponge Park pilot from 50-odd open spaces to more than a 100 open spaces. However, the selection of the next 100 Sponge Park sites should be scientifically evaluated. This section proposes an approach using available data.

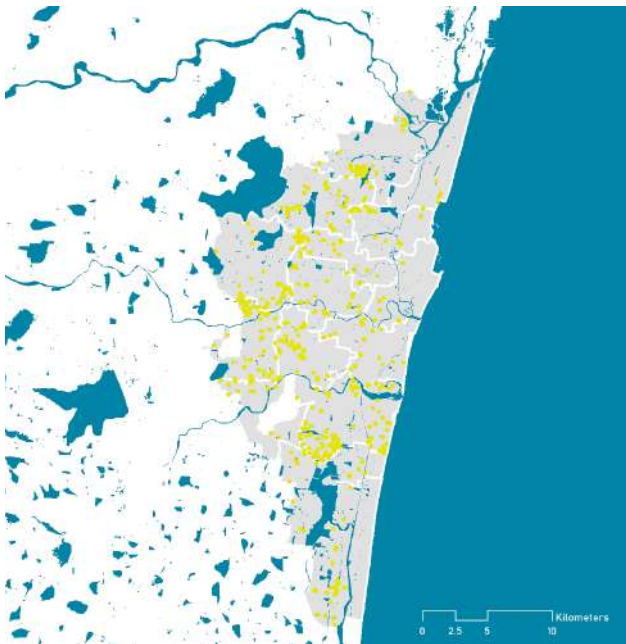


Fig. 1.13 Distribution of small OSRs

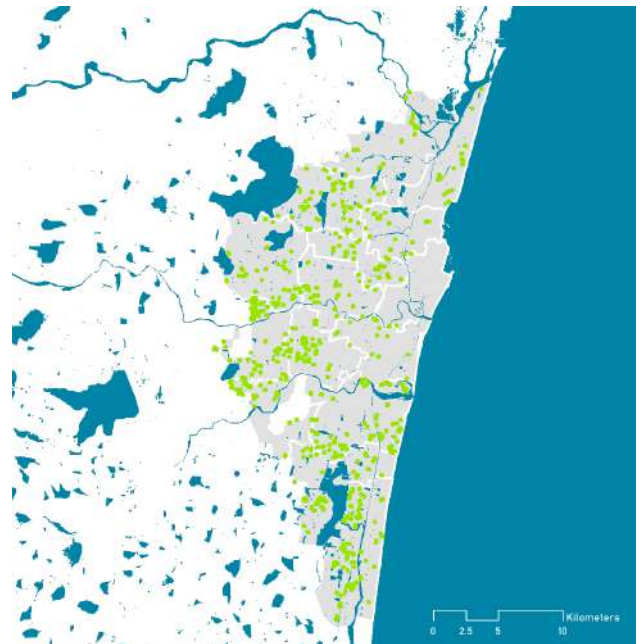


Fig. 1.14 Distribution of medium OSRs

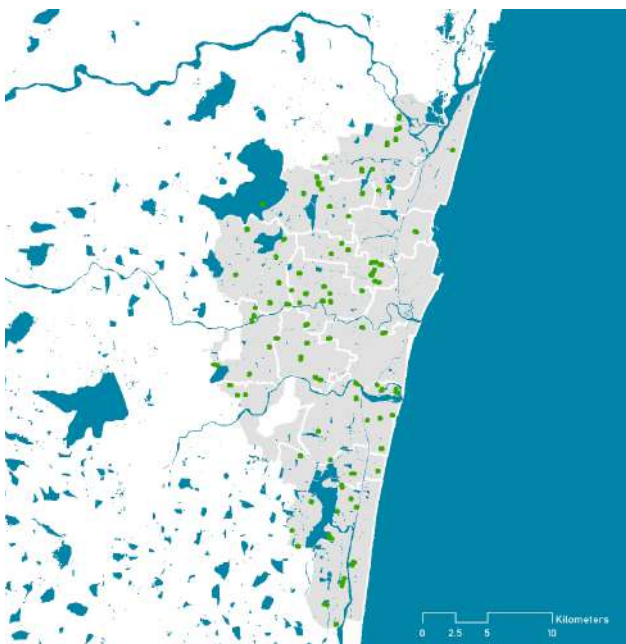


Fig. 1.15 Distribution of Large OSRs

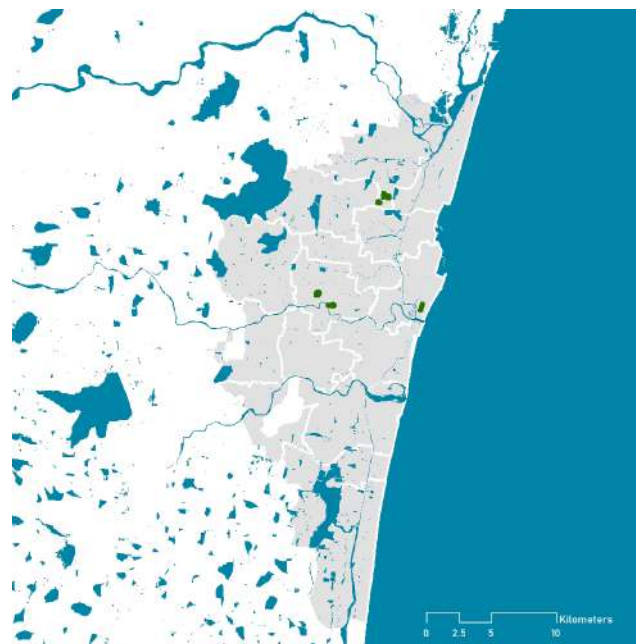


Fig. 1.16 Distribution of Special OSRs

Environmental Suitability for Sponge Parks

Environmental factors like soil, geology, and hydrology are key factors to determine whether upgrading an OSR into a Sponge Park will provide ecosystem services like stormwater regulation, flood mitigation and aquifer recharge. The first step of prioritising which OSRs should be selected as a Sponge Park pilot is based on environmental suitability.

All OSRs are assigned a 4-point environmental suitability ranking for each of the following factors:

1. Soils: Soil is a determining factor for the functionality of a Sponge Park to address the risks of flooding and water scarcity. OSRs with sandy soil will have greater infiltration rates than clay

or shale which would allow little to no shallow aquifer recharge. (Refer to Figure 1.7)

2. Geology: Geology is the structure of the land based on historic sediment, glacial, or volcanic movements. In Chennai, OSRs over alluvium deposited by rivers would be more porous for deep aquifer recharge compared to granite (Refer to Figure 1.8)

3. Flood hazard: OSRs in 5 year return period flood zones have a greater need for Sponge Parks than areas that flood from higher return period storms (Refer to Figure 1.9)

4. Ground water categorisation: OSRs located over aquifer zones that are critically depleted have a greater need for Sponge Parks than overexploited or safe aquifers (Refer to Figure 1.10)

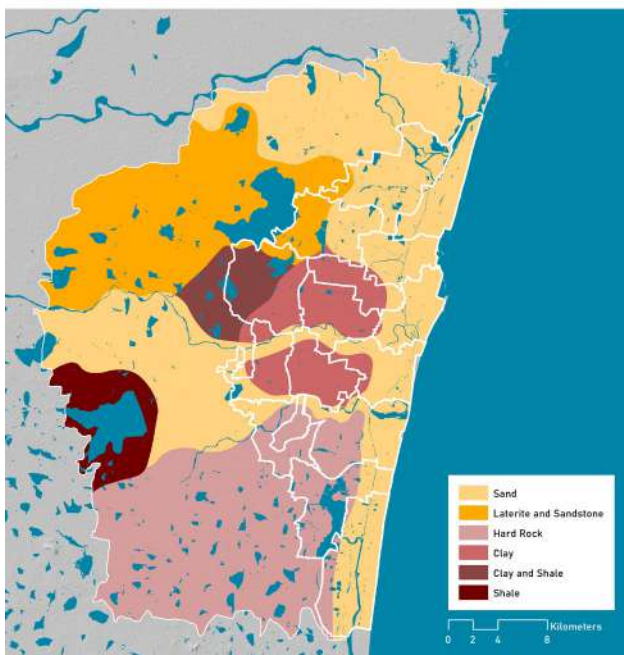


Fig. 1.17 Prioritization framework-OSRs based on Soil type

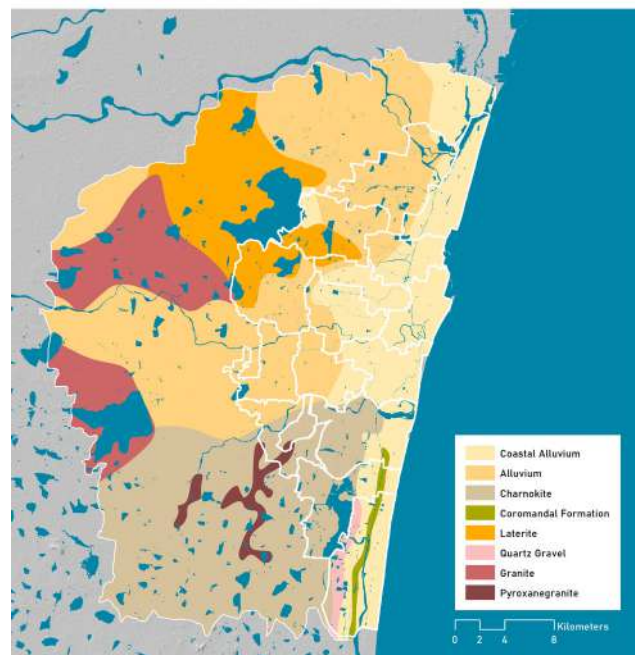


Fig. 1.18 Prioritization framework-OSRs based on Geology

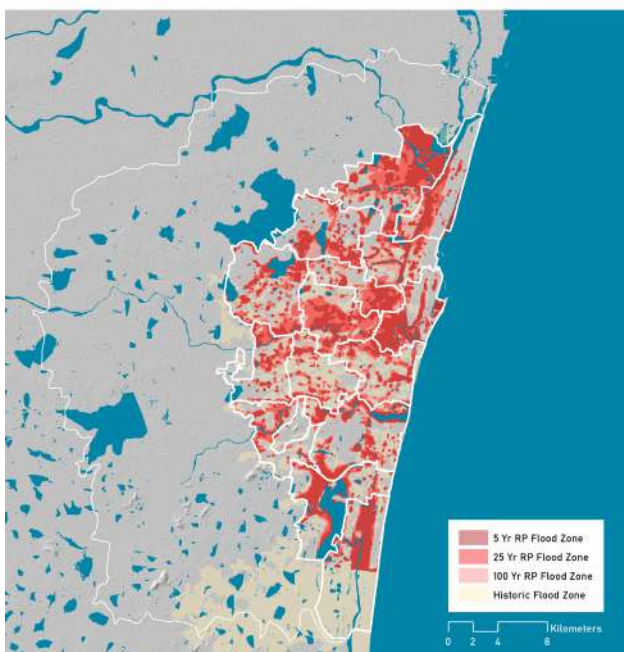


Fig. 1.19 Prioritization framework-OSRs in Flood hazard zones

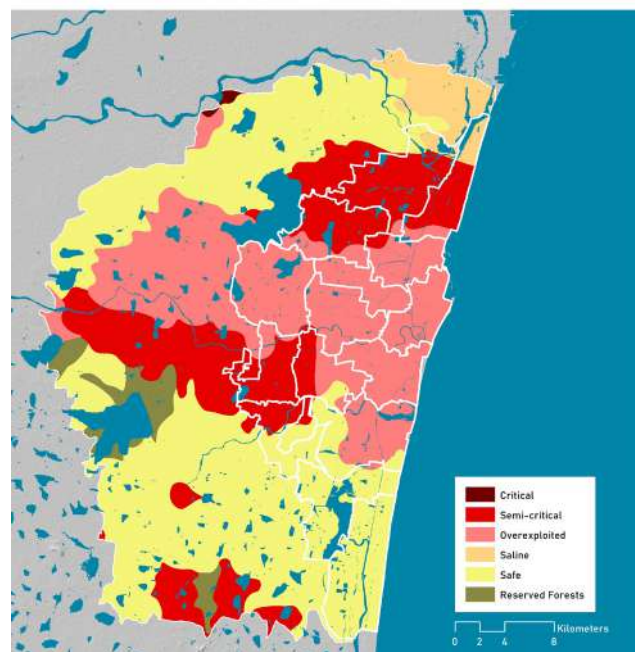


Fig. 1.20 Prioritization framework-OSRs based on ground water categorization

Social Need for Parks and Open Spaces

Chennai's residents have a park area of only 0.46 m² per capita while the WHO recommended minimum park area is 9 m² per capita. and social needs. The relative lack of open spaces in the form of parks with recreational amenities impacts the physical and mental health of Chennaites. The transformation of OSRs into a Sponge Park assumes the integration of social infrastructure with functional blue-green infrastructure. As such, social need for parks at the ward level is measured as an index with the following criteria:

1. Park area per capita: This is an effective metric to address park equity within high density wards that may have a park but the area is not adequate to meet WHO standards (Refer to Figure 1.13) .

2. Areas within 10 minutes of a Park: An isochrone analysis revealed which areas can access multiple parks within a 10 minutes walk compared to areas in red that have no parks nearby. Areas with low access have higher need (Refer to Figure 1.14)

3. Share of built-up area: Wards with high percentage of built-up including buildings and roads are more susceptible to extreme heat due to urban heat island effect and have a greater need for urban greening or forestry to mitigate hear risk (Refer to Figure 1.15)

4. Greenery: NDVI/SAVI analysis is used as a proxy for greenery to determine which areas are relatively less green. Low green cover suggests higher need for Sponge Parks due to associated flood risk and heat risk (Refer to Figure 1.16)

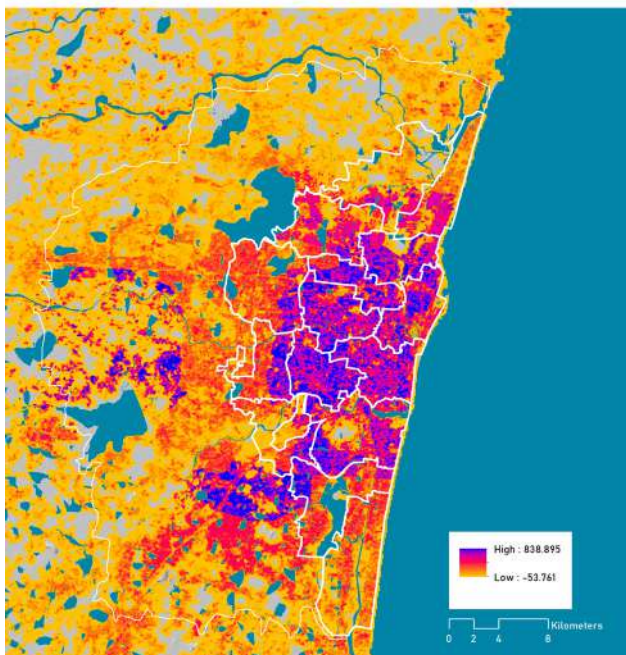


Fig. 1.21 Prioritization framework based on population density

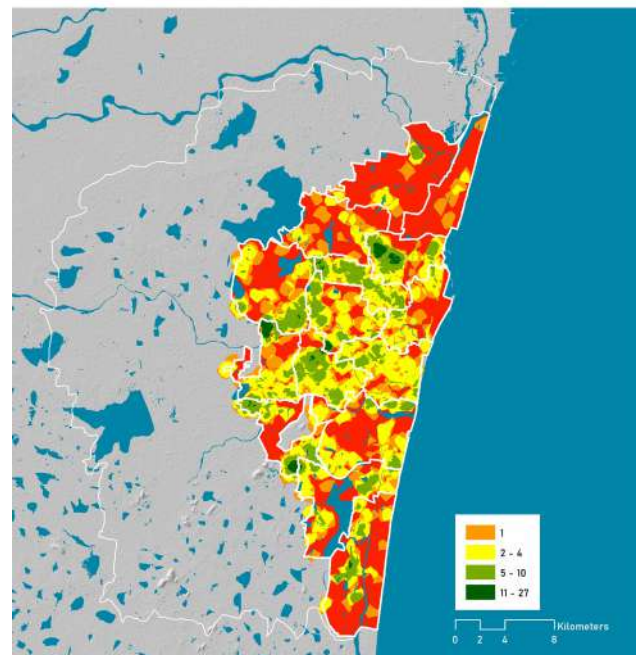


Fig. 1.22 Prioritization framework based on number of Parks within 10mins

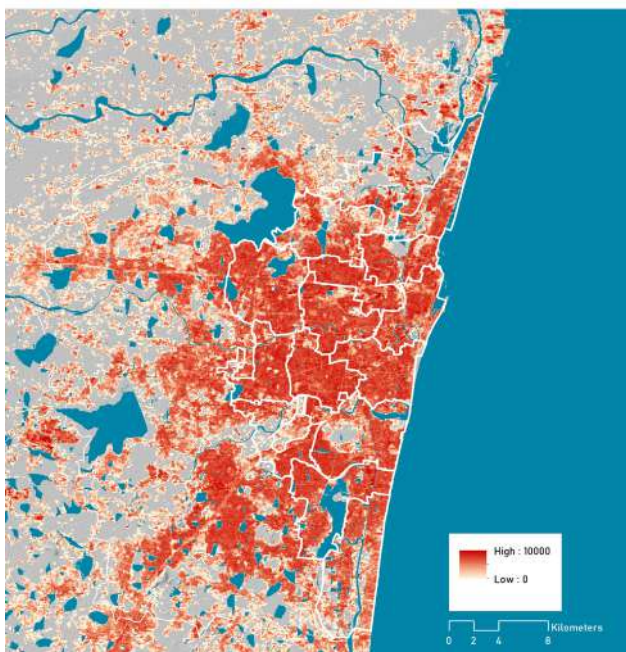


Fig. 1.23 Prioritization framework based on Built up area

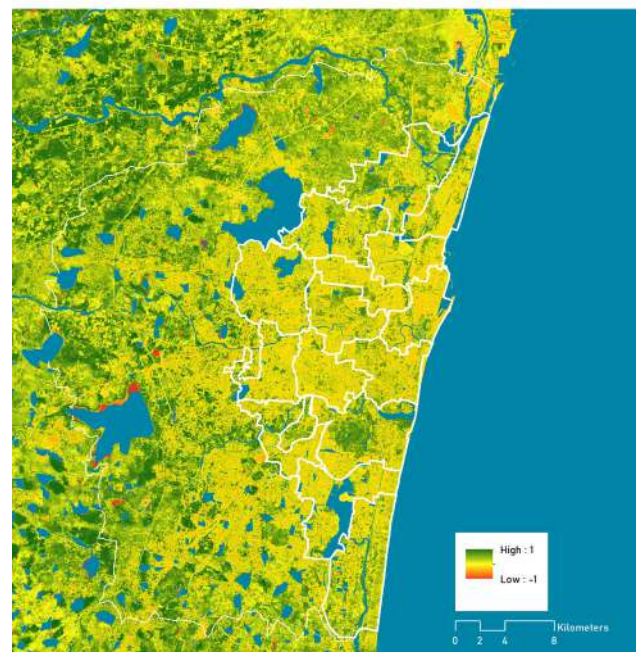


Fig. 1.24 Prioritization framework based on Greenery

Ranking of OSR's by Environmental Suitability Index

Using the preliminary prioritisation framework based on soil, geology, flood hazard, and ground water status data reveals a cluster of highest priority OSRs across multiple Zones and Wards. The OSRs are categorised as Highest Priority and High Priority based on the top two quantile of the Environmental Suitability Index. This index scoring was assigned to each OSR based on the rankings assigned through the unweighted indicing of the four environmental variables.

This exercise is meant to be a prefeasibility study to identify OSR candidates that are highly suitable to perform the functions of the Sponge Park. As a result these candidate OSRs should be examined in more detail to understand other factors that may remove it from consideration such as surrounding land uses, the lack of sewerage resulting in the mixing of sewage and stormwater, and the risk of point source contamination for industrial or toxic sources. These elements can create a very high risk for compromising the aquifer which is a source of water for many Chennai residents.

Additionally, localised soil assessments, geologic testing, hydrological modelling, and aquifer measurements have to be made to confirm the OSR's suitability as a future Sponge Park.

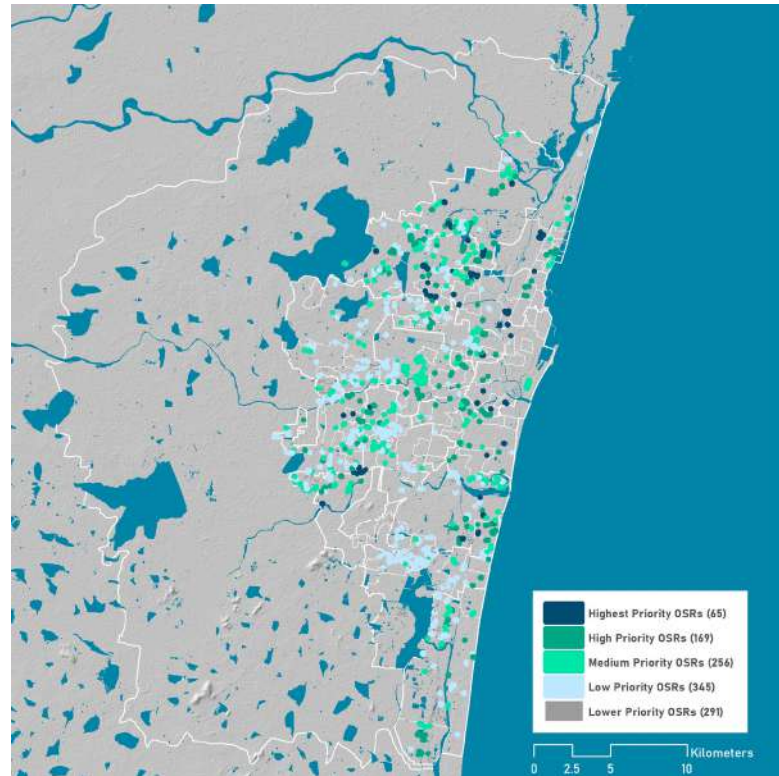


Fig. 1.25 Map showing ranking OSRs

Ranking of Wards by Park Need Index

Based on the systematic analysis of park access and a preliminary understanding of built-up density and relative greenery, the Park Need Index was developed using the unweighted indicing of the four park and urban form variables.

As a prefeasibility study, this highlights some of the densely populated but relatively marginalised wards of Chennai with high park need. These places stand to benefit greatly from an increase in the number, acreage, and greenery of open spaces. The transformation of OSRs into Sponge Parks would have a greater social impact in these areas.

The prioritisation framework integrates environmental suitability and social sensibilities by recommending OSRs with high or highest priority rankings located within a ward of high or highest park need should be the top candidates for Sponge Park upgrades.

Figure 1.21 shows map of OSRs with their priority rankings overlaid on wards showing their level of park need.

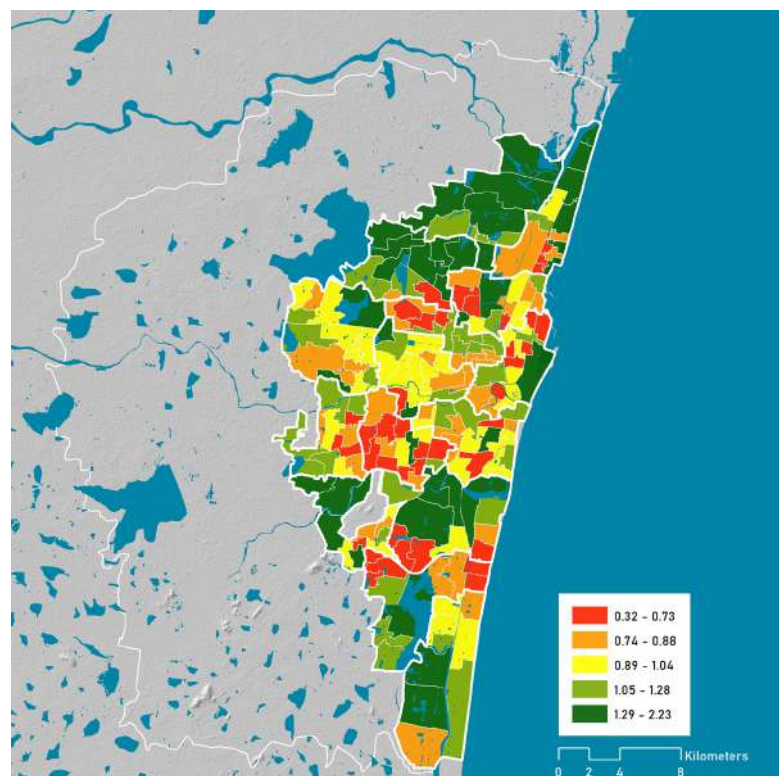


Fig. 1.26 Map showing Social Needs index

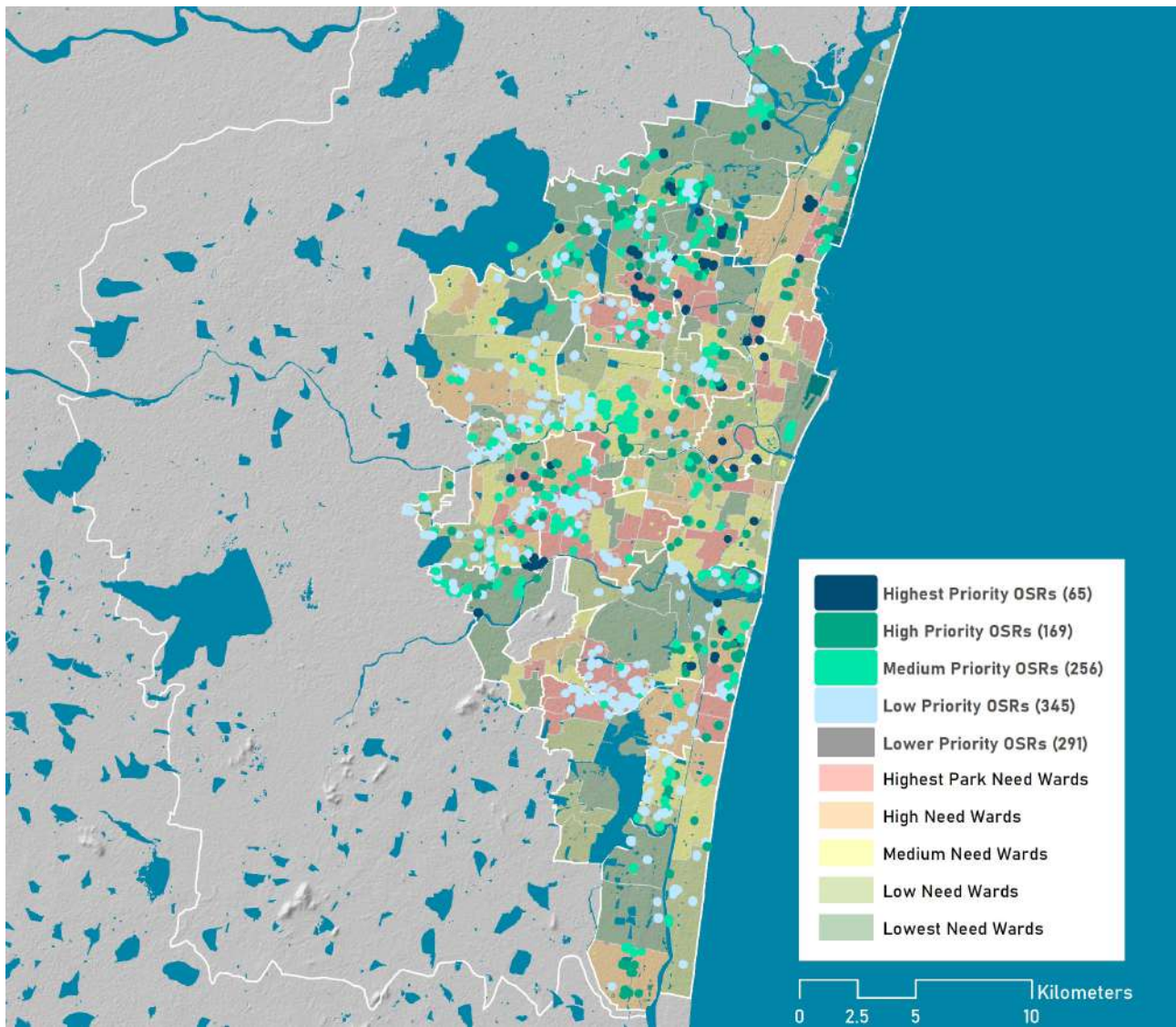


Fig. 1.27 Map showing various typologies of OSRs

Zone	Total OSRs	Small OSRs (S)			Medium OSRs (M)			Large OSR (L)			Special OSR (X)		
		OSRs (S)	Highest Priority	High Priority	OSRs (M)	Highest Priority	High Priority	OSRs (L)	Highest Priority	High Priority	OSRs (X)	Highest Priority	High Priority
1	24	5	1	1	18	0	7	1	0	0	0	0	0
2	84	47	0	0	22	0	0	12	0	0	3	0	0
3	100	39	3	0	52	4	0	9	0	0	0	0	0
4	35	17	5	8	17	4	5	1	0	1	0	0	0
5	10	7	0	2	2	0	1	0	0	0	1	0	0
6	68	30	1	2	28	5	4	10	0	1	0	0	0
7	80	33	0	0	39	0	0	8	0	0	0	0	0
8	68	31	2	3	25	0	2	9	0	1	3	0	0
9	36	18	1	1	15	1	0	3	0	0	0	0	0
10	86	39	1	3	42	2	2	5	0	0	0	0	0
11	130	57	1	5	66	3	3	7	0	1	0	0	0
12	50	16	0	0	31	0	0	3	0	0	0	0	0
13	182	97	0	5	73	0	8	12	0	0	0	0	0
14	59	16	0	1	37	0	1	6	0	1	0	0	0
15	113	28	0	3	71	0	5	14	0	1	0	0	0
	1125	480	15	34	538	19	38	100	0	6	7	0	0

1.2. Prioritization of Sponge parks

Summary of priority OSRs

Prioritisation refers to having a systematic way to determine which OSRs can be upgraded to have the most positive environmental and social impact on communities. The study identified 112 Priority OSRs due to their high environmental suitability rankings and location within wards with high park needs. (Refer to Figure 1.28)

The following pages summarise which wards with high or highest park need have OSRs that ranked high on suitability. ANNEX A provides a detailed attribute table for all Priority OSRs as well as Zonal summaries.

GCC is provided with a geodatabase of all OSRs and Wards along with attributes and rankings. Zonal Engineers can use this prioritisation tool with ward representatives to assess the upgrading of which OSRs will benefit the surrounding community and ground truth the city level study with ward level observations about the open space and the stormwater drainage networks.

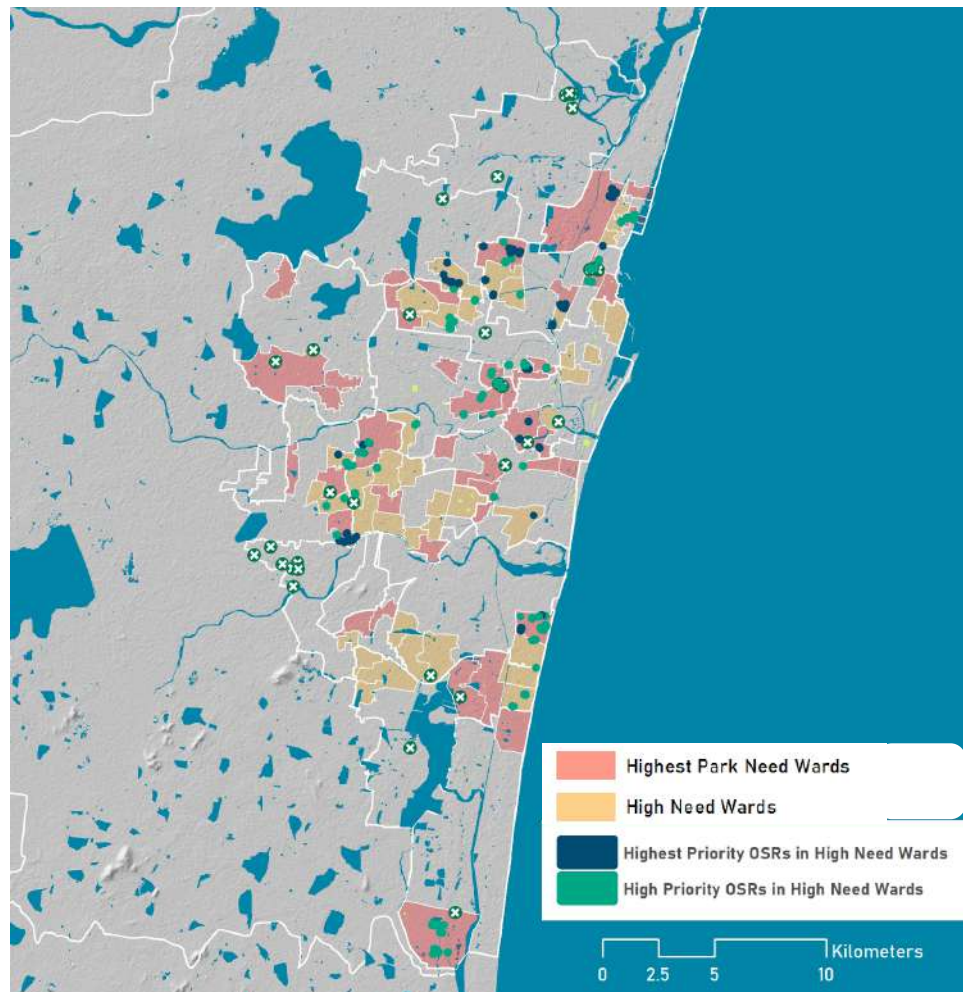


Fig. 1.28 Map showing highest Priority OSRs in High Need wards

ZONE	Total OSRs	# of High Priority OSR	# of Highest Priority OSR	# Wards Lower Need	# Wards Low Need	# Wards Medium Need	# Wards High Need	# Wards Highest Need	"# High Priorty OSRs in High Need Wards"
1	24	6	5	6	1	1	3	2	9
2	84	17	7	5	3	0	0	0	0
3	100	21	11	7	2	0	1	1	7
4	35	9	15	2	2	4	4	3	23
5	10	3	6	1	2	4	2	6	3
6	68	14	1	0	6	0	5	3	13
7	80	0	0	2	3	6	4	0	0
8	68	18	0	2	2	6	3	1	8
9	36	19	3	1	4	7	4	1	3
10	86	7	1	1	1	2	3	9	8
11	130	13	9	0	6	2	3	2	13
12	50	5	1	5	1	3	2	1	0
13	182	18	6	5	2	1	1	4	13
14	59	3	0	1	3	0	2	5	3
15	113	16	0	2	2	3	2	0	9
Total	1125	169	65	40	40	39	39	38	112

Summary of priority OSRs in North Chennai

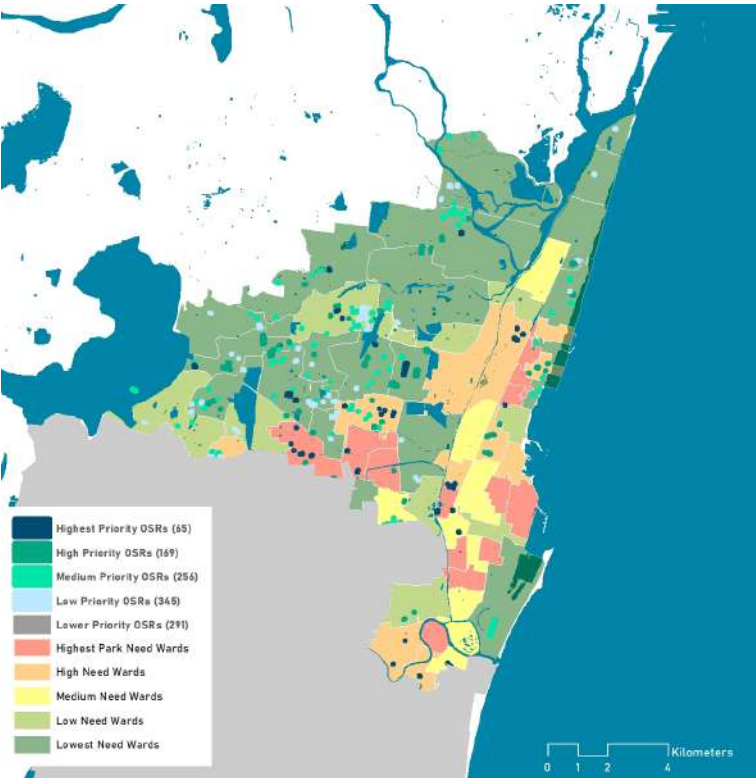


Fig. 1.29 Map showing Priority OSR wards in North Chennai

#	Zone	Ward	Typology	Area (Ac)	"Ward Park Need Category"	"OSR Ranking"
1	1	7	M	0.54	High	27
2		7	M	0.28	High	26
3		7	M	0.30	High	26
4		7	M	0.26	High	26
5		11	M	0.52	High	23
6		11	M	0.35	High	23
7		11	S	0.06	High	23
8		11	M	0.33	High	23
9		13	S	0.15	Highest	26
10	3	29	S	0.07	Highest	26
11		29	M	0.23	Highest	26
12		29	M	0.25	Highest	25
13		29	M	0.44	Highest	25
14		29	S	0.08	Highest	25
15		29	S	0.06	Highest	25
16		29	M	0.35	Highest	22

#	Zone	Ward	Typology	Area (Ac)	"Ward Park Need Category"	"OSR Ranking"
17	4	34	S	0.15	High	25
18		34	S	0.04	High	25
19		34	S	0.11	High	25
20		34	S	0.16	High	24
21		34	M	0.22	High	24

Summary of priority OSRs in Central Chennai

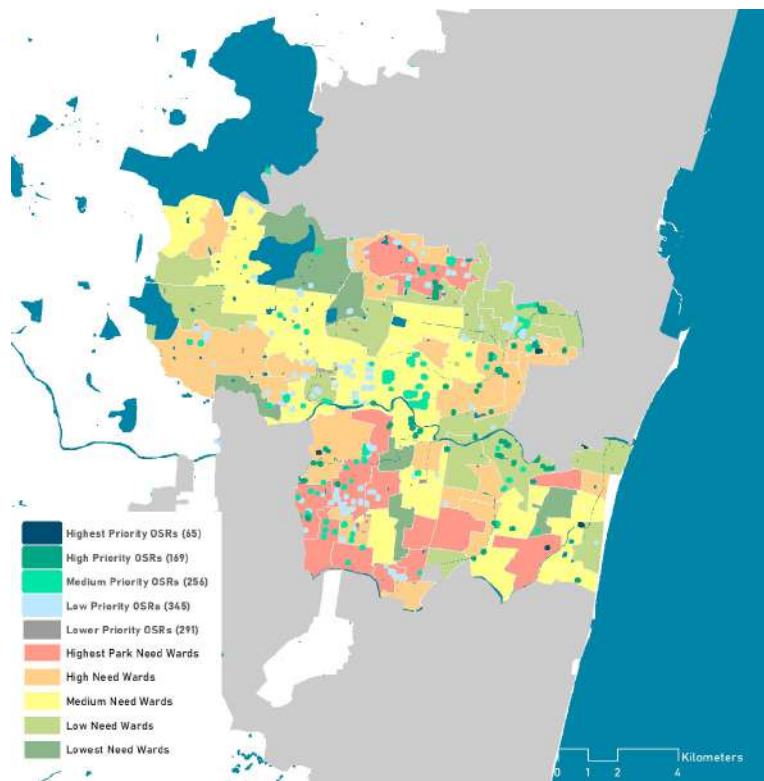


Fig. 1.30 Map showing Priority OSR wards in Central Chennai

#	Zone	Ward	Typology	Area (Ac)	"Ward Park Need Category"	"OSR Ranking"
1	6	67	M	0.32	Highest	22
2		68	M	0.33	Highest	22
3		68	M	0.65	Highest	22
4		68	S	0.12	Highest	22
5		68	M	0.73	Highest	22
6		68	M	0.82	Highest	22
7		75	S	0.04	High	22
8		75	M	0.28	High	22
9		76	L	1.20	High	24
10		76	M	0.46	High	22
11		76	S	0.02	High	22
12		76	M	0.67	High	22
13		77	M	0.28	High	22

#	Zone	Ward	Typology	Area (Ac)	"Ward Park Need Category"	"OSR Ranking"
14	8	99	S	0.05	High	22
15		99	M	0.21	High	22
16		99	L	1.40	High	22
17		100	S	0.15	High	22
18		100	M	0.29	High	22
19		100	S	0.05	High	22
20		105	S	0.03	Highest	22
21		105	S	0.05	Highest	22
22	9	115	M	0.22	Highest	23
23		117	S	0.11	High	23
24	10	123	S	0.04	Highest	27
25		127	S	0.11	High	24
26		127	M	0.22	High	23
27		127	M	0.28	High	23
28		127	S	0.05	High	22
29		127	S	0.02	High	22
30		128	M	0.21	Highest	22
31		128	S	0.04	Highest	22
32		129	M	0.42	Highest	22

Summary of priority OSRs in South Chennai

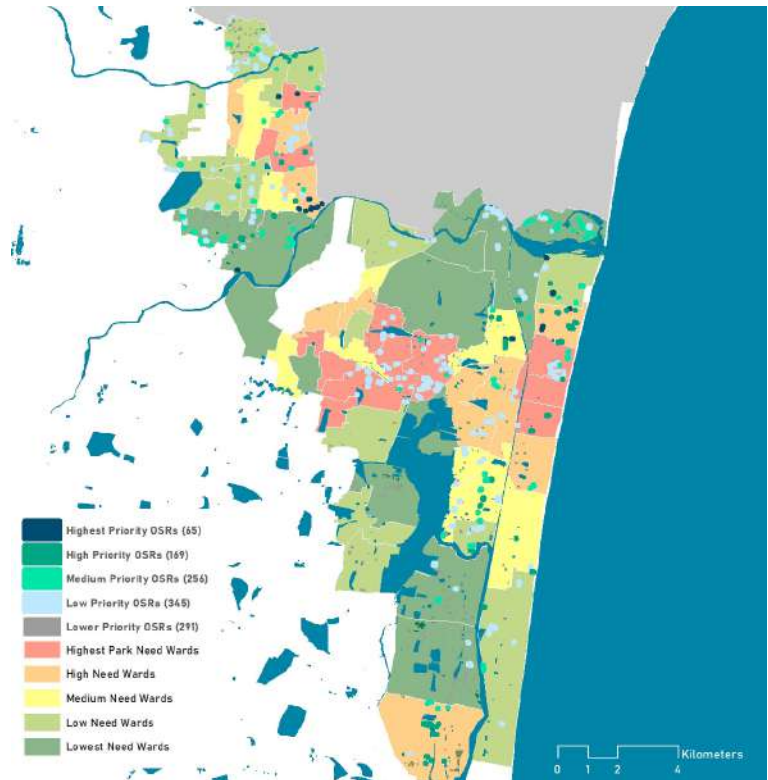


Fig. 1.31 Map showing Priority OSR wards in South Chennai

#	Zone	Ward	Typology	Area (Ac)	"Ward Park Need Category"	"OSR Ranking"
1	11	148	S	0.11	Highest	24
2		148	M	0.68	Highest	23
3		148	L	1.46	High	22
4		152	M	0.24	Highest	22
5		152	M	0.23	Highest	22
6		155	S	0.07	High	25
7		155	M	0.23	High	25
8		155	S	0.08	High	25
9		155	S	0.10	High	25
10		155	S	0.12	High	24
11		155	M	0.27	High	24
12		155	M	0.27	High	24
13		155	S	0.14	High	22

#	Zone	Ward	Typology	Area (Ac)	"Ward Park Need Category"	"OSR Ranking"
14	13	179	M	0.62	High	26
15		179	S	0.19	High	24
16		179	S	0.03	High	23
17		179	M	0.21	High	23
18		179	S	0.07	High	22
19		179	M	0.34	High	22
20		179	S	0.17	High	22
21		179	S	0.09	High	22
22		179	M	0.34	High	22
23		179	M	0.66	High	22
24	13	179	M	0.25	High	22
25		179	M	0.51	High	22
26		179	M	0.97	High	22
27		181	S	0.05	Highest	22
28		183	M	0.27	Highest	23
29	14	183	L	1.00	Highest	22

1.2. Prioritization of Sponge parks

There are more than a 1,100 OSRs across Chennai of varying sizes but the gradual scaling up of Sponge Parks will start with 50 - 100 OSRs at a time. The prioritisation framework provides a high level prefeasibility of OSRs that are environmental suitable and socially beneficial as a Sponge Park. However, a ground level assessment of soil, hydrology, ecology, and community needs has to be followed before a candidate OSR is selected for transformation into a Sponge Park. A summary checklist of actions to be conducted for the final prioritisation of Sponge Parks is below.

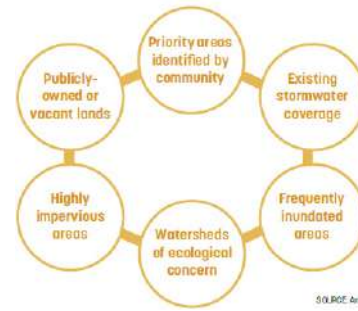


Fig. 1.32 Consideration of local inputs, environmental issues, and political ease to prioritize project

1. Aquifer Recharge and water Quality

The porosity of soil and geology in OSRs was a primary consideration for environmental suitability. However, local conditions can greatly modify soil conditions through compaction or construction. Soil profile testing within OSR boundaries to determine infiltration rates and screening the contributing catchment area for sewage in stormwater conduits or an industrial point pollution source. The presence of either means the Sponge Park should not be receiving runoff beyond its boundary if chosen for concept design.

- ✓ Assess soil infiltration rate and depth to groundwater table to estimate aquifer recharge benefits.
- ✓ Ensure catchment area has no point pollution sources and OSR can support adequate filtration to prevent aquifer contamination as a Sponge Park



Fig. 1.33 Study adjacent land uses and social uses to identify project site within catchment area

2. Flood Mitigation

The environmental suitability ranking prioritised areas that are flood prone to storm events with smaller return periods. However, local instances of water logging that may not show up on metropolitan scale flood models are also suitable sites for Sponge Parks. Essentially, the Sponge Park site should be the natural low point of the targeted catchment area where runoff will tend to collect. A catchment level analysis of factors like imperviousness, stormwater drain coverage and capacity, and local flooding nodes needs to be modelled before an OSR is chosen for concept and detailed design.

- ✓ Calculate contributing catchment area and runoff volume for 5, 10, 25 year RP storms to determine if OSR site can mitigate flooding as a Sponge Park

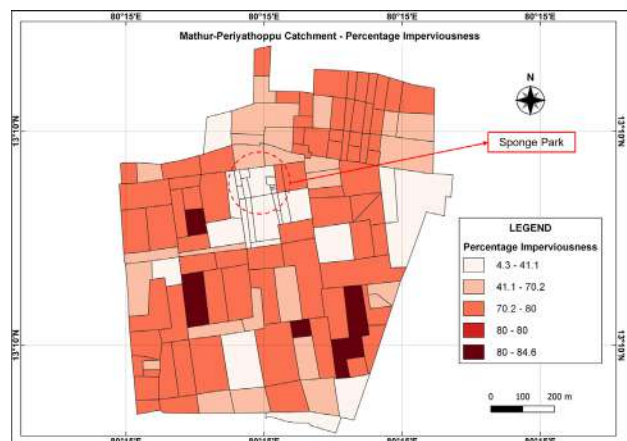


Fig. 1.34 Study adjacent land uses and social uses to identify project site within catchment area

3. Urban Greenery and Ecology

The social needs ranking prioritised areas with relatively low greenery or tree cover and high built-up density. The latest and localised canopy cover and greenery needs to be evaluated along with any potential for ecological connectivity with surrounding landscapes. Most importantly, a quick ambient temperature scan can be conducted to determine whether the neighbourhood suffers from extreme heat. Community engagement with vendors, workers, and open space users are also valuable to determine the need for a Sponge Park to mitigate the heat island effect.

- ✓ Study ecological corridor, habitat Potential, and heat island effect

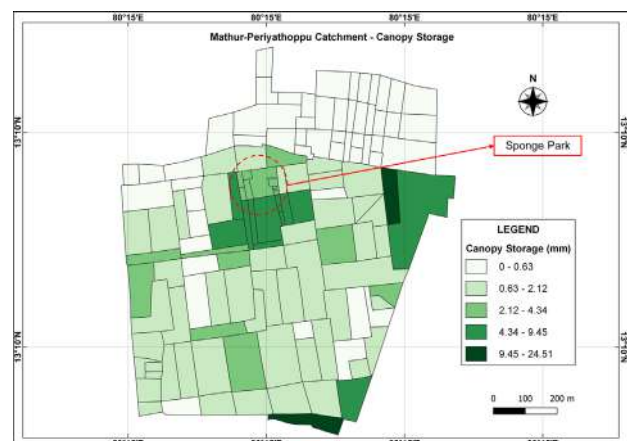


Fig. 1.35 The sub-catchments were estimated from the data sets for 'Tree canopy'.

4. Community Needs

The parks need index score assigned to the OSRs are based on a high level analysis of parks access and park area per capita. However, park accessibility and utility is not only about proximity but multiple factors including park hours, perception of safety, and quality of amenities. The transformation of an OSR into a Sponge Park is an opportunity to provide under served neighbourhoods with much needed amenities apart from creating a recreational open space in an area lacking parks. Walking interviews with community representatives or facilitated community engagement exercises gathering feedback on open spaces across dimensions like Access, Inclusion, Safety, Service, and

In the prioritisation phase, community inputs on perceived risks can provide more insights on flooding, water scarcity, and extreme heat stressors. The community will also be able to validate the impact of the lack of open spaces and the social facilities desired in the neighbourhood. A quick social audit of existing facilities and the socio-economic profile of the neighbourhood within the walking catchment area can help determine the provision of programs like playgrounds, outdoor gymnasiums, community gardens, or public toilets.

Focus group discussions to specifically understand the needs of women and other user groups including LGBTQ persons, informal workers, differently abled, children, youth, and senior citizens.

Finally, community concerns and thoughts about a Sponge Park have to be taken into account before finalising a highly ranked OSR as a Sponge Park site for design and implementation.

- ✓ Engage community to understand social and climate needs that can be fulfilled by the social facilities and landscape provided in the potential Sponge Park



Fig. 1.36 Community Engagement with women in Kannagi Nagar



Fig. 1.37 Community Engagement with women in Kannagi Nagar



Fig. 1.38 Community Engagement with women in Kannagi Nagar

 Access	 Inclusion	 Safety	 Service
Is the Sponge Park widely available & easy to reach, enter, and use by all user groups?	Does the Sponge Park account for physical, socio-economic, and special needs?	Is the Sponge Park perceived to be safe & does it provide security to all user groups?	Does the Sponge Park provide an adequate level of service with amenities for all?

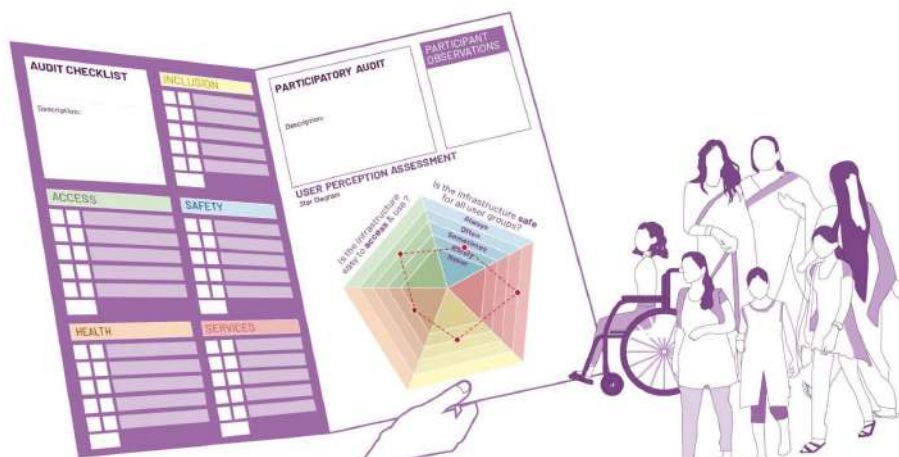


Fig. 1.39 Prioritization of gender inclusion and needs of marginalised communities

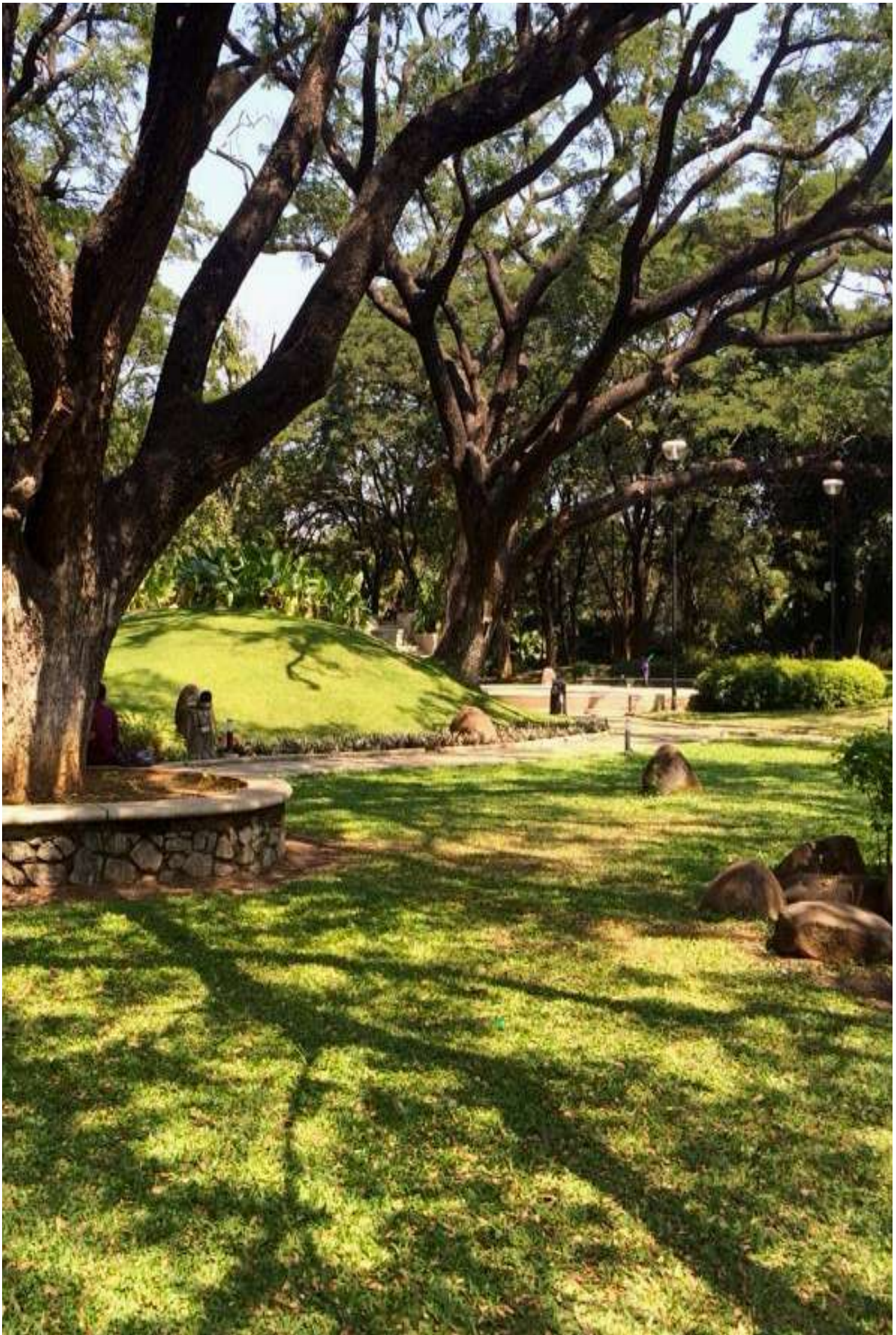


Image Credit - Semmozhi Poonga

2 DESIGNING SPONGE PARKS

How to Read this Chapter

2.1. Sponge Park Systems

2.1.1. Soil and Grading

2.1.2. Hydrology and Blue green Infrastructure

2.1.3. Vegetation and Planting

2.1.4. Amenities and Social Infrastructure

2.2. Sponge Park Typologies

2.2.1. Small Sponge Park

2.2.2. Medium Sponge Park

2.2.3. Large Sponge Park

2.2.4. X -Large Sponge Park

2.3. Design Criteria for Sponge Park System

How to read this chapter ?

Sponge Park systems



S.1. SOIL & GRADING

Modifying soil composition, improving soil health, and contouring earthworks to create zones for intensive planting, programmed spaces, and hydrology

Grading	Shape clear highs, lows, and drainageways
Amendment	Address soil compactness and quality
Enhance	Improve soil fertility for intensive planting
Porosity	Increase infiltration rates in recharge zones

For overview of checklists and general guidelines, refer to: **Pg 48**

Strategies

-  Survey
-  Grading
-  Soil Amendment
-  Enhance
-  Infiltrate

For detailed guidelines refer to ANNEX B and refer to: **Pg 236**



S.2. HYDROLOGY & BLUEGREEN

Ensuring the sequence, sizing, and detailing of BGI components strategically delays, stores, and stores runoff while recharging the aquifer

Delay	Intercept rainfall and slow down runoff
Store	Detain stormwater temporarily or for reuse
Filter	Remove runoff pollutants and sediments
Recharge	Promote deep and shallow aquifer recharge

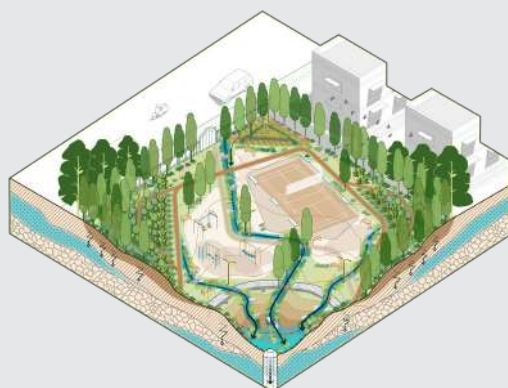
For overview of checklists and general guidelines, refer to: **Pg 48**

Strategies (BGI Toolkits)

-  T1. Bioswales
-  T2. Recharge Pit
-  T3. Raingarden (Building)
-  T4. Raingarden (Streets)
-  T5. Retention Pond
-  T6. Infiltration Basin
-  T7. Sunken Court
-  T8. Water Plaza
-  T9. Constructed Wetlands

For detailed guidelines refer to ANNEX B and refer to: **Pg 238**

Typologies of Sponge Parks



Small Sponge Park

For more Information on small typology

Pg 56



Medium Sponge Park

For more Information on medium typology

Pg 62



S.3. VEGETATION & PLANTING

Working with existing vegetation and native species to create a biodiverse, resilient and aesthetic habitat and microclimate that is optimised for maintenance

Biodiversity	Improve urban ecology with native species
Maintainability	Ensure planting thrives with moderate care
Aesthetics	Cultivate landscape character and diversity
Resilience	Building climate resilience with planting

For overview of checklists and general guidelines, refer to: **Pg 50**

Strategies



For detailed guidelines refer to ANNEX B and refer to:

Pg 258



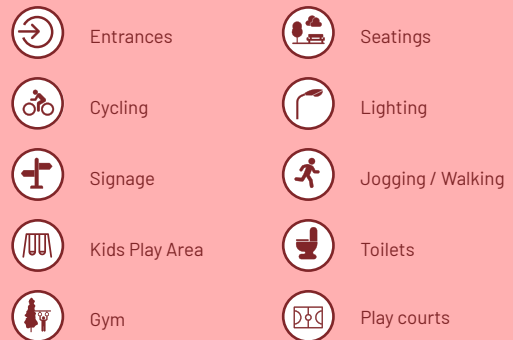
S.4. AMENITIES & SOCIAL FACILITIES

Catering to the needs of local communities by maximising access, fostering inclusion, ensuring safety of women, and programming the park for diversity

Inclusion	Ensure the social needs of all park user groups
Accessibility	Accommodate diverse abilities and schedules
Safety	Provide safe environments for all genders
Services	Provide amenities for all ages and interests

For overview of checklists and general guidelines, refer to: **Pg 52**

Strategies



For detailed guidelines refer to ANNEX B and refer to:

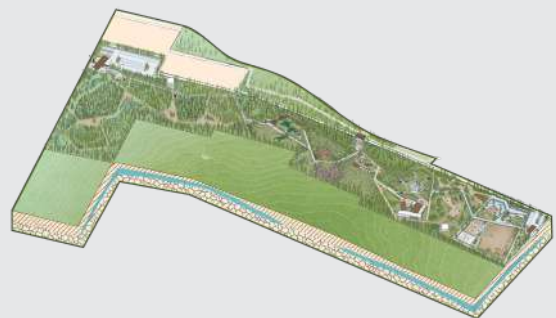
Pg 272



Large sponge park

For more Information on large typology

Pg 68



X Special Case

For more Information on X special case

Pg 74

2.1. Sponge Park Systems



S.1. Soil and Grading

Soil composition and geology greatly determines the functionality of Sponge Park as a blue-green infrastructure for aquifer recharge. Sandy or silty soil over porous geology have high infiltration potential. However, even in less porous areas with clayey soil or rocky geology, Sponge Parks can delay and store stormwater when graded with runoff pathways leading to depressions or pits designed for specific storm event volumes. Additionally, urban soils can be amended to have greater saturation capacity for temporary storage, enhanced with organic matter to support dense vegetation, or engineered for higher infiltration in recharge areas.



Fig. 2.1 Comprehensive soil testing provides critical data for Sponge Park design

Grading

- ✓ Measure the site's elevation, slopes, existing high and low points to determine natural drainage patterns.
- ✓ Define a clear grading strategy to receive storm water, convey runoff through bioswales, and store runoff in depressions
- ✓ Minimise cut and fill or reuse soil material to achieve grading strategy for managing runoff and promoting aquifer recharge

Amendment

- ✓ Conduct physical soil tests to assess soil type, texture, compaction, and structure
- ✓ Improve water holding capacity of compacted soils through tilling and mixing with sand, gravel, and engineered soil

Enhance

- ✓ Conduct biogeochemical soil tests to assess alkalinity, salinity, and nutrient values
- ✓ Improve nutrient quality of soils in planting and forest zones with addition of organic matter including from composting or mulching

Infiltration

- ✓ Determine infiltration rate of soil using permeameter or infiltrometer devices and vertical infiltration rate through 150mm of soil
- ✓ Engineer soil mixes to increase sandy or gravel content in recharge areas to optimise infiltration rates

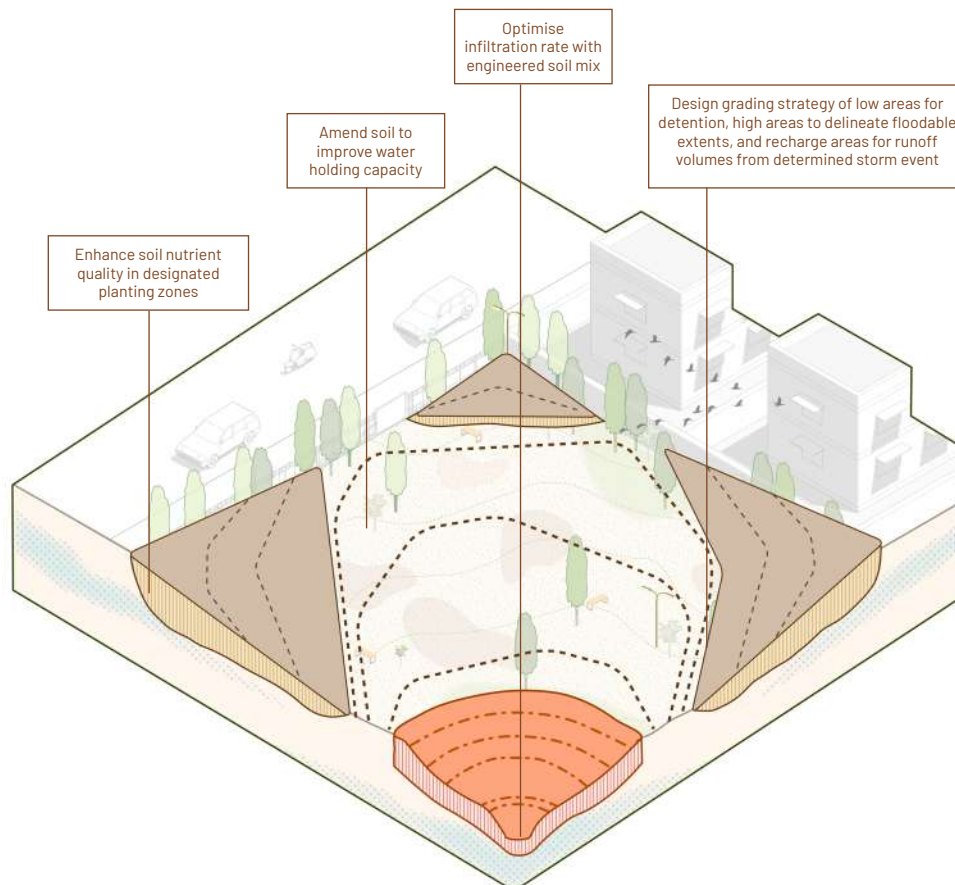
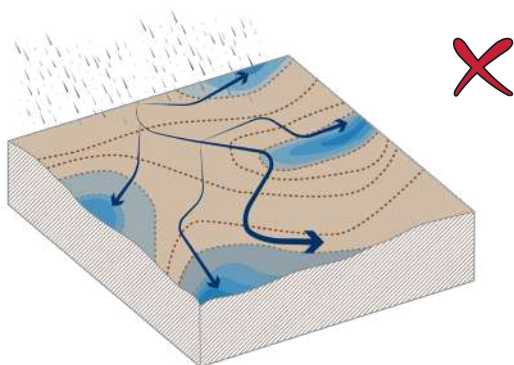
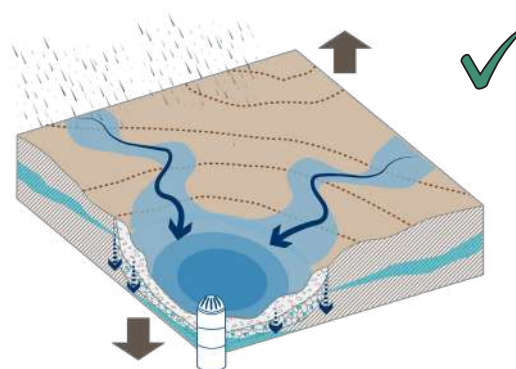


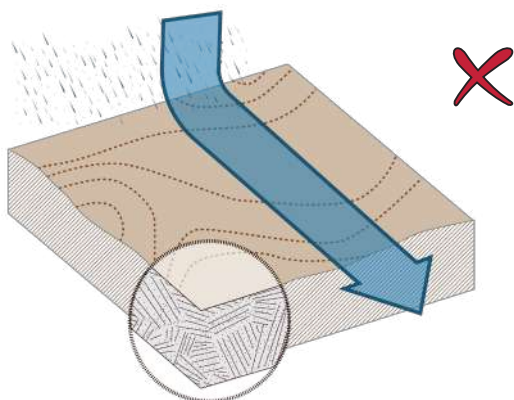
Fig. 2.2 Soil and grading strategies for different zones in a Sponge Park



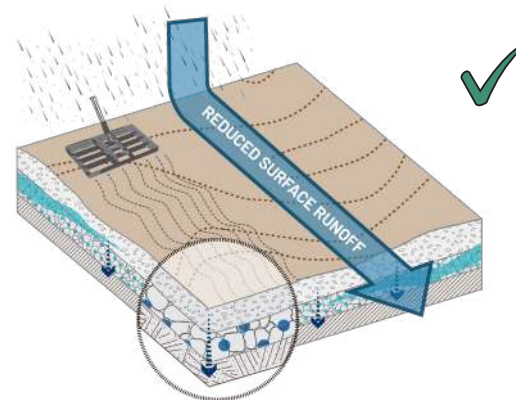
Don't allow storm water to stagnate in areas without clear drainage or infiltration zones



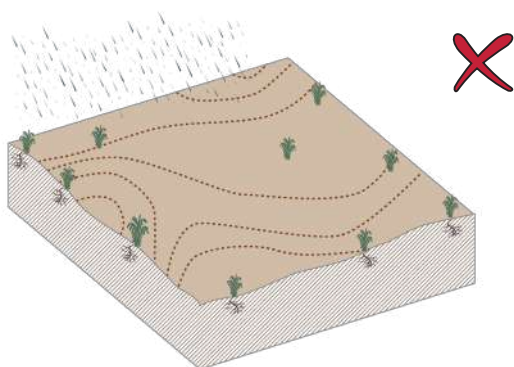
Do grade the site with clear drainageways and depressions for the conveyance, detention, and infiltration of runoff



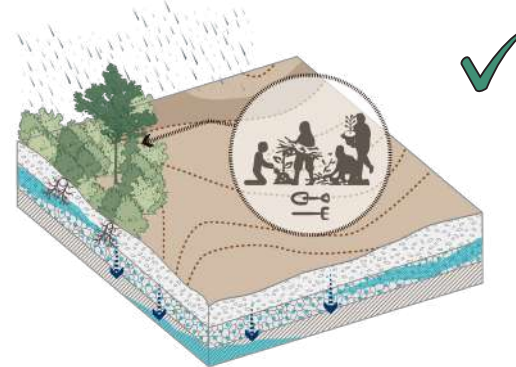
Don't allow soil to remain compacted since that limits the capacity for water holding and supporting plant growth



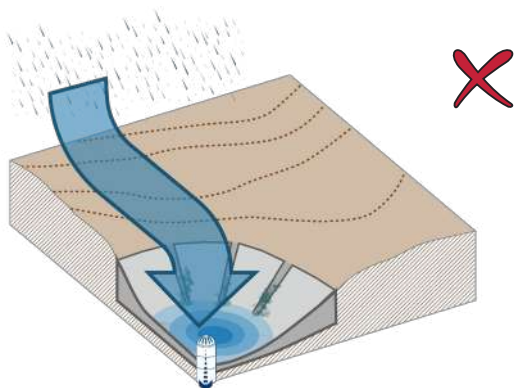
Do amend the soil through tilling and mixing with appropriate mix of sand and gravel to increase water holding capacity



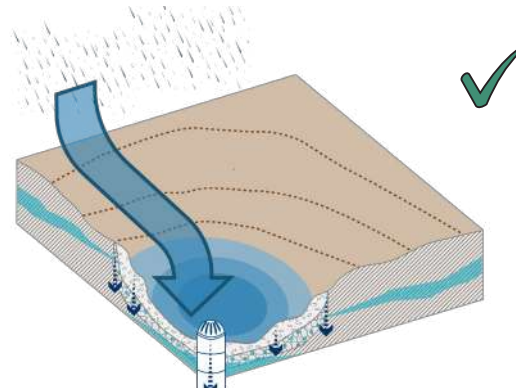
Don't begin planting without conducting geochemical testing and evaluating nutrient quality of soil to support intensive vegetation



Do enhance the nutrient quality of soil through additional of organic matter in areas designated for forests or gardens



Don't create concrete pits for collection of runoff for infiltration



Do create gently graded depressions in recharge zones with high infiltration soil mixes and layers for filtering stormwater



S.2. Hydrology and Blue-green Infrastructure

Hydrology refers to the circulation and distribution of water over and through land. Understanding the hydrology of a Sponge Park site includes the volume of precipitation over the area of the park as well the volume of runoff from contributing catchments and how quickly the stormwater saturates the soil, infiltrates into the aquifer, or continues as flood waters for different intensities of storm events. Through grading and the implementation blue-green infrastructure (BGI) components as a network, Sponge Parks can mitigate flooding from 5 to 25 year return period storm events. The functions of BGI are described in the checklist and diagrams.

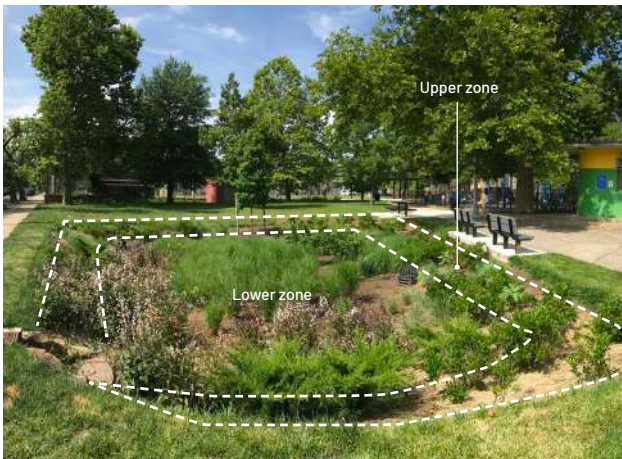


Fig. 2.3 Reference Image- Stinger Square Playground Rain Garden

Delay

- ✓ Design opportunities for delay around inlets through forebays and higher elevations through canopy cover for interception
- ✓ Convey stormwater into designated storage and recharge zones through curvilinear bioswales with appropriate depth and slope

Store

- ✓ Design gently graded depressions, pits, and ponds for temporary detention of stormwater designed for storage of runoff from determined storm event intensity
- ✓ Size storage volumes based on capacity for 5, 10, or 25 year storm event and depths that are safe for park users

Filter

- ✓ Contain sediments from runoff at source or inlets and design long-winded conveyance channels or bioswales with vegetation to filter runoff
- ✓ Ensure that stormwater runoff is adequately filtered by bioswales and layers of filter within recharge well are able to remove pollutants including hydrocarbons.

Recharge

- ✓ Designate natural low areas or gently graded low pits or basins with high infiltration soil as aquifer recharge zones
- ✓ Conduct comprehensive impact assessment on aquifer if Sponge Park is treating runoff from catchment beyond park boundaries.

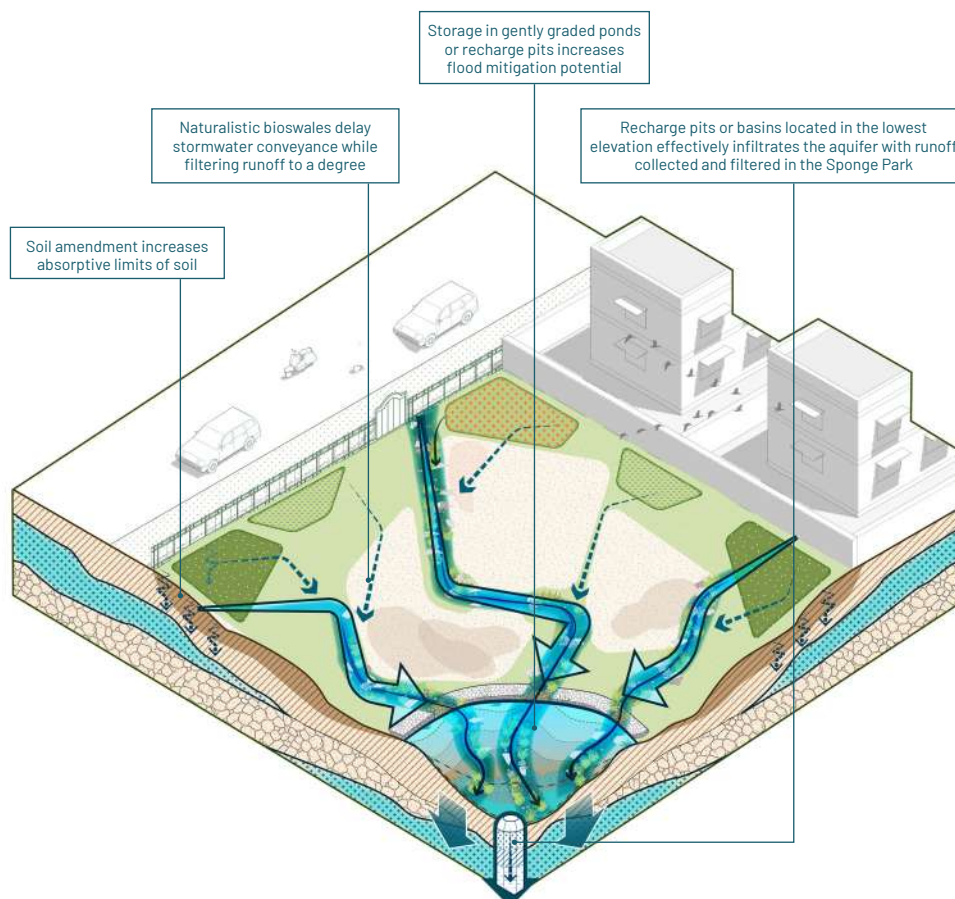
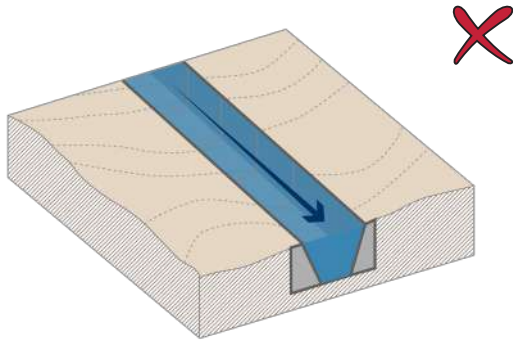
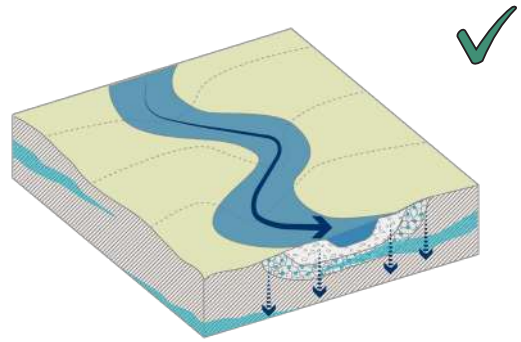


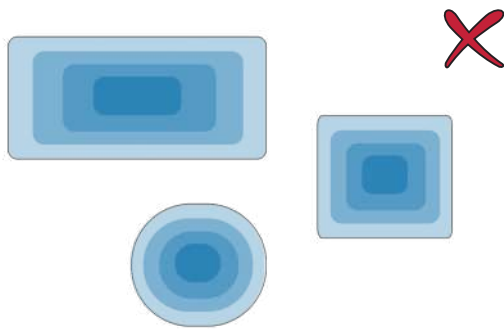
Fig. 2.4 Axon showing the various indicator to consider for hydrology



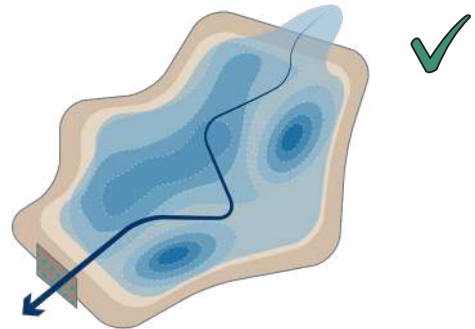
Don't convey runoff through channelised and impervious structures



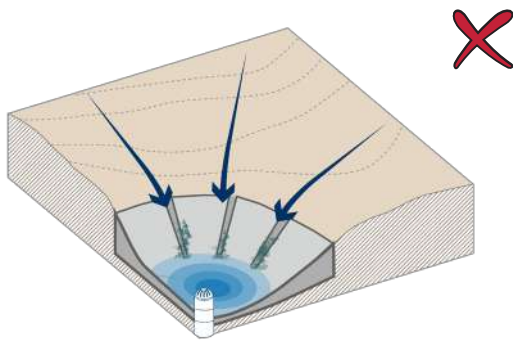
Do convey runoff through curvilinear and vegetated bioswales that delay and filter runoff with some shallow recharge



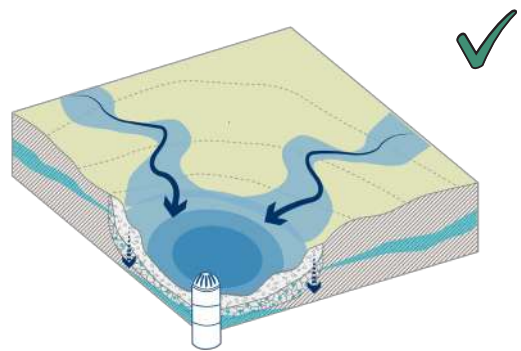
Don't design constructed ponds, detention areas and recharge pits as geometric structures with high proportion of concrete



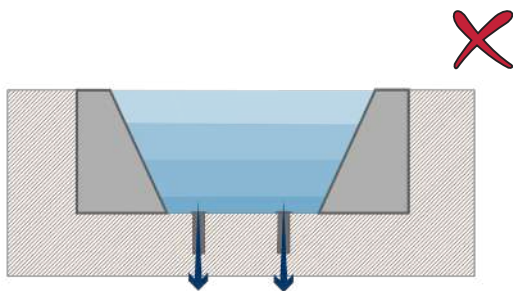
Do design BGI components with storage functions as curvilinear forms with grading inspired by natural ponds



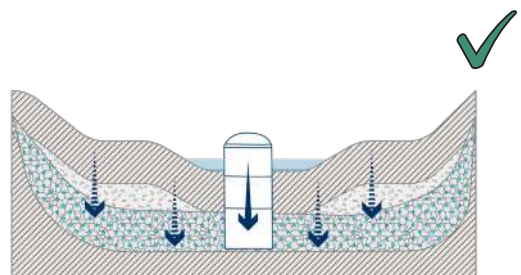
Don't design steep recharge pits with direct conveyance from channelised structures that don't control sediment and litter



Do design gently graded recharge pits or infiltration basins with inlets from bioswales that collect leaf litter and sediment



Don't design steep structures with sharp slope of 1:1 or 1:2



Do design BGI components with 1:3 slope and organic profiles



S.3. Vegetation and Planting

Vegetation and Planting is the layer within Sponge Parks that improves urban ecology by providing habitats and contributes to the aesthetic character. Vegetation plays an integral role in the delay and filtering functions blue-green infrastructure. Additionally, greenery mitigates extreme heat risks as tree canopies provide shade and planting around social spaces reduces ambient temperature. Planting help address multiple climate risks while bringing multiple co-benefits towards public health, biodiversity, and social well-being. With careful design and species selection, the maintenance requirements of planting can be minimised.



Fig. 2.5 Reference Image - Washington & Stenton (credit - Philadelphia water department)

Biodiversity

- ✓ Improve urban ecology by creating diverse habitats within Sponge Parks including forests, wetlands, meadows, and ponds
- ✓ Prioritise native plant tree, shrub, and grass species including species that attract pollinators.
- ✓ Design layered planting schemes that replicate the canopy, midstorey, understory, and groundcover structure of natural communities

Maintenance

- ✓ Work with species with low maintenance requirements
- ✓ Design structures within BGI components to capture leaf litter in designated places and collect regularly for on-site composting
- ✓ Provide adequate level of care including trimming of planting near active social amenities and pathways

Resilience

- ✓ Prioritise native plant species which are heat tolerant, flood tolerant, and resilient to droughts
- ✓ Plant a diversity of species to be resilient to losses from disease
- ✓ Locate large canopies and planting zones around seating areas, playgrounds, and community amenities

Aesthetics

- ✓ Create naturalistic landscapes with structural diversity and seasonal variations to create visually interesting and mentally rejuvenating spaces

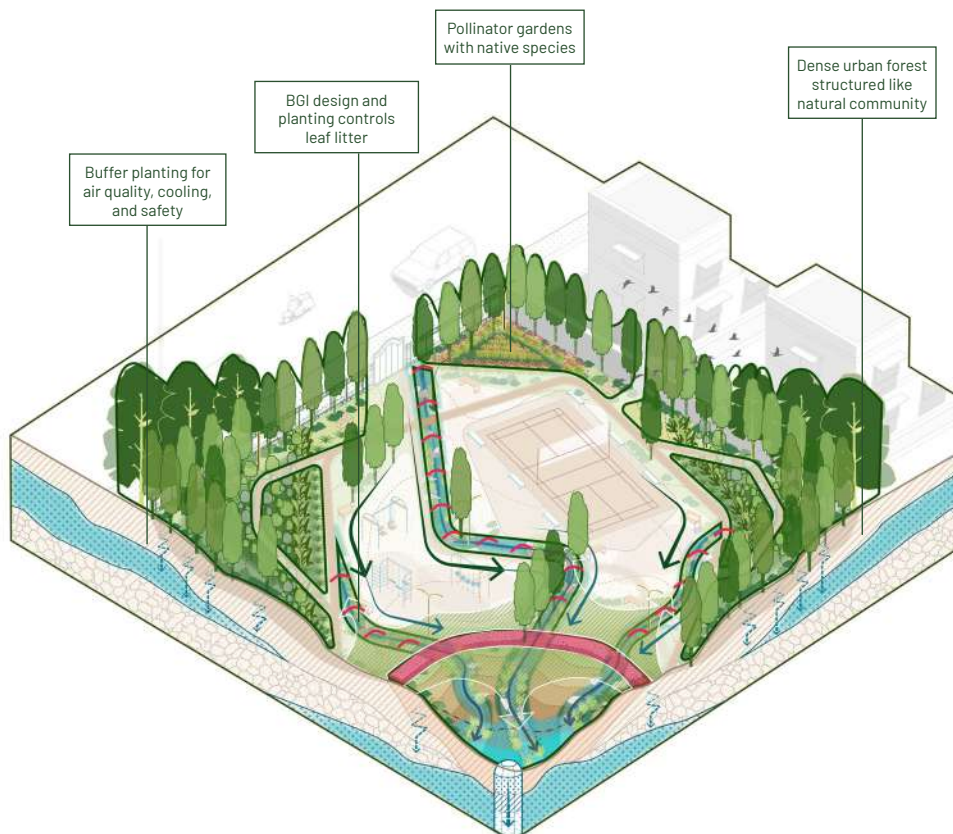
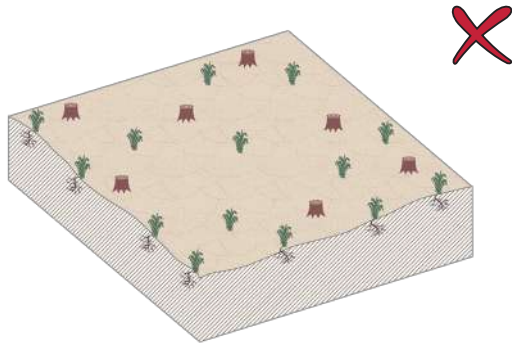
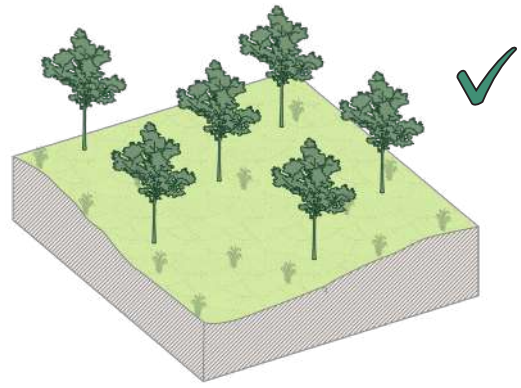


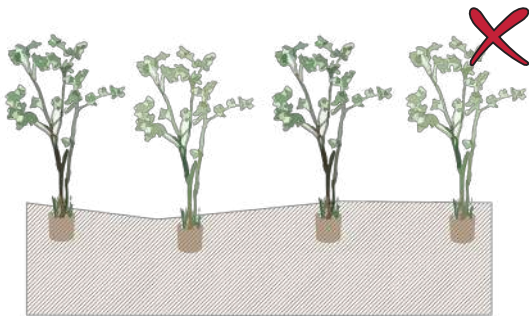
Fig. 2.6 Axon showing the various indicator to consider for vegetation



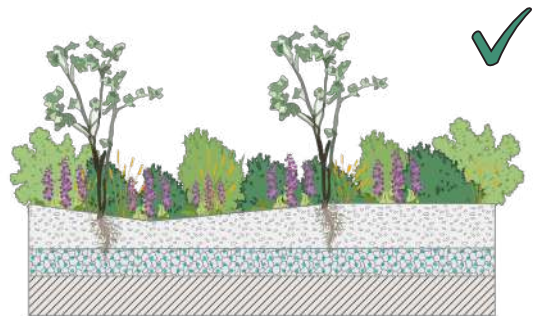
Don't remove existing trees and ignore vegetation patterns



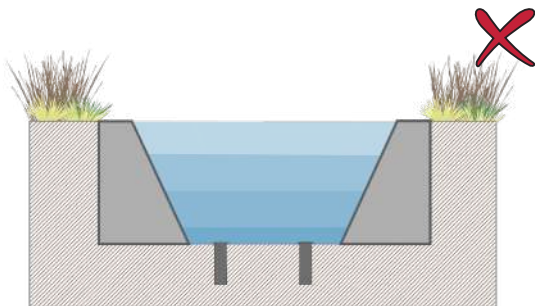
Do conduct biodiversity and tree audits to preserve all trees, manage invasive species, and enhance existing vegetation



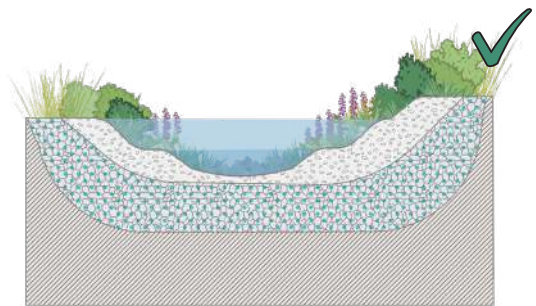
Don't plant singular species in widely spaced rows



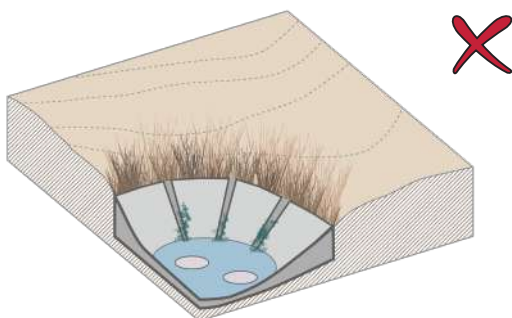
Do plant multiple species with structural diversity and layering to replicate dense, natural plant communities



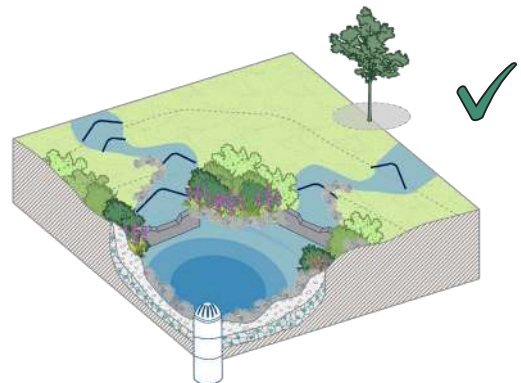
Don't carry out planting that is separate from BGI components or planted on the fringes of retention or recharge zones



Do integrate planting with gently graded BGI components to create habitats and aquatic ecosystems where possible



Don't construct depressions or pits that allow leaf litter to accumulate in the bottom



Do collect leaf litter and sediments within bioswales and check dams to avoid clogging or siltation of storage and recharge zones



S.4. Amenities and Social Facilities

The integration of social infrastructure with blue-green infrastructure helps Sponge Parks fulfill the fundamental role of open spaces - which is to provide recreational amenities, improve public health, and contribute to quality of life. makes the Sponge Park a vibrant public space. Gender inclusion will be primary concern in the design of furnishings, lighting, signage, and vegetation. Sponge Parks need open and contained spaces and moments of community and solitude for a diversity of user groups including marginalised population to claim the public space as individuals or groups. The checklist ensure BGIs and park programs fulfill social needs.



Fig. 2.7 Reference Image - Universally designed recreation space

Inclusion

- ✓ Provide amenities and recreational features that cater to a wide range of ages, diverse abilities, and broad interests.
- ✓ Design diversity of social spaces and furnishings that encourage young girls, women, LGBTQ, and differently abled individuals or groups to claim the public spaces of the park

Safety

- ✓ Ensure clear sightlines through vegetation, adequate lighting, clearly marked entryways and signage towards exit, and well-maintained pathways
- Design BGI components that are shallow, gently graded, and clearly marked with signage and lighting

Accessibility

- ✓ Expand park hours to ensure people of all ages and from all walks of life can use the park specially during hours or extreme heat in the afternoon when most parks are typically closed
- ✓ Ensure that the park is accessible to individuals with disabilities by providing ramps, wheelchair-friendly surfaces, accessible seating, and signage with braille

Services

- ✓ Provide a variety of amenities to meet broad needs (public toilets) and specific needs (nursing rooms)
- ✓ Secure funding to maintain services and events important to the community

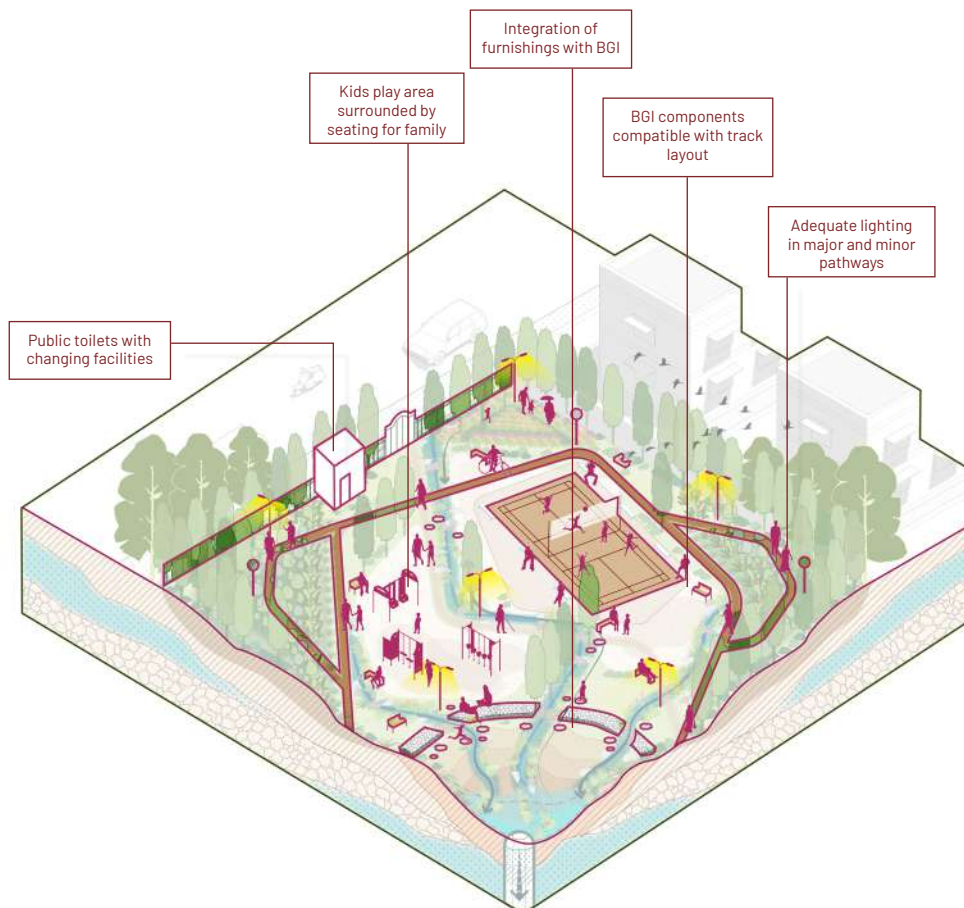
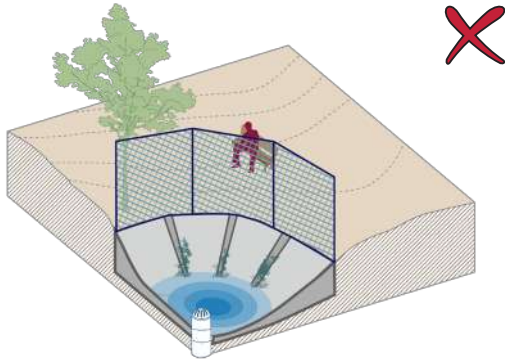
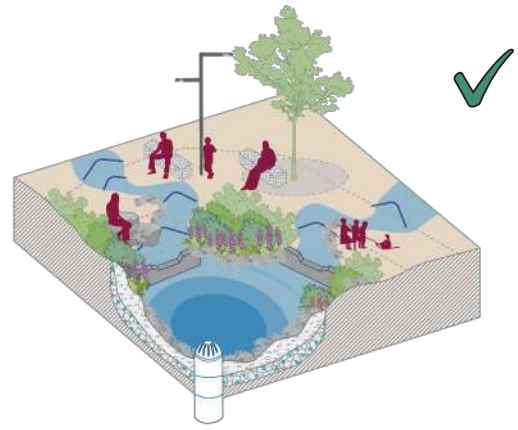


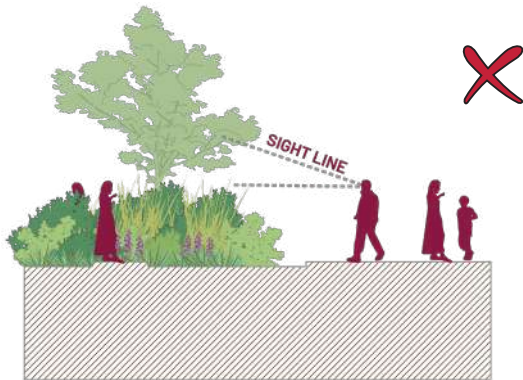
Fig. 2.8 Axon showing the various indicators to consider for social amenities



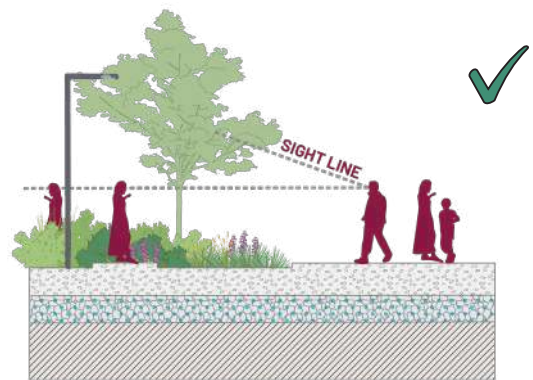
Don't separate BGI from social uses, furnishings, and program



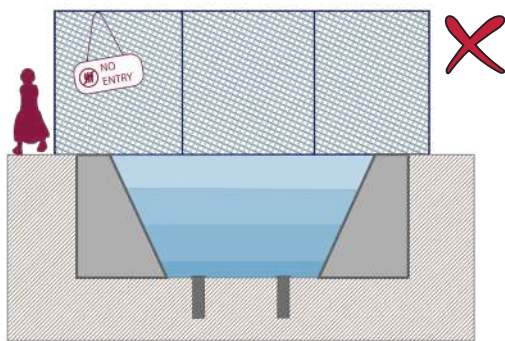
Do integrated BGI with park functions as a social amenity



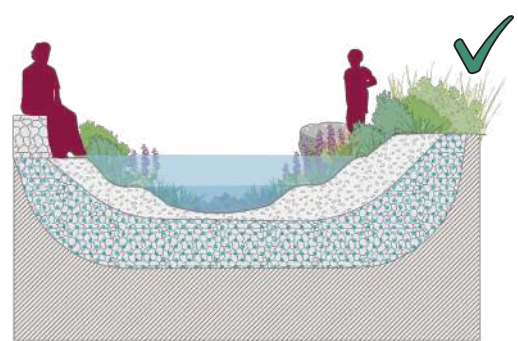
Don't allow overgrowth of planting around walkways



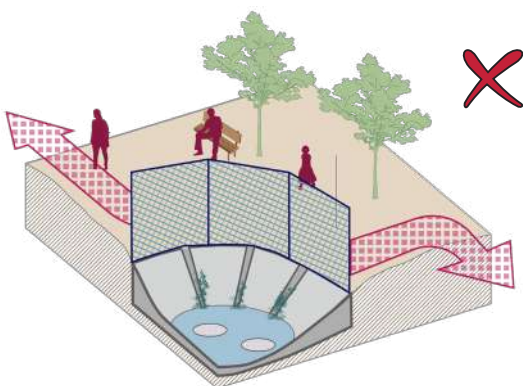
Do maintain sightlines and provide lighting with planting



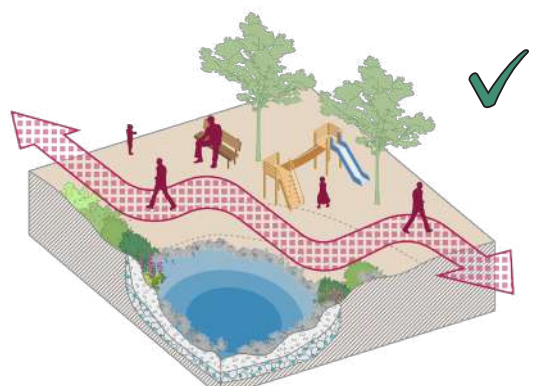
Don't design BGI with depths that are dangerous for children



Do provide gentle slopes and opportunities for nature play in BGI



Don't build BGI over existing park amenities and pathways



Do accommodate existing amenities and practices with BGI

2.2. Sponge Park Typologies

Typologies Of Sponge Parks

Building on the classification of OSRs, Sponge Park typologies is based on the size of open spaces. Small Sponge Parks (S) are smaller than 0.2 acres, Medium Sponge Parks (M) are between 0.2 to 1 acres, Large Sponge Parks (L) are between 1- 5 acres, and Special Cases (X) are larger than 5 acres.

Park sizes are reliable indicator for the hydrological functions an open space can accommodate as a Sponge Park. Additional

considerations such as the volume of storage that can be graded, the potential for habitat creation through forestry, and number and nature of social amenities are also related to the size of the park. As such, Sponge Park Typologies of S, M, L, and X will be used to illustrate what are the possibilities and limitations of BGI. It is assumed that GCC could build the capacity to carry out the entire infrastructure lifecycle for Small Sponge Parks while bigger parks require the procurement of services based on size and complexity.

Small Sponge park in OSRs smaller than 0.2 Acres

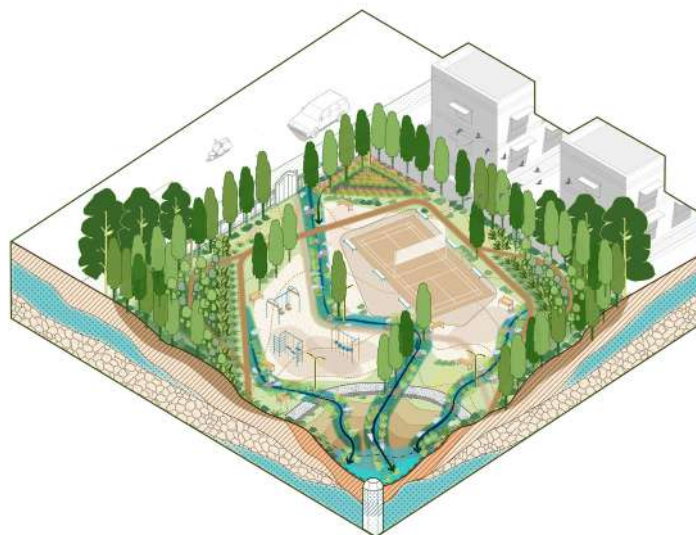


Fig. 2.9 Representative visualisation of Small Sponge Parka

Medium Sponge Park in OSRs between 0.2 - 1 Acres



Fig. 2.10 Representative visualisation of Medium Sponge Parka

Large Sponge Park
in OSRs between 1 - 5 Acres



Fig. 2.11 Representative visualisation of Large Sponge Parks

X Special Case
in OSRs larger than 5 Acres

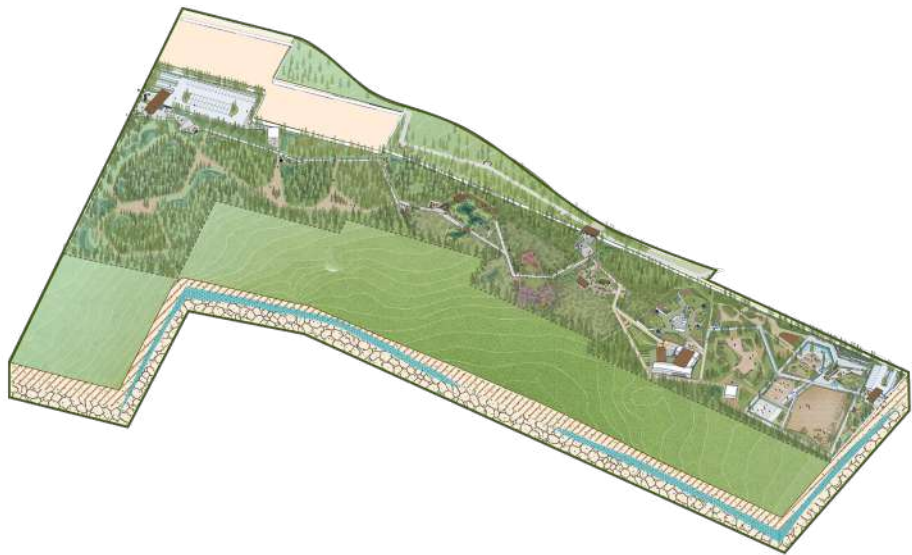


Fig. 2.12 MRepresentative visualisation of Special Case Sponge Parks

2.2.1. Small Sponge Park

How to assess Small OSRs?

Small OSRs are constrained open spaces smaller than 0.1 acres that can accommodate limited hydrological functions as a Sponge Park. They are also more likely to have existing social amenities or some form of vegetation. As a result, the transformation is usually surgical and requires a moderate capital investment.

Since a small OSR cannot accommodate a lot of runoff volume, it is important to understand the soil's capacity for storage and

infiltration. In almost every case, a small OSR can manage runoff generated within the open spaces or the roof of adjacent buildings. There will likely be less potential to filter the runoff through extensive bioswales or multiple detention structures or large infiltration basins. As such, bringing in runoff from roads or surrounding catchments with high pollutant and sediment load is not recommended. Due to its simplicity, GCC should build the internal capacity to transform small OSRs into Sponge Parks

Checklist For Site Assessments to Design Sponge Park Systems

 Soil ✓ Site survey to examine any depressions in the site. ✓ Identification of high and low points. ✓ Conduct a soil and geotechnical survey to analyze the soil type ✓ Also conduct chemical and granular profile test below ground level. ✓ For checklist "S.1. Soil and Grading" - Pg 48	 Hydrology ✓ After selecting the OSR land, understand the local catchment and hydrology model. ✓ Understand water flow and water logging system. ✓ Analysing the depth of water and quality of aquifer. ✓ For checklist "S.2. Hydrology and Blue Green Infrastructure" - Pg 50	 Vegetation ✓ Survey the number of trees in the site ✓ Audit to measure tree caliper (DBH) above 6" to 12" tree ground line level to maintain trees without relocating. ✓ Conduct species audit to remove the invasive species - For checklist "S.3. Vegetation and Planting" - Pg 52	 Amenities ✓ Check for the entry and exit points ✓ Analyze onsite and offsite safety concerns ✓ Research on the user desires and history of the site ✓ For checklist "S.4. Social and Inclusive Amenities" - Pg 54

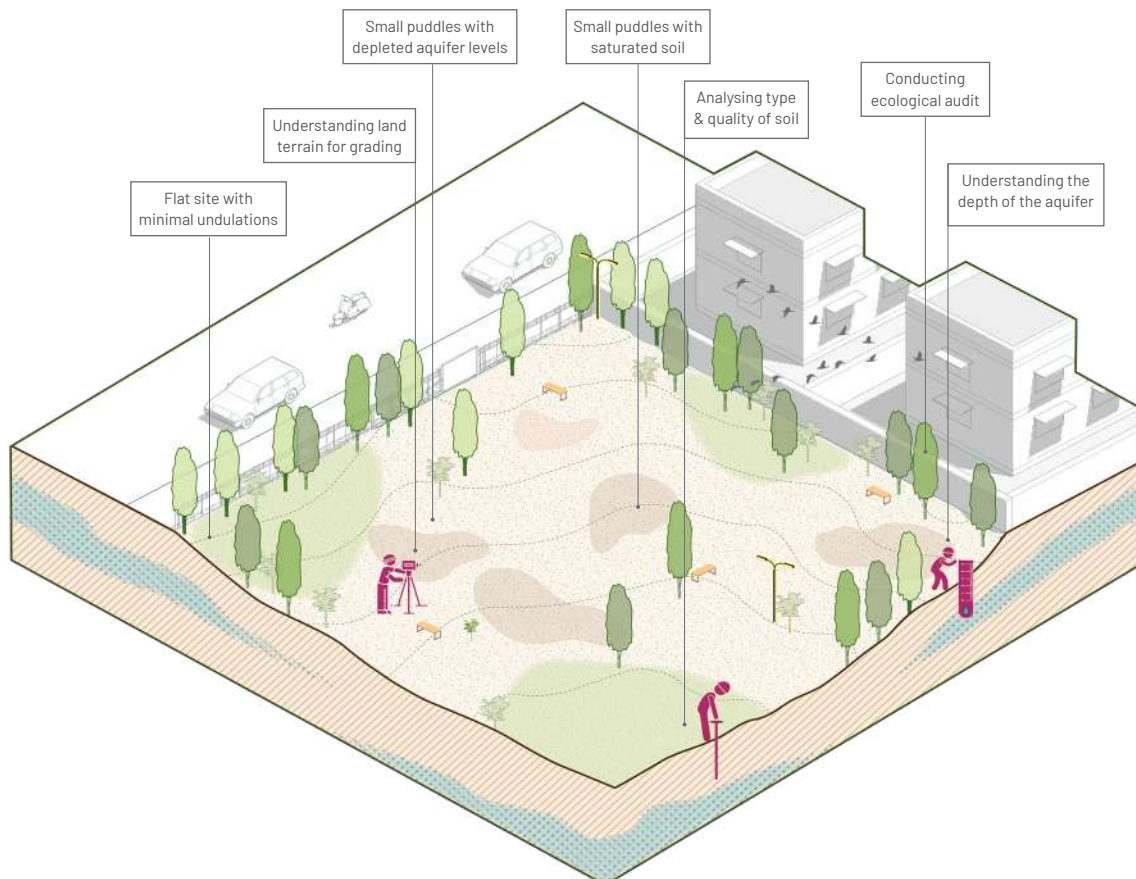


Fig. 2.13 Axon showing the Existing scenario of small osr lands

How to design Small Sponge Parks ?

Transforming one Small OSR into a Sponge Parks may not make a big impact on mitigating flood or water scarcity risk but with 481 OSRs, simple interventions in the form of recharge pits and wells spread across the city collectively builds resilience.

For Small Sponge Parks, understanding the lay of the land will inform a simple grading strategy to convey stormwater towards the lowest point where the runoff can be recharge. Runoff generated

within the park is conveyed via bioswales. Bioswales connected to raingardens that collect from downspouts along buildings can bring runoff from surrounding buildings towards the recharge pit or well.

The park's planting strategy and amenities layout will be carved around this schema in order to integrate social infrastructure with BGI and find opportunities for dense forestry projects or pollinator gardens. Small Sponge Parks can be invaluable to many localities.

Design Criteria For Sponge Park Systems

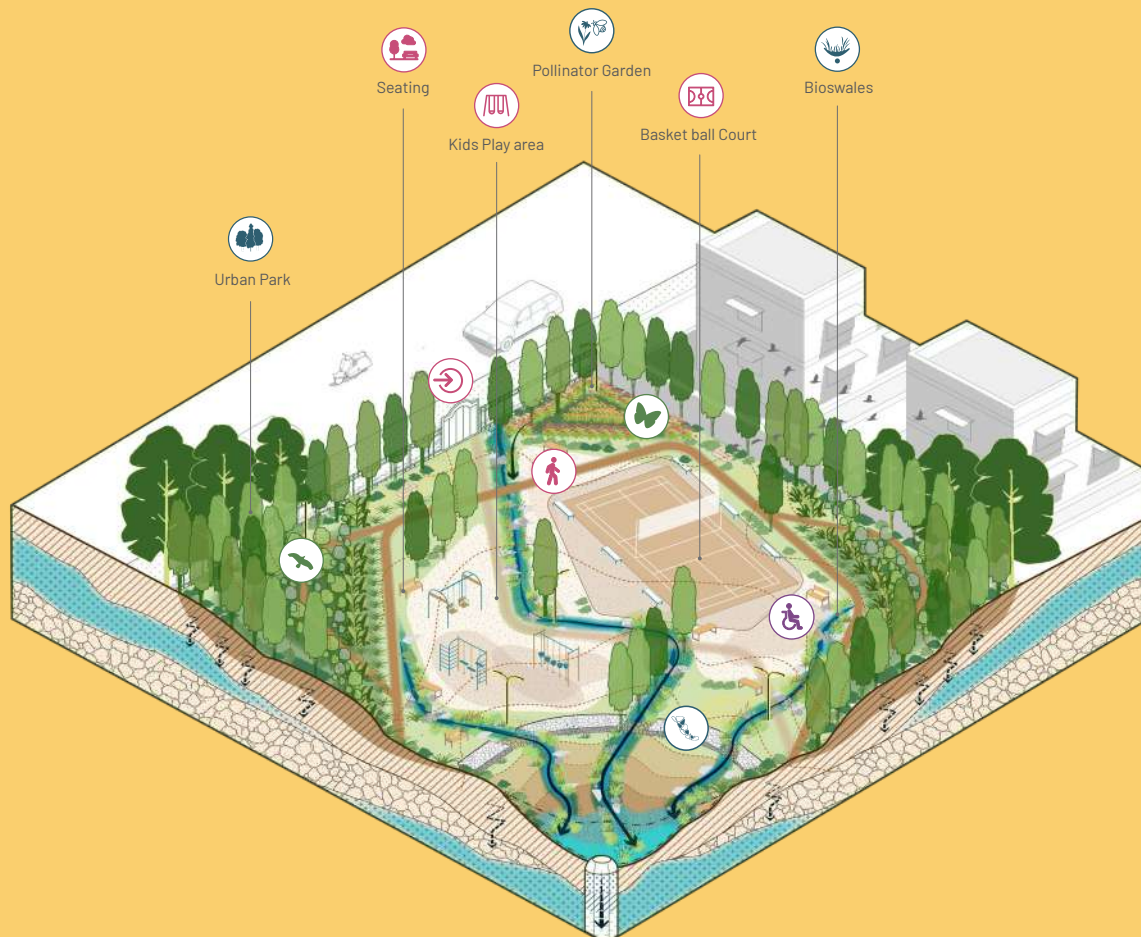


Fig. 2.14 Axon showing the proposed scenario of small sponge park

Functions of Small Sponge Park

The hydrological functions of Small Sponge Park is limited by size both in its capacity to mitigate extreme flood events and infiltrate runoff beyond its boundary. Nevertheless, a well designed Sponge Park with at least one recharge pit or well can funnel a good volume of rainfall into the aquifer during the monsoons.

It is important the Small Sponge Park is graded with depressions and pits that are sized to manage upto a 5 year return period storm.

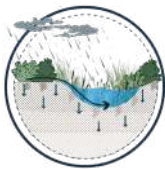
With soil amendment, the runoff generated by the park itself will be slow and less in volume. Only after the soil has saturated from shallow aquifer recharge, rainwater will begin to flood the extended flood zones.

While a Small Sponge Park will have modest storage functions, it can perform filter functions adequately. Table 2.1 below summarises the BGI toolkits applicable to Small Sponge Parks



Delay

By incorporating features like swales, permeable surfaces, and vegetation buffers, Sponge Parks can delay the flow of water, allowing more time for infiltration and reducing peak flows during heavy rainfall events.



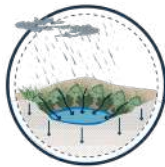
Filter

Through natural filtration processes facilitated by vegetation, soil, and engineered media, pollutants and sediments are removed from storm water runoff before it enters groundwater or surface water bodies.



Store

Sponge Parks are designed to temporarily store storm water runoff. Features such as rain gardens, retention ponds, and infiltration basins capture excess water, reducing pressure on drainage systems and preventing flooding downstream.



Recharge

By promoting infiltration and allowing water to percolate through soil layers, these parks replenish recharge wells and contribute to sustainable water management.

Table 2.1. Performance Ability of BGI toolkits in Small Park

BGI Toolkits	Delay	Filter	Store	Recharge
T.1. Bioswales	●	●	○	●
T.2. Recharge Pit	●	○	○	●
T.3. Raingardens - buildings	●	●	○	○
T.4. Raingardens - Street	N/A			
T.5. Retention pond	N/A			
T.6. Infiltration basin	N/A			
T.7. Sunken court	N/A			
T.8. Water plaza	N/A			
T.9. Constructed wetlands	N/A			

Performance ability of BGI Toolkits : ● High ● Moderate ○ Low

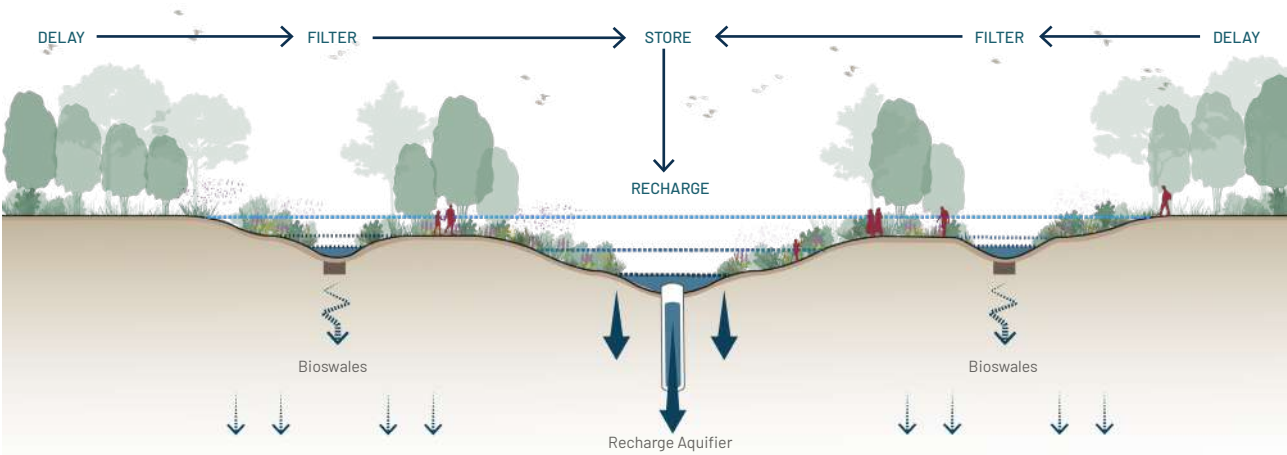


Fig. 2.15 Sequence of BGI functions during a storm event in small sponge park

MODERATE FLOOD
5 year return period

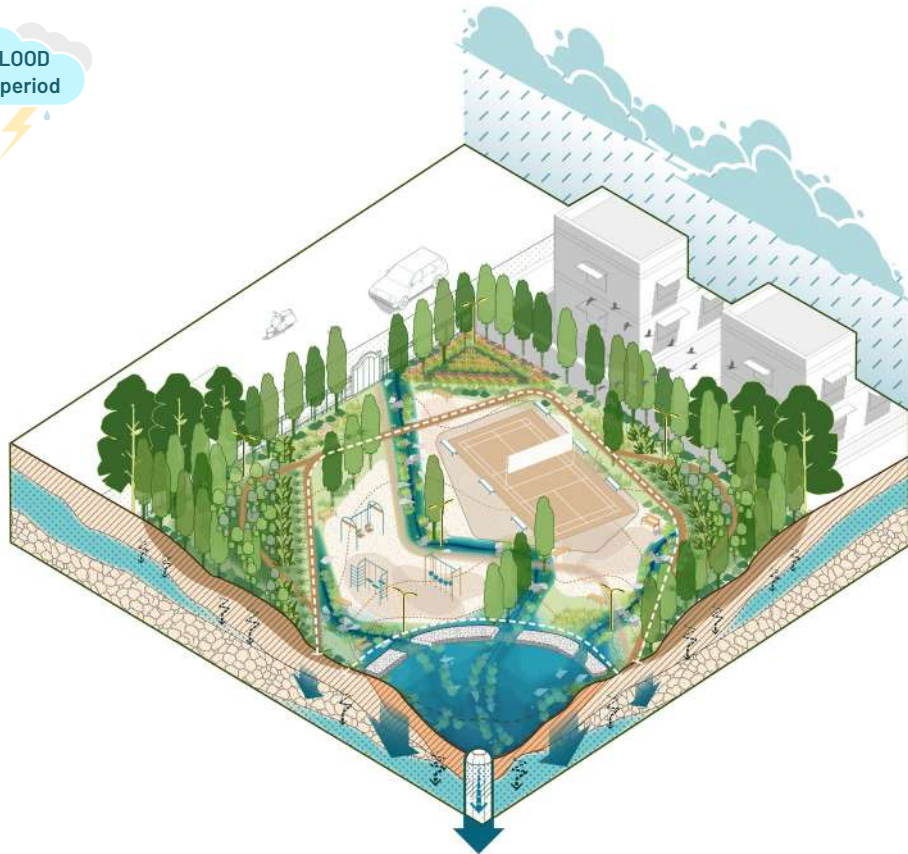


Fig. 2.16 Axon showing the small sponge park during moderate rainfall

HEAVY FLOOD
25 year return period

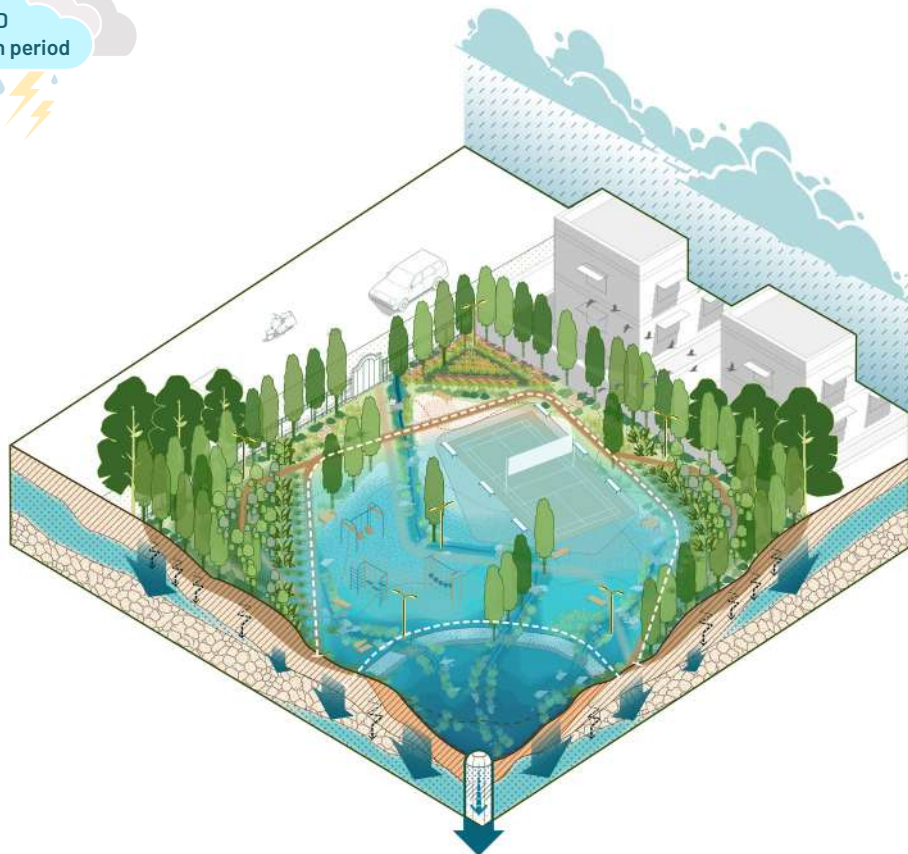


Fig. 2.17 Axon showing the small sponge park during peak floods

Case Studies

1 - Sankt Kjelds Square and Bryggervangen

Sankt Kjelds Square and Bryggervangen are urban redevelopment projects showcasing innovative approaches to sustainable urban design, green infrastructure, and community-oriented development. These projects are part of Copenhagen's broader efforts to create vibrant, livable neighborhoods while addressing environmental challenges and enhancing quality of life for residents. Sustainable drainage features were integrated to capture and treat rainwater, reducing runoff and mitigating urban flooding.



- Area - 8.6 Acres
- Designed by - SLA
- Highest °C : 21.1°C (July)
- Lowest °C : -1.1°C (February)
- Highest rainfall : 53.3mm (August)
- Lowest rainfall : 27.9mm (April)



Fig. 2.18 Various sustainable drainage systems

KEY TAKEAWAYS

- Features pedestrian-friendly pathways, seating areas, recreational spaces, and public art installations
- The square features rain gardens, which are planted areas designed to capture and absorb rainwater runoff from paved surfaces.
- Includes an abundance of vegetation, including trees, shrubs, and native plants selected for their ability to thrive in urban conditions.
- Blue-green infrastructure (BGI) are integrated into the square's design to manage storm water in an environmentally friendly manner.
- BGI features may include bioswales, infiltration basins, and detention ponds that slow down and treat storm water runoff before it enters the sewer system or local water bodies.



Fig. 2.19 overall view of Sankt Kjelds Square

2 - Gowanus Canal Sponge Park

The concept of the Gowanus Canal Sponge Park represents an innovative approach to storm water management and urban revitalization centered around the restoration and enhancement of the Gowanus Canal area. The park is designed to function as a "sponge," absorbing and filtering storm water runoff to mitigate flooding, improve water quality, and create valuable green space within the urban landscape. The park incorporates extensive green infrastructure elements, such as rain gardens, bioswales, vegetated areas, and permeable surfaces.



- Area - 11.4 Acres
- Designed by - SASAKI
- Highest °C : 28°C (July)
- Lowest °C : -1.6°C (February)
- Highest rainfall : 53.3mm (August)
- Lowest rainfall : 27.9mm (April)



Fig. 2.20 Various BGI components of the park

KEY TAKEAWAYS

- The park acts as a "sponge" by absorbing and storing rainwater during storm events, reducing the volume and velocity of runoff entering the Gowanus Canal.
- This sponge effect helps prevent combined sewer overflow (CSO) events and alleviates pressure on the city's sewer system by retaining and slowly releasing storm water.
- Storm water captured by the park's green infrastructure features undergoes natural filtration processes as it percolates through soil and vegetation.
- Pollutants, sediments, and contaminants are removed or reduced, leading to improved water quality in the Gowanus Canal and nearby water bodies.
- In addition, Park supports ecological restoration and habitat creation.



Fig. 2.21 Overall view of Gowanus canal park

2.2.2. Medium Sponge Park

How to assess Medium OSRs?

Medium OSRs are between 0.1 - 1 acres and ideally sized to accommodate a range of hydrological functions as a Sponge Park. They can fit multiple social amenities and modest forestry projects or habitat creation. As a result, the transformation of medium OSRs can have a highly positive effect on a neighbourhood.

A Medium OSR can usually accommodate the runoff volume of surrounding neighbourhood catchment areas depending on the the

soil's capacity for storage and infiltration. Extensive bioswales and multiple detention structures or large infiltration basins can be used to filter sediments and pollutants from runoff.

Due to the range of complexity required for the design of Medium Sponge Parks, GCC will need to procure technical design services and qualified contractors to transform medium OSRs into Sponge Parks

Checklist For Site Assessments to Design Sponge Park Systems

 Soil ✓ Site survey to examine any depressions in the site. ✓ Identification of high and low points. ✓ Conduct a soil and geotechnical survey to analyze the soil type ✓ Also conduct chemical and granular profile test below ground level. ✓ For checklist "S.1. Soil and Grading" - Pg 48	 Hydrology ✓ After selecting the OSR land, understand the local catchment and hydrology model. ✓ Understand water flow and water logging system. ✓ Analysing the depth of water and quality of aquifer. ✓ For checklist "S.2. Hydrology and Blue Green Infrastructure" - Pg 50	 Vegetation ✓ Survey the number of trees in the site ✓ Audit to measure tree caliper (DBH) above 6" to 12" tree ground line level to maintain trees without relocating. ✓ Conduct species audit to remove the invasive species - For checklist "S.3. Vegetation and Planting" - Pg 52	 Amenities ✓ Check for the entry and exit points ✓ Analyze onsite and offsite safety concerns ✓ Research on the user desires and history of the site ✓ For checklist "S.4. Social and Inclusive Amenities" - Pg 54

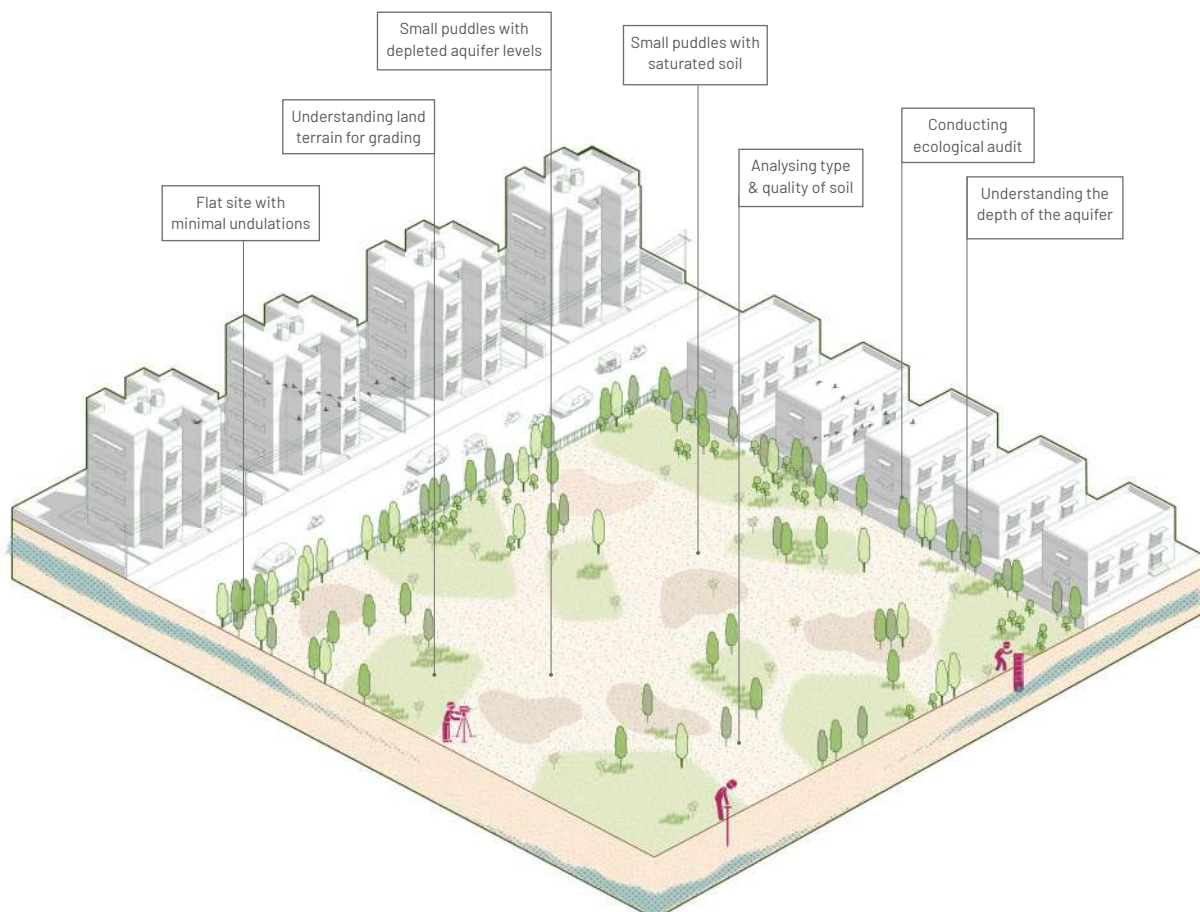


Fig. 2.22 Axon showing the Existing scenario of medium osr lands

How to design Medium Sponge Parks ?

Transforming Medium OSRs into a Sponge Parks can have help mitigate flood and water scarcity risks for their immediate neighbourhoods. With 538 OSRs, integrated interventions in the form of bioswales, recharge pits, retention ponds, infiltration basins, spread across the city will significant build Chennai's resilience.

For Medium Sponge Parks, understanding the lay of the land is critical to identify low points for temporary detention and infiltration.

Runoff from surrounding catchment areas and streets should be brought in via raingardens and forebays that filter sediments and pollutants. Bioswales can connect a network of constructed ponds, sunken courts and other retention areas before bringing runoff from storm events into infiltration basis on recharge pits. While there are ample opportunities for dense forestry projects or pollinator gardens in Medium Sponge Parks, they have to be integrated with the social amenities and facilities that serve the larger neighbourhood.

Design Criteria For Sponge Park Systems

 S.1. Soil & Grading • Soil amendment is done in the designated high planting zones • Land is graded to create a extended flood zones • Natural grading of the site is used to incorporate BGI (Sponge) toolkits to capture runoff from all zones	 S.2. Hydrology & Blue-green • Understanding water flow helps determine the capacity and design BGI to manage storm water runoff. • Designing BGI with appropriate water depths ensures that surfaces remain accessible and safe for maintenance activities. • For more "S.2. Blue-green Infrastructure (Sponge) Toolkits" - Pg 82	 S.3. Vegetation & Planting • Based on the audits conducted various zones like urban forest, pollinated garden & ground cover with native species Pg 266 are created • Speed areas of greenary is created with native species • 7 types of planting mixes were incorporated in the site "S.3. Types Of Plant Mixes" - Pg 103	 S.4. Amenities & Social Facilities • Continuous jogging and walking trail is incorporated compatible with BGI components • Playgrounds were provided with different sizes and ground mix Pg 272 • Proper seatings, signages, sightlines and lighting are provided to feel safe. check "S.4. Amenities and social facilities" - Pg 115



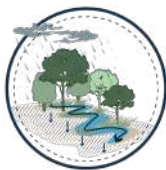
Fig. 2.23 Axon showing the proposed scenario of Medium sponge park

Functions of Medium Sponge Park

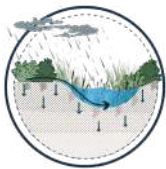
The hydrological functions of Medium Sponge Park can help mitigate extreme flood events and infiltrate runoff beyond its boundary. Especially at 0.2 acres and above, a well designed Sponge Park with retention bonds and infiltration basins can funnel a good volume of rainfall into the aquifer during the cloudbursts.

It is important the Medium Sponge Park is graded with depressions and pits that are sized to manage upto a 25 year return period

storm. Extensive grading and soil amendment can allow the Sponge Park to temporary store runoff from surrounding catchments. Only after the shallow ponds and soil has saturated from shallow aquifer recharge, rainwater will begin to flood other ponds and extended flood zones. A well designed Medium Sponge Park can satisfactorily provide all the hydrological functions of delay, filter, store, and recharge. Table 2.2 below summarises the BGI toolkits applicable and their performance in Medium Sponge Parks



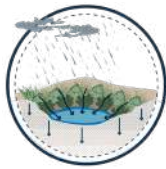
Delay
By incorporating features like swales, permeable surfaces, and vegetation buffers, Sponge Parks can delay the flow of water, allowing more time for infiltration and reducing peak flows during heavy rainfall events.



Filter
Through natural filtration processes facilitated by vegetation, soil, and engineered media, pollutants and sediments are removed from storm water runoff before it enters groundwater or surface water bodies.



Store
Sponge Parks are designed to temporarily store storm water runoff. Features such as rain gardens, retention ponds, and infiltration basins capture excess water, reducing pressure on drainage systems and preventing flooding downstream.



Recharge
By promoting infiltration and allowing water to percolate through soil layers, these parks replenish recharge wells and contribute to sustainable water management.

Table 2.2. Performance Ability of BGI toolkits in Medium Park

BGI Toolkits	Delay	Filter	Store	Recharge
T.1. Bioswales	●	●	○	●
T.2. Recharge Pit	○	○	○	●
T.3. Raingardens – builings	○	●	○	○
T.4. Raingardens – Street	○	●	●	○
T.5. Retention pond	○	●	●	○
T.6. Infiltration basin	●	●	●	●
T.7. Sunken court	○	○	●	●
T.8. Water plaza	N/A			
T.9. Constructed wetlands	N/A			

Performance ability of BGI Toolkits : ● High ● Moderate ○ Low

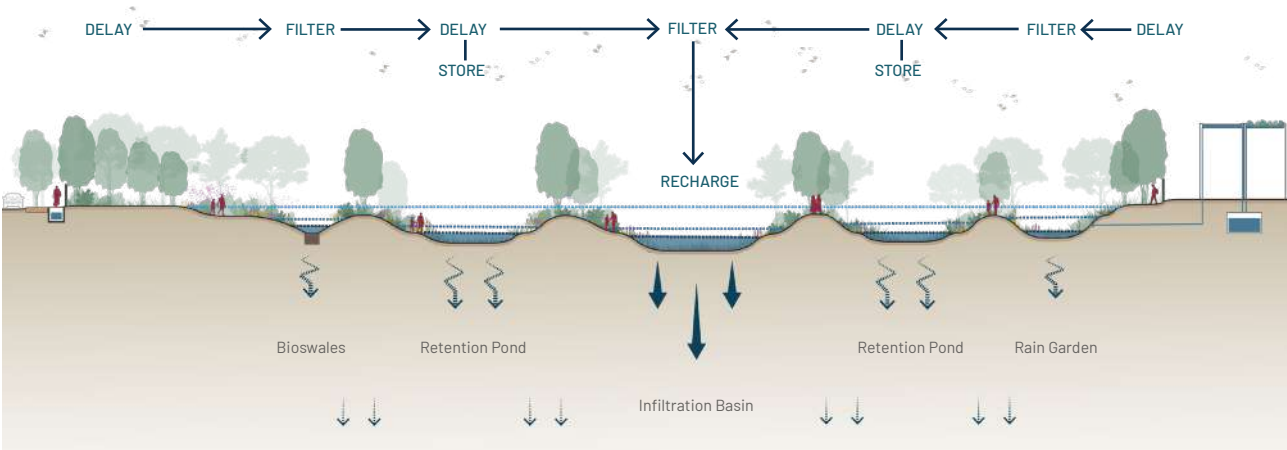


Fig. 2.24 Sequence of BGI functions during a storm event in Medium sponge park

MODERATE FLOOD
5 year return period

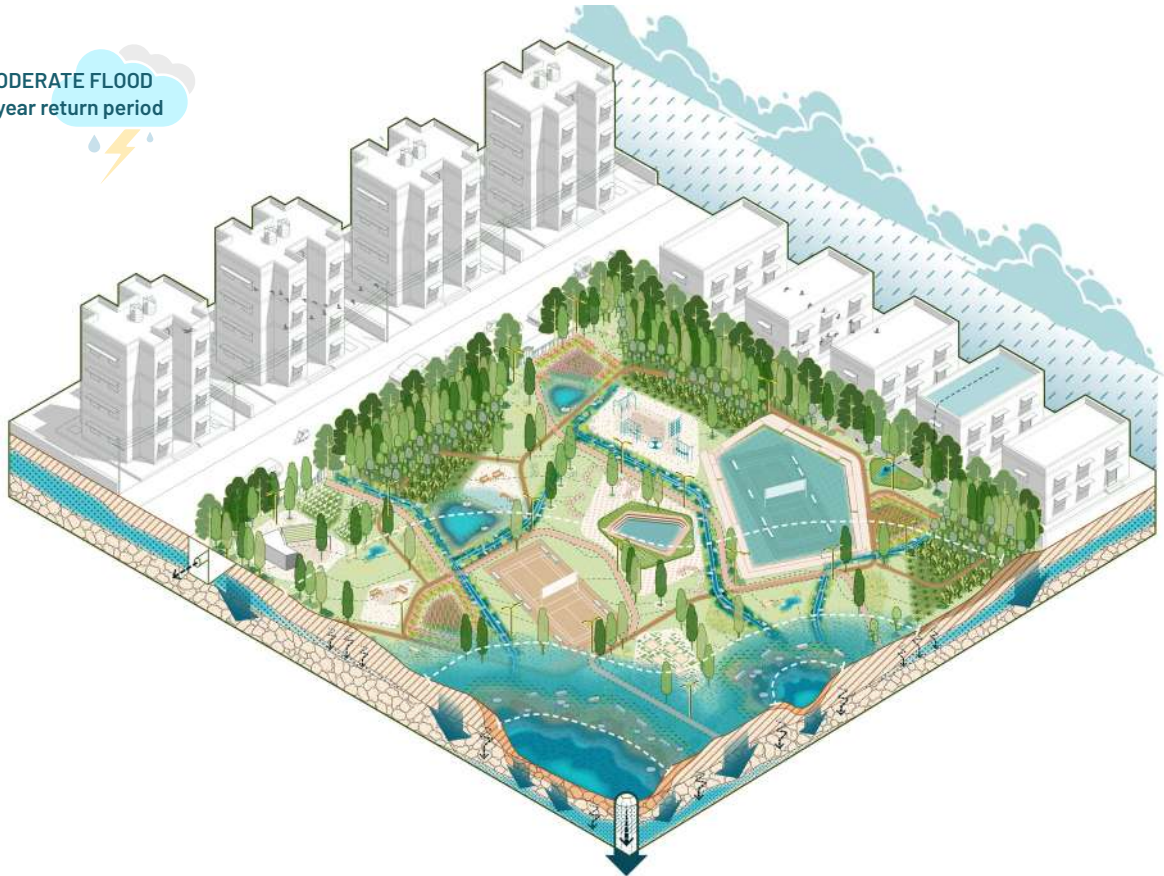


Fig. 2.25 Axon showing the medium sponge park during Floods

HEAVY FLOOD
25 year return period

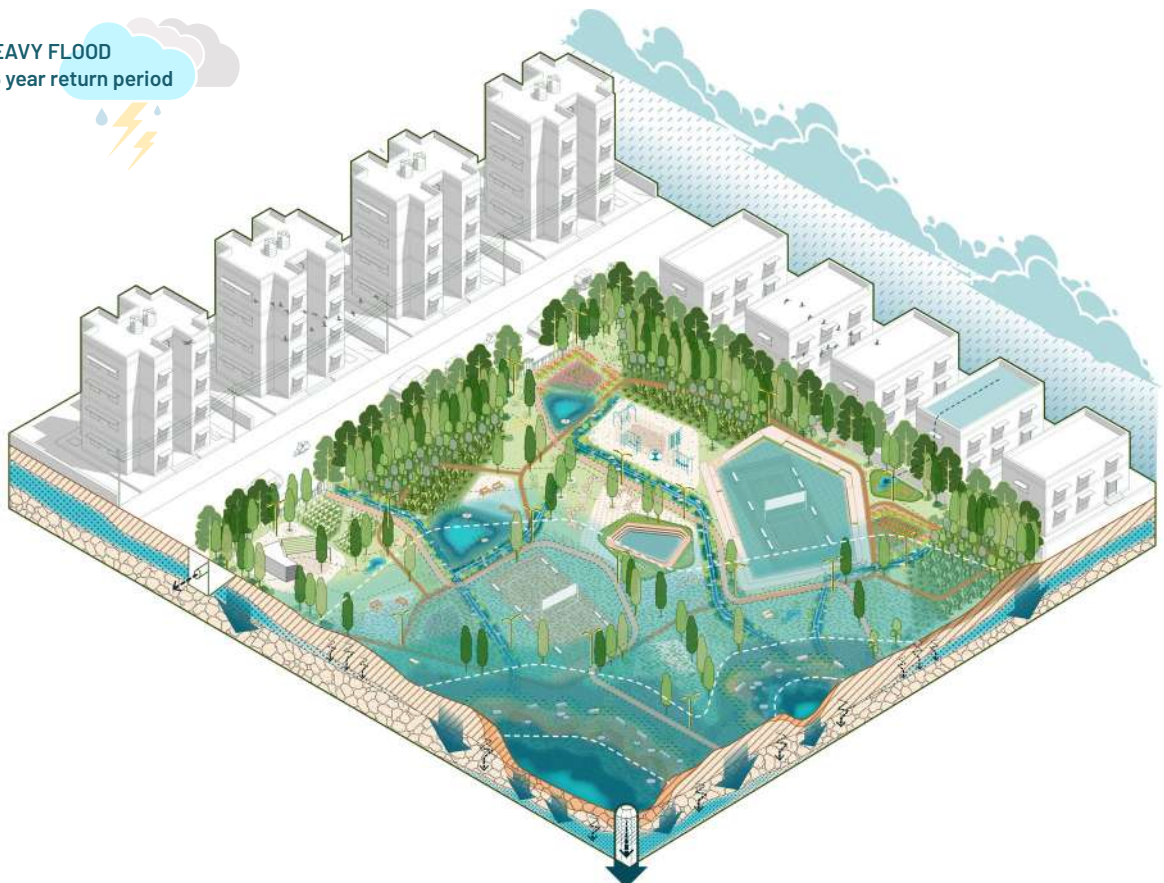


Fig. 2.26 Axon showing the medium sponge park during moderate rainfall

Case Studies

1 - Tanners Springs Park

Nestled in Portland, Oregon's Pearl District is Tanner Springs Park, a singular urban green space. Tanner Springs Park is an excellent example of how urban planning, ecological restoration, and community involvement can come together to create dynamic, sustainable public spaces that benefit locals and tourists alike by raising awareness of environmental issues and improving quality of life. Tanner Springs Park incorporates a central wetland area which emphasizes the restoration of natural hydrological processes in an urban context, showcasing sustainable storm water management techniques.



- Area - 0.92 Acres
- Designed by - Atelier Dreiseitl
- Highest °C : 28.3°C (August)
- Lowest °C : 2.2°C (December)
- Highest rainfall : 226mm (November)
- Lowest rainfall : 12.7mm (July)



Fig. 2.27 includes permeable paving, raingarden and biofiltration swales

KEY TAKEAWAYS

- The wetland serves as a constructed ecosystem that captures and treats storm water runoff from surrounding streets and buildings.
- Water is circulated through the park, mimicking natural processes of filtration and purification, before being discharged back into the city's storm water system.
- Native plant species were carefully selected to enhance biodiversity and create a resilient urban ecosystem.
- The park showcases innovative storm water management strategies, demonstrating how urban green spaces can contribute to water quality improvement and habitat conservation.
- The park reflects Portland's commitment to environmental stewardship, green infrastructure, and the integration of nature into the urban fabric.



Fig. 2.28 Image Of Central Wetland Area Surround By Bioswales

2 - Dr. Shivarama Karanth Park - Rainwater harvesting park

The park's design incorporates various rainwater harvesting structures, including rooftop harvesting, surface runoff collection, and groundwater recharge systems which were aimed at promoting rainwater harvesting techniques and raising awareness about sustainable water management practices among residents and visitors in Bangalore, India. The park serves as a demonstration site for various rainwater harvesting methods and technologies, showcasing how urban landscapes can integrate water conservation strategies while providing recreational and educational amenities.



- Area - 1.2 Acres
- Designed by - Bangalore Water Supply and Sewerage Board
- Highest °C : 33.3°C (April)
- Lowest °C : 16.6°C (December)
- Highest rainfall : 132mm (September)
- Lowest rainfall : 2.5mm (January)



Fig. 2.29 Various water filtration methods

KEY TAKEAWAYS

- The park features interactive exhibits and demonstrations that educate visitors about different rainwater harvesting methods and technologies
- The park showcases sustainable landscaping practices, such as native plantings, permeable surfaces, and bio-filtration features.
- Vegetated swales, rain gardens, and water-efficient irrigation systems demonstrate how green infrastructure can enhance water infiltration and reduce runoff.
- The park serves as a hub for community engagement and environmental education, hosting workshops, seminars, and outreach programs on rainwater harvesting and water conservation.

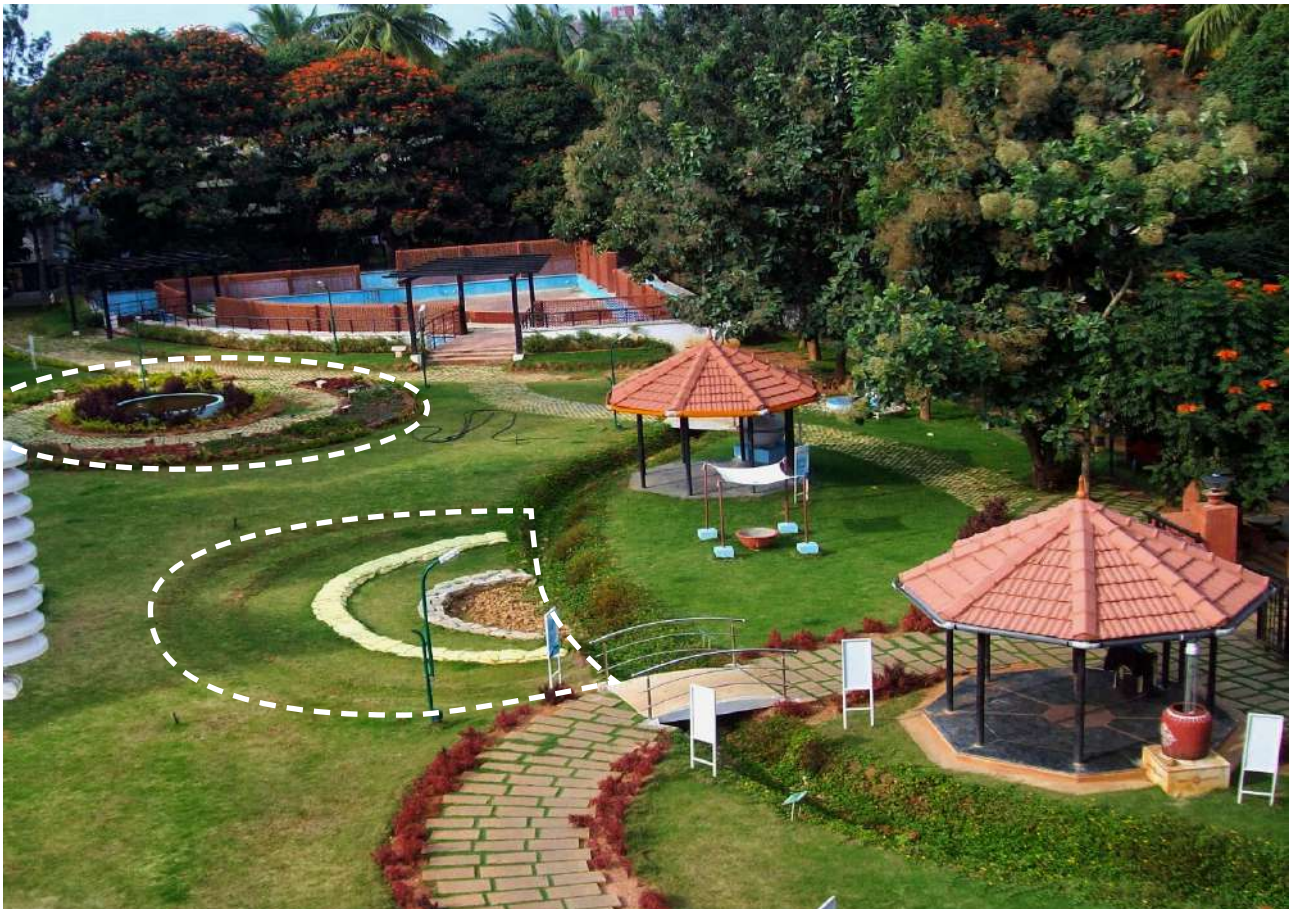


Fig. 2.30 Overall view of Rainwater harvesting park

2.2.3. Large Sponge Parks

How to assess large OSRs?

Large OSRs are between 1 - 5 acres and ideally sized to accommodate a range of hydrological functions as a Sponge Park. They can fit social amenities of zone wide importance and significant forestry projects or habitat creation. As a result, the transformation of Large OSRs can have a transformative effect on a neighbourhood and the Zone at large depending on the level of investment.

A Large OSR can accommodate the runoff volume of surrounding neighbourhood catchment areas depending on the the soil's capacity for storage and infiltration. A cascading network of bioswales, retention ponds, and constructed wetlands s can be used to filter sediments and pollutants from runoff. Due to the complexity required for the design of Medium Sponge Parks, GCC will need to procure technical design services and qualified contractors to transform large OSRs into Sponge Parks

Checklist For Site Assessments to Design Sponge Park Systems

 Soil ✓ Site survey to examine any depressions in the site. ✓ Identification of high and low points. ✓ Conduct a soil and geotechnical survey to analyze the soil type ✓ Also conduct chemical and granular profile test below ground level. ✓ For checklist "S.1. Soil and Grading" - Pg 48	 Hydrology ✓ After selecting the OSR land, understand the local catchmenet and hydrology model. ✓ Understand water flow and water logging system. ✓ Analysing the depth of water and quality of aquifer. ✓ For checklist "S.2. Hydrology and Blue Green Infrastructure" - Pg 50	 Vegetation ✓ Survey the number of trees in the site ✓ Audit to measure tree caliper (DBH) above 6" to 12" tree ground line level to maintain trees without relocating. ✓ Conduct species audit to remove the invasive species - For checklist "S.3. Vegetation and Planting" - Pg 52	 Amenities ✓ Check for th entry and exit points ✓ Analyze onsite and offsite safety concerns ✓ Research on the user desires and history of the site ✓ For checklist "S.4. Social and Inclusive Amenities" - Pg 54

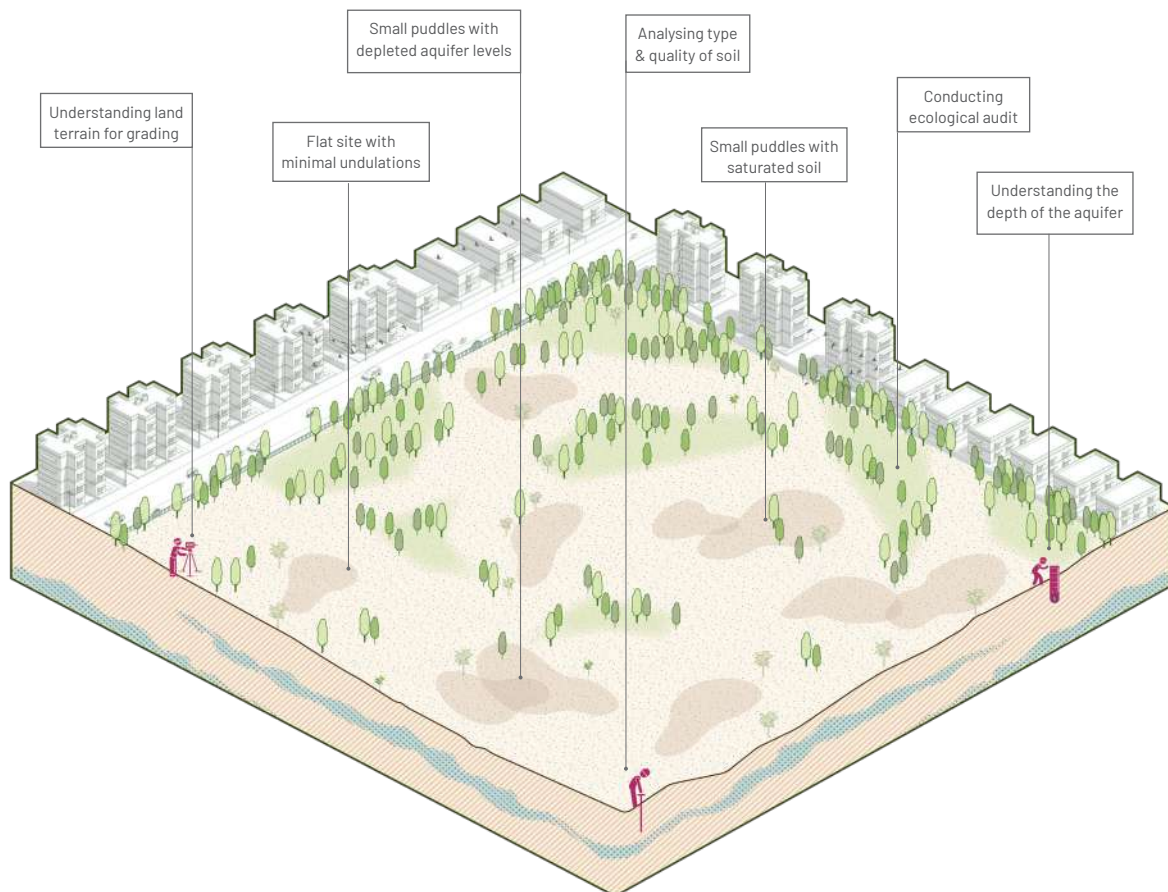


Fig. 2.31 Axon showing the Existing scenario of Large OSR

How to design Large Sponge Parks ?

Transforming Large OSRs into a Sponge Parks can have help mitigate flood and water scarcity risks for their surrounding neighbourhoods. With 100 OSRs, integrated interventions in the form of water plazas, sunken courts, constructed ponds and wetlands, spread across strategic locations will build resilience for a cluster of wards in each Zone. For Large Sponge Parks, significant grading may be required to manage large volumes of runoff from surrounding catchment areas and streets. Multiple

layers of treatment are needed via raingardens, forebays, and constructed ponds that filter sediments and pollutants. A network of detention and filtration structures connected by bioswales should cascade into infiltration basins, wetlands, and recharge pits for shallow and deep aquifer recharge. Large forestry projects have to be developed in a compatible manner with the numerous social amenities and facilities that need to serve the diverse needs of multiple neighbourhoods.

Design Criteria For Sponge Park Systems



Fig. 2.32 Axon showing the proposed scenario of Large sponge aprks

Functions of Large Sponge Park

The hydrological functions of Large Sponge Park can mitigate extreme flood events and infiltrate runoff multiple neighbourhoods in a ward. Especially at 2 acres and above, a well designed Sponge Park with water plaza and constructed wetland can detain and recharge the aquifer during the extreme storm events.

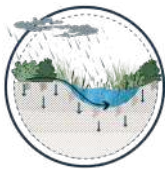
It is important the Large Sponge Park is graded with detention and filtration structures sized to manage up to a 25 year return period

storm. Extensive grading and soil amendment should improve the capacity to temporarily store runoff from surrounding catchments. A cascading network of detention ponds, sunken courts, constructed wetlands and plazas should create multiple pathways for flooding and storage. A well designed Large Sponge Park should provide all the hydrological functions of delay, filter, store, and recharge. Table 2.3 below summarises the BGI toolkits applicable and their performance in Large Sponge Parks



Delay

By incorporating features like swales, permeable surfaces, and vegetation buffers, Sponge Parks can delay the flow of water, allowing more time for infiltration and reducing peak flows during heavy rainfall events.



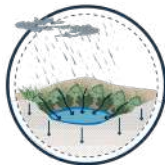
Filter

Through natural filtration processes facilitated by vegetation, soil, and engineered media, pollutants and sediments are removed from storm water runoff before it enters groundwater or surface water bodies.



Store

Sponge Parks are designed to temporarily store storm water runoff. Features such as rain gardens, retention ponds, and infiltration basins capture excess water, reducing pressure on drainage systems and preventing flooding downstream.



Recharge

By promoting infiltration and allowing water to percolate through soil layers, these parks replenish recharge wells and contribute to sustainable water management.

Table 2.3. Performance Ability of BGI toolkits in Large Park

BGI Toolkits	Delay	Filter	Store	Recharge
T.1. Bioswales	●	●	○	●
T.2. Recharge Pit	●	○	○	●
T.3. Raingardens – builings	●	●	○	○
T.4. Raingardens – Street	●	●	●	○
T.5. Retention pond	●	●	●	○
T.6. Infiltration basin	●	●	●	●
T.7. Sunken court	○	○	●	●
T.8. Water plaza	●	○	●	●
T.9. Constructed wetlands	●	●	●	●

Performance ability of BGI Toolkits : ● High ● Moderate ○ Low

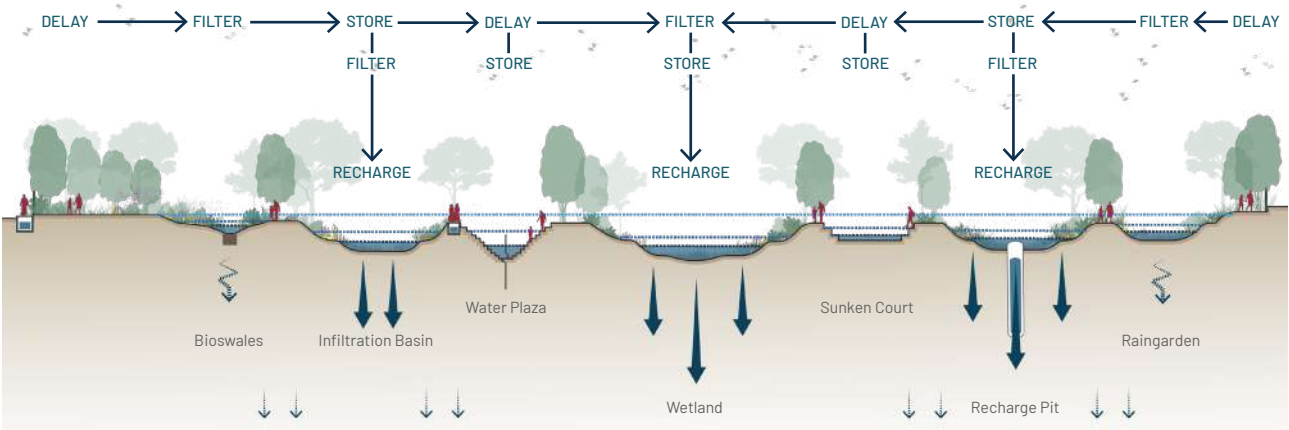


Fig. 2.33 Sequence of BGI functions during a storm event in Large sponge parks

MODERATE FLOOD
5 year return period

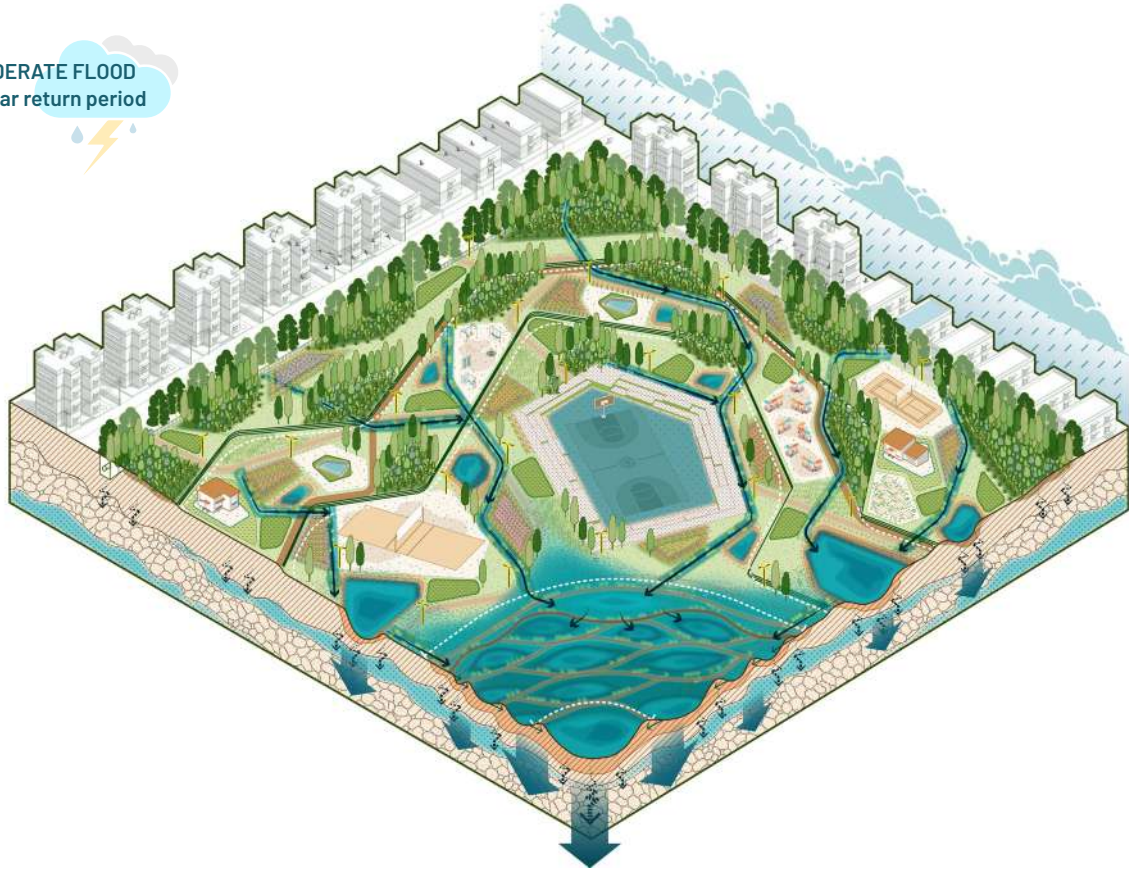


Fig. 2.34 Axon showing the Large sponge park during Floods

HEAVY FLOOD
25 year return period

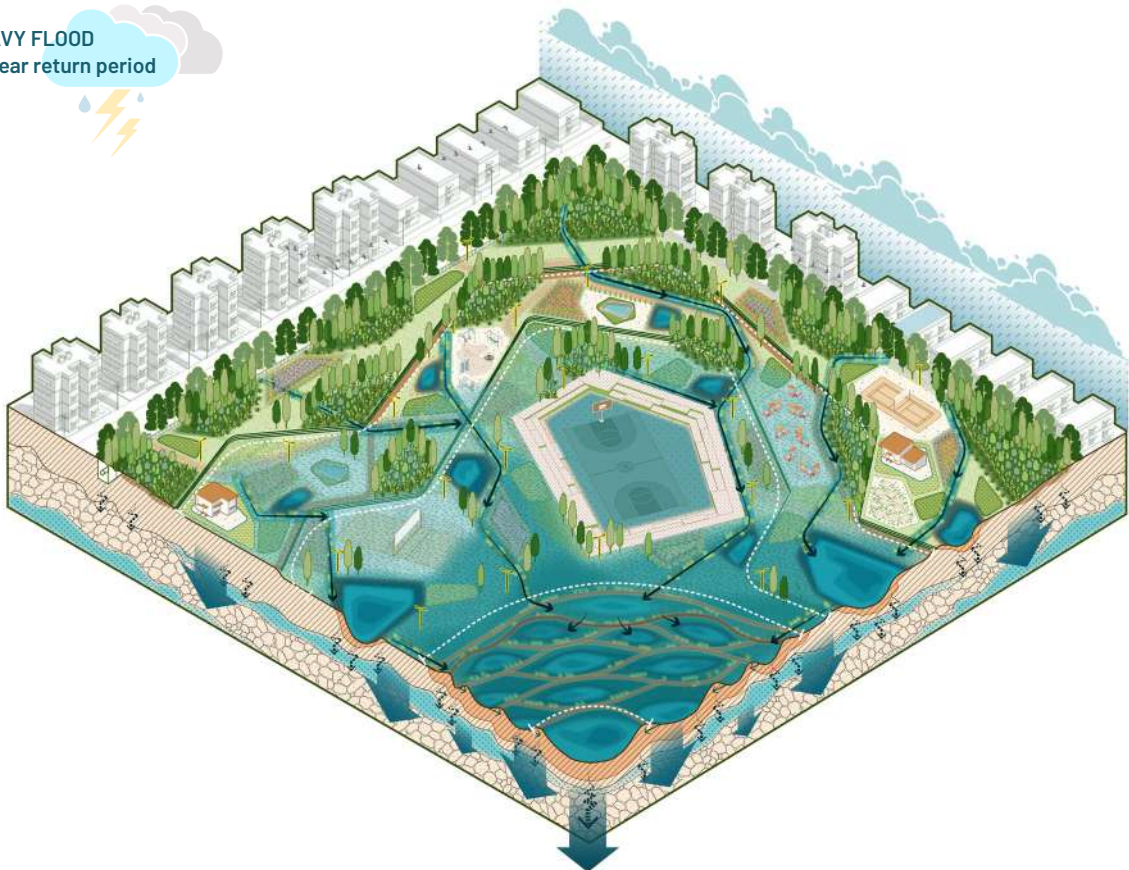


Fig. 2.35 Axon showing the Large sponge park during moderate rainfall

Case Studies

1 - Qunli Storm water Wetland Park

The Qunli Storm water Wetland Park, is a innovative park serves as a model for integrating ecological restoration, storm water management, and public recreation within an urban setting. represents a paradigm shift in urban design, demonstrating how landscape architecture can contribute to ecological restoration, storm water management, and community well-being in rapidly growing cities. The primary objective of the Qunli Storm water Wetland Park is to manage and treat storm water runoff from the surrounding urban area.



- Area - 84 Acres
- Designed by - Turenscape
- Highest °C : 27.2°C (July)
- Lowest °C :-23.3°C (December)
- Highest rainfall : 111.7mm (July)
- Lowest rainfall : 0.0mm (January)



Fig. 2.36 Images of vegetated swales that capture and filter storm water

KEY TAKEAWAYS

- The park incorporates a series of constructed wetlands, detention basins, and vegetated swales that capture and filter storm water, reducing peak flows and improving water quality.
- Wetland ecosystems within the park support a variety of plant and animal species, contributing to the overall health of the urban environment
- The park is designed to retain and infiltrate storm water through natural processes, reducing the burden on conventional drainage infrastructure.
- Permeable surfaces, such as wetland soils and vegetated areas, facilitate groundwater recharge and minimize surface runoff.
- The park's design promotes resource conservation, resilience to climate change, and integration with the natural landscape



Fig. 2.37 Aerial view of Qunli Storm water Wetland Park

2 - Houtan Park

Houtan Park, is a renowned example of innovative urban design that integrates ecological principles, sustainable practices, and public amenities within a densely populated urban area. Houtan Park is characterized by its focus on ecological restoration, transforming a former industrial site into a vibrant urban green space. The park's design incorporates native vegetation, wetland habitats, and naturalistic landscapes that mimic the region's natural ecology and is designed to enhance the resilience of the urban environment to climate change and extreme weather events.



- Area - 34.5 Acres
- Designed by - Turenscape
- Highest °C : 31.6°C (July)
- Lowest °C : 1.6°C (January)
- Highest rainfall : 160mm (June)
- Lowest rainfall : 33mm (December)



Fig. 2.38 Series of criteria of how water is filtered in the park

KEY TAKEAWAYS

- One of the central features of Houtan Park is its innovative storm water management system, which utilizes ecological principles to capture, treat, and recycle rainwater.
- The park includes constructed wetlands, bioswales, and permeable surfaces that filter and purify storm water runoff, reducing pollution and mitigating flooding
- The park's water features, such as ponds, channels, and waterfalls, help regulate local microclimates, improve air quality, and support biodiversity.
- Park provides a range of recreational and cultural amenities for visitors, including walking paths, viewing platforms, art installations, and outdoor gathering spaces.



Fig. 2.39 overall view of Minghu wetland park

2.2.4. X-Special OSR Sponge Park

Site Assessments And Design Services to be Procured

Special case Sponge Parks at the scale of 5 acres or more can significant impact on mitigating flood, water scarcity and heat risks. They can also provide social amenities of citywide importance. Therefore, the design and implementation of very large-scale sponge parks require careful consideration of site conditions and objectives. In many cases, the existing conditions of the site in terms of soil compactness, elevation, and green cover will not fully align with the park's goals of integrating green-blue infrastructure and community-oriented activities.

To bridge this gap, comprehensive site surveys are essential, including overall site assessments, soil tests, hydrological studies, geotechnical investigations, catchment analyses, and topography assessments. Using the findings from these surveys, sponge parks are strategically designed with criteria by system, encompassing soil quality and grading, hydrology and blue-green infrastructure, vegetation and planting strategies, as well as amenities and social infrastructure.

Given the extensive space needed for implementing all components of sponge parks, procurement and construction should involve collaboration with specialized consultants who understand best practices for green infrastructure.

The development process also requires various levels of detailed drawings and specifications relevant to the integration of Best Management Practices (BGI) components. These drawings and specifications guide the construction team in executing the design accurately and efficiently, ensuring that the sponge park achieves its objectives of storm water management, community engagement, and ecological enhancement.

Refer to Chapter 4.x on Procuring for Sponge Parks.

Checklist For Site Assessments For Sponge Park Systems

 Soil ✓ Site survey to examine any depressions in the site. ✓ Identification of high and low points. ✓ Conduct a soil and geotechnical survey to analyze the soil type ✓ Also conduct chemical and granular profile test below ground level. ✓ For checklist "S.1. Soil and Grading" - Pg 48	 Hydrology ✓ After selecting the OSR land, understand the local catchment and hydrology model. ✓ Understand water flow and water logging system. ✓ Analysing the depth of water and quality of aquifer. ✓ For checklist "S.2. Hydrology and Blue Green Infrastructure" - Pg 50	 Vegetation ✓ Survey the number of trees in the site ✓ Audit to measure tree caliper (DBH) above 6" to 12" tree ground line level to maintain trees without relocating. ✓ Conduct species audit to remove the invasive species - For checklist "S.3. Vegetation and Planting" - Pg 52	 Amenities ✓ Check for the entry and exit points ✓ Analyze onsite and offsite safety concerns ✓ Research on the user desires and history of the site ✓ For checklist "S.4. Social and Inclusive Amenities" - Pg 54

Design Criteria For Sponge Park Systems

 S.1. Soil & Grading • Soil amendment is done in the designated high planting zones • Land is graded to create a extended flood zones • Natural grading of the site is used to incorporate BGI (Sponge) toolkits to capture runoff from all zones	 S.2. Hydrology & Blue-green • Understanding water flow helps determine the capacity and design BGI to manage storm water runoff. • Designing BGI with appropriate water depths ensures that surfaces remain accessible and safe for maintenance activities. • For more "S.2. Blue-green Infrastructure (Sponge) Toolkits" - Pg 82	 S.3. Vegetation & Planting • Based on the audits conducted various zones like urban forest, pollinated garden & ground cover with native species are created • Speed areas of greenery is created with native species • 7 types of planting mixes were incorporated in the site "S.3. Types Of Plant Mixes" - Pg 103	 S.4. Amenities & Social Facilities • Continuous jogging and walking trail is incorporated compatible with BGI components • Playgrounds were provided with different sizes and ground mix • Proper seatings, signages, sightlines and lighting are provided to feel safe. check "S.4. Amenities and social facilities" - Pg 115

Case Studies

1 - Minghu wetland park – rainwater harvesting park

Mingu Wetland Park, also known as Minguwan Urban Wetland Park, is a significant ecological and recreational area located in. This park represents a urban wetland restoration and sustainable development, providing valuable habitat for wildlife, recreational opportunities for visitors, and ecological education for the community. The park's location at the intersection of urban and natural landscapes makes it an important ecological corridor and habitat for migratory birds. The park was developed through the restoration of degraded wetland areas, which were transformed into diverse wetland habitats.



LIUPANSHUI

- Area - 296.5 Acres
- Designed by - Turenscape
- Highest °C : 24.4°C (July)
- Lowest °C : -0.5°C (January)
- Highest rainfall : 175mm (June)
- Lowest rainfall : 2.54 (January)



Fig. 2.40 Series of criertia of how water is filtered in the park

KEY TAKEAWAYS

- Mingu Wetland Park incorporates storm water management features to mitigate flooding and improve water quality in the surrounding area.
- Natural filtration processes within the wetland ecosystem help to trap sediments and pollutants, enhancing overall water quality.
- The park's diverse habitats, such as marshes, ponds, and mudflats, support wildlife conservation and promote ecological resilience in an urban environment.
- Mingu Wetland Park showcases the cultural significance of wetlands in Taiwanese history and highlights the importance of wetland conservation in urban planning.



Fig. 2.41 overall view of Minghu wetland park

1 - Urban wetland park

The proposed park is intended to be an Integrated Public Space development that would restore an Urban Wetland that is in danger of disappearing and allow biodiversity to flourish in addition to serving as a community learning and enjoyment area. The general guidelines for landscape design includes natural biodiversity, nature-based recreation, low-impact development, and environmental education. The wetland's interpretation as an urban infrastructure, social amenity, and habitat for biodiversity is on display in the park.



- Area - 16 Acres
- Designed by - Sponge Collaborative
- Highest °C : 37.1°C (May)
- Lowest °C : 21.6°C (January)
- Highest rainfall : 281.9mm (November)
- Lowest rainfall : 10.1mm (March)



Fig. 2.42 Series of Images of Entrance way, boardwalks on the wetlands

KEY TAKEAWAYS

- The Chettiyar Agaram Lake is preserved in the Wetland Zone, which also improves the waterbody's edge by adding wetland plant species to support biodiversity and build an ecosystem.
- The lake viewing platform offers a comprehensive perspective of the lake as well as information on plant and wildlife species.
- The Flowering Avenue features a lawn that people can use for play areas and seating as well as a rammed earth pathway that winds through a dense stand of red poinsettias and mature trees.
- The Boardwalk is a raised path that offers access to multiple activity zones, covered lounging areas, and a range of wetland vegetation, including grasses and flowering shrubs.



Fig. 2.43 Masterplan of urban wetland park

2. Kilbakkam climate interpretation park

One of the major public infrastructure projects that the Chennai Metropolitan Area's CMDA undertook is the Kilbakkam Climate Park and Archaeological Interpretation Centre. To cope up with climate change in Chennai, it will highlight the significance of regional landscapes and blue-green infrastructure. Critical regional landscapes, proving BGI for climate adaptation strategies, and raising community education and understanding about climate change are all taken into account in the proposed design. As a multipurpose infrastructure, the proposed park is meant to be a destination for culture, recreation, urban ecology, archeological interpretation, and community building in the surrounding area.



- Area - 16.9 Acres
- Designed by - Sponge Collaborative
- Highest °C : 37.1°C (May)
- Lowest °C : 21.6°C (January)
- Highest rainfall : 281.9mm (November)
- Lowest rainfall : 10.1mm (March)

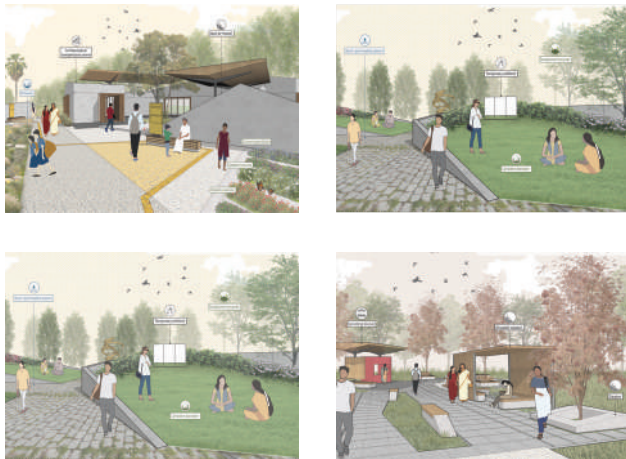


Fig. 2.44 Series of Images of Entrance way, boardwalks on the wetlands

KEY TAKEAWAYS

- The purpose of sponge park infrastructure, a sustainable approach to water management, is to generate an interpretation through the use of vegetation and natural solutions to store, filter, and recharge water.
- Parks are an excellent means of enhancing resilience, habitat, and wildlife surrounding the park.



Fig. 2.45 Masterplan of Kilbakkam climate interpretation

2.3. Design Criterias for Sponge Park System



S.1. Soil and Grading

1. Surveying Of The Soil

- To conduct a comprehensive soil survey, begin by reviewing existing maps, aerial photographs, and satellite imagery to understand landscape features and historical land use.
- Conduct field visits to observe and document soil profiles systematically, collecting samples with augers or probes at representative locations covering diverse soil types and landscapes.
- Record soil characteristics like color, texture, and structure in the field, and analyze samples in a laboratory for physical, chemical, and biological properties such as texture, organic matter, pH levels, and nutrient content.
- Integrate field observations with laboratory results to classify and map soil types using GIS tools, following established classification systems like USDA Soil Taxonomy.
- Develop detailed soil maps depicting spatial distribution and suitability for specific land uses.
- Compile survey findings into a report with recommendations for land use planning, agricultural practices, and environmental management, validated through field verification and stakeholder collaboration to ensure accuracy and relevance hydrometer analysis.
- Unified Soil Classification System (USCS): The USCS categorizes soils into different groups based on their particle size distribution. It classifies soils into groups such as gravel (GW), sand (SW), silty sand (SM), clayey sand (SC), clay (CL), and more.

2. Grading of the soil

- Soil grading involves analyzing the distribution of particle sizes within a soil sample. Soil particles are categorized into different size ranges, typically ranging from gravel to clay.
- Soil particles are classified into various standard size classes: (gravel: coarse particles with sizes greater than 2 mm, sand: particles ranging from 2 mm down to 0.05 mm, silt: fine particles ranging from 0.05 mm to 0.002 mm, clay: Very fine particles smaller than 0.002 mm)
- A grain size distribution curve is used to represent the percentage of soil particles falling within different size ranges.
- Soil grading is critical in determining soil behavior, such as permeability, compressibility, and shear strength. It influences the suitability of soils for various engineering applications like foundation design, earthworks, and construction materials.
- Soil grading influences soil texture, which in turn affects soil properties like water-holding capacity, drainage, and susceptibility to erosion.
- Geotechnical engineers use soil grading data to assess the engineering properties of soils and determine appropriate construction methods and soil improvement techniques
- Soil grading is determined through laboratory tests such as sieve analysis, sedimentation analysis (hydrometer test), or laser diffraction analysis, depending on the required level of accuracy and particle size range.

3. Soil Amendment

- Soil amendment refers to the process of improving the quality and fertility of soil by adding substances that enhance its structure, nutrient content, water retention, and overall health.
- This practice is essential for optimizing soil conditions to support healthy plant growth, improve crop yields, and promote sustainable land use.
- Soil amendments can include organic materials such as compost, manure, and plant residues, which enrich the soil with essential nutrients and organic matter.
- Inorganic amendments like lime, gypsum, and perlite are used to adjust soil pH, improve drainage, and enhance soil structure.
- By applying soil amendments, people can address soil deficiencies, promote beneficial microbial activity, and create an optimal growing environment for plants.
- The choice of soil amendments depends on specific soil characteristics, crop requirements, and desired land management objectives, ultimately contributing to improved soil fertility and ecosystem health.
- Regular soil testing and monitoring guide the selection and application of appropriate amendments to sustainably enhance soil quality over time.
- Raise or lower soil pH levels to create optimal conditions for specific plants or crops.
- Correct excessively acidic (low pH) or alkaline (high pH) soils that hinder nutrient availability.



Fig. 2.46 Reference - Soil amendment



Fig. 2.47. Reference - Soil grading

4. Soil Enhancement Techniques

- After the process of soil amendment, the amended soil is enhanced and upgraded by evaluating slope gradients, surface drainage patterns, and existing landforms.
- We can clearly desire the outcomes and objectives for topographic enhancements based on project goals, land use requirements, and aesthetic preferences.
- Consider factors such as water management, erosion control, accessibility, and landscape design concepts. Determine areas for cutting (removal of soil) and filling (addition of soil) to achieve desired contours and slopes.
- Contour the land by reshaping slopes and creating terraces or berms to control erosion and manage water runoff.
- Adjust slope gradients to improve stability, accessibility, and usability of the land for intended purposes.
- Ensure proper compaction of soil layers during earthmoving activities to enhance soil stability and prevent settling.
- Enhance soil aggregation and porosity for better aeration, water infiltration, and root penetration.
- Reduce compaction and increase soil friability to support root growth and microbial activity.

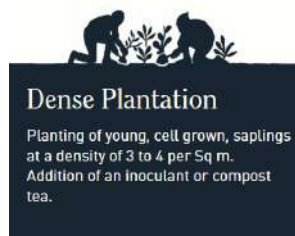


Fig. 2.48. Reference - Soil grading

5. Infiltration of the Soil

- For assessing the soil hydraulic properties, infiltration experiments should be carried out at site areas.
- The experiments are to be carried out in the month of January, one month post the monsoon period in Chennai, hence it is assumed that the site conditions were reasonably unsaturated. The experiments were performed at two different depths within a particular site for determining the saturated hydraulic conductivity at different soil layer depths. Saturated hydraulic conductivity indicates the infiltration capacity of the soil.
- Soils with low saturated hydraulic conductivity will have low infiltration capacity and hence will be more prone to water logging conditions.
- The more permeable the soil is, more will be saturated hydraulic conductivity, allowing more infiltration and percolation of water into the soil. Hence the determination of the saturated hydraulic conductivity of the native soil helps in understanding the behaviour of the catchment in response to rainfalls.
- The Guelph permeameter measures the steady state rate of water recharge into unsaturated soil, while a constant head of water is made available in a cylindrical well-hole (approximately 20 cm in depth) from which water discharges into the soil.
- This rate of steady flow, along with the dimensions of the cylindrical well hole and water depth in it are used to estimate the saturated hydraulic conductivity of the soil.
- Various factors influencing the soil infiltration depends on the soil texture of the site, soil structure, soil moisture content apart from these its also influenced by the vegetation and organic matter, surface condition of the site.



Fig. 2.49 Reference - Infiltration test conducted using



S.2. Hydrology and Blue Green Infrastructure

Adopting the guidelines for Blue-green infrastructure (BGI) components optimizes storm water management and delivers several benefits related to the environment, economy, society, physical and mental health, and well-being.

Urbanized regions can control storm water runoff in ways that resemble natural ground cover conditions, at least in part, using a wide range of BGI components with the incorporated principles of **Delay**, **Store**, **Filter**, and **Recharge**. The BGI (Sponge) toolkits are arranged in this section according to typologies and their deliverable functions that match the urban systems that can be modified and adapted in the future.

This section provides more detailed descriptions and illustrations of the BGI components that enable Sponge Parks to fulfill their hydrological and risk reduction functions. The BGI components are described for their suitability, performance capability, and

maintenance with technical details explained through drawings and tables.

The purpose of this toolkit is to assist Chennai's planning authorities, department engineers, and civil society activists in comprehending how the OSR spaces can be modified or updated to sponge parks that can manage flood and water resources while enhancing the public realm.

To facilitate the strategic implementation of Small Sponge Parks, the unit costing with the schedule of rates have been provided for the BGI toolkits that are suitable for the scale. Detailed guidelines and considerations for the positioning, sizing, and maintenance of BGI components are provided in ANNEX B.

Table 2.4. Performance Ability of BGI toolkits across Sponge parks

BGI (Sponge) Toolkits		Principles				Typologies			
		Delay	Store	Filter	Recharge	Small	Medium	Large	X - Special
	T.1. Bioswales	●	○	●	○	●	●	●	●
	T.2. Recharge Pit	○	○	○	●	●	●	●	●
	T.3. Raingarden (Buildings)	○	○	○	○	●	●	●	●
	T.4. Raingarden (Streets)	○	○	○	○		●	●	●
	T.5. Retention Pond	○	●	○	○		●	●	●
	T.6. Infiltration Basin	●	○	○	●		●	●	●
	T.7. Sunken Court	○	●	○	○			●	●
	T.8. Water Plaza	○	●	○	○			●	●
	T.9. Constructed Wetlands	●	●	●	○			●	●

Performance ability of BGI Toolkits : ● High ○ Moderate ○ Low



Fig. 2.50. Reference - Bioswales



Fig. 2.51. Reference - Recharge Wells



Fig. 2.52. Reference - Rain Garden



Fig. 2.53. Reference - Retention Pond



Fig. 2.54. Reference - Infiltration basin



Fig. 2.55. Reference - Sunken Court



Fig. 2.56. Reference - Water plaza



Fig. 2.57. Reference - Constructed wetlands



T.1. Bioswales

The purpose of planted and managed swales, or bioswales channels, is to transmit storm water at a low velocity and encourage natural treatment and infiltration. Storm water from roads and other impervious surfaces can be efficiently conveyed and treated via bioswales channels. When the drainage area, terrain, soils, slope, and safety considerations allow for their implementation, they can be used on medians or beside roads. Most swales are kept as lawn areas and planted with turf grass.

Indicators To Consider

Suitability	Performance Ability	Limitations	Maintenance
- Water depth - 1.5 to 3m - Slope - 0.5 % - 4 % - Infiltration Rate - 25-75mm/hr - Soil mix - sand + loam + compost - Planting mix - Bioswales mix "Bioswales Mix" - Pg 107 - Maintenance lvl - Low - Community engagement - Medium lvl of acceptance	DELAY ● STORE ● FILTER ○ RECHARGE ● Legend ● Highly Effective in all conditions ● Moderately/ Conditionally Effective ○ Not Effective / Not Applicable	- If slope of existing bioswales is higher than 3%, the slope must be decreased using check dams or a sequence of terraced bioswales. 6" should be the maximum amount of ponding in the swale. - Typically, amended soil in the bioswales should be between 12"-18" thick .	- Removal of debris/litter from the system - Clearing of inlets, culverts and outlets from debris and sediment. - Check "4.2.1. General Site Maintenance" for more details - Check "MAINTAINENCE OF" - pg 63 for more details

Table 2.5. Schedule of Rates - 1m x 1m x 1m

Components	SOR number	Quantity	Units	UnitRate
Excavation		0.6	Cmt	Rs 230
curb		3	Rmt	Rs 750
Water inlet grating		0.5	Nos.	Rs 450
Water outlet grating		0.25	Nos.	Rs 450
Boulder		0.25	LS	Rs 150

Components	SOR number	Quantity	Units	UnitRate
Shrub		1	Sqm	Rs 1,800
Soil		0.3	Cmt	Rs 2,000
Gravel		0.1	Cmt	Rs 1,200
Perforated pipe		1	Rmt	Rs 600
overflow pipe		1	Rmt	Rs 200

References



Fig. 2.58 Reference Images of Bioswales

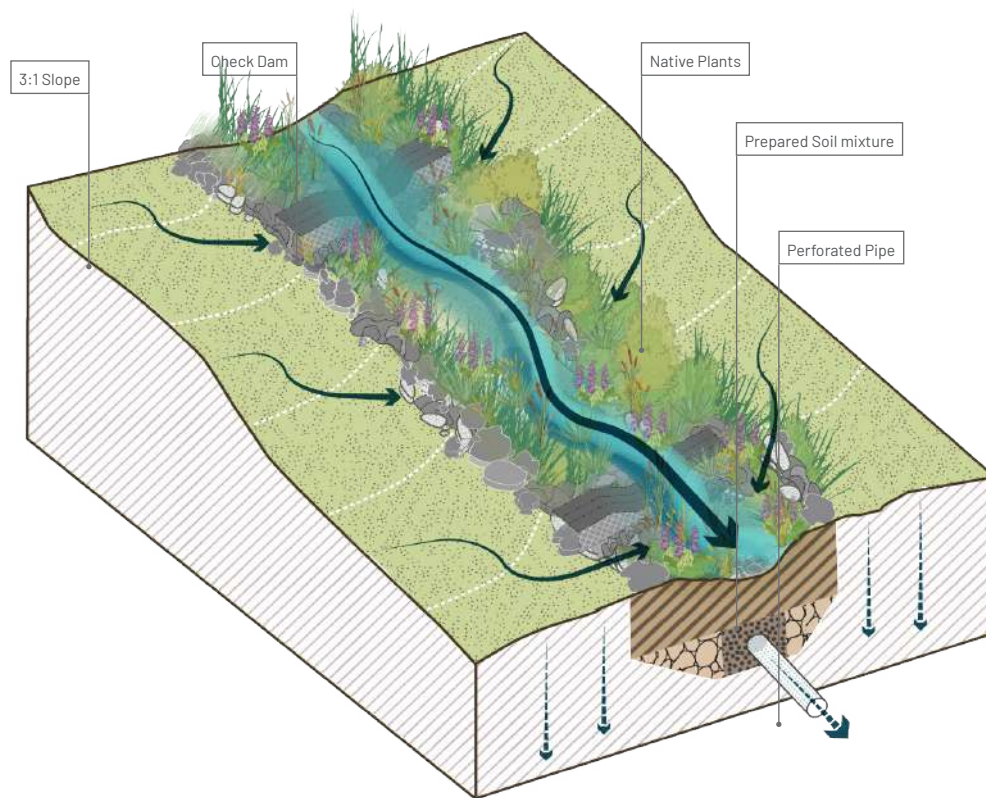


Fig. 2.59. Axon showing Bioswales Details

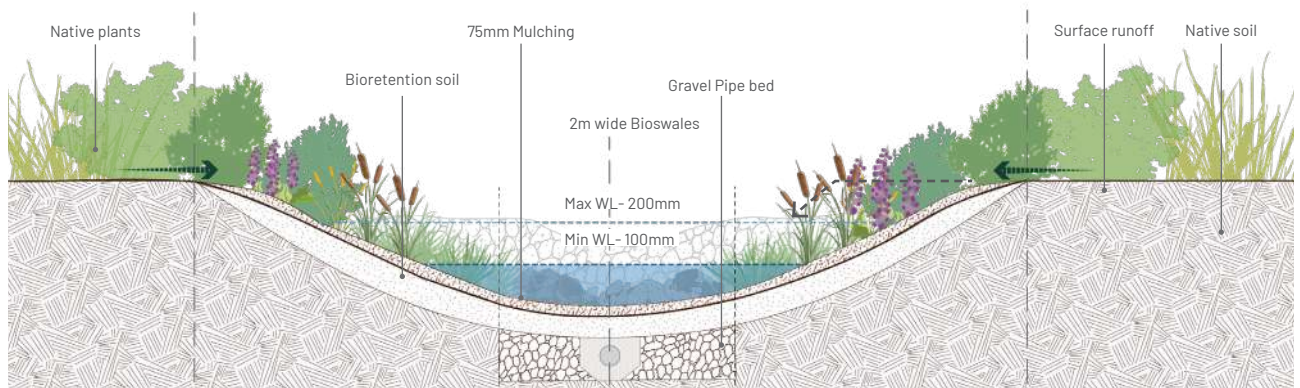


Fig. 2.60. Section of Bioswales

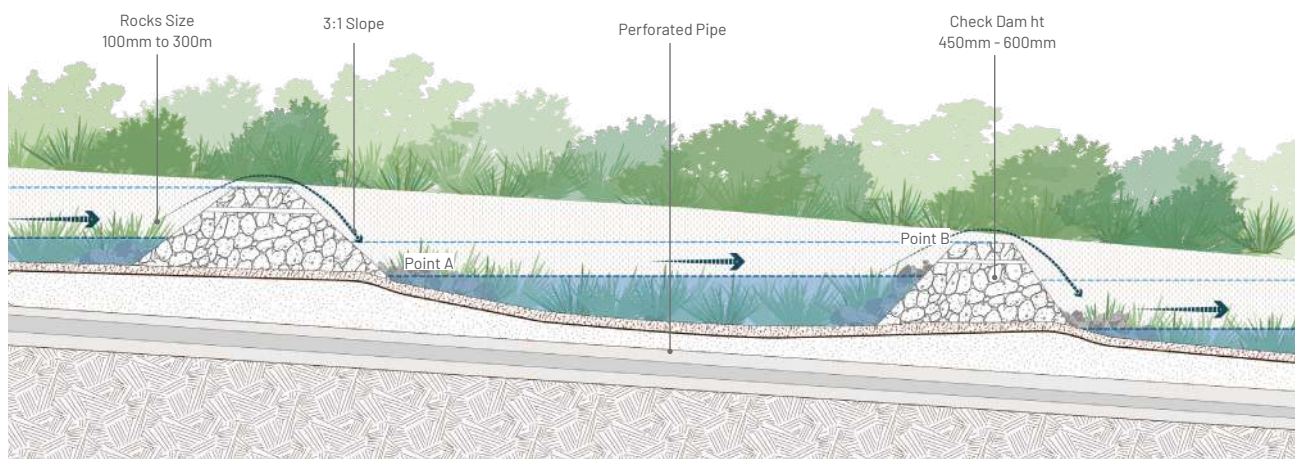


Fig. 2.61. Checkdam Details



T.2. Recharge Wells

Recharge wells are artificial groundwater recharge methods that release water directly into zones of deep water holding capacity. The aquifer-covering material can be used to casing recharge wells. A screen can be inserted into the well at the injection zone if this material is not well-consolidated. Since subsurface groundwater recharge requires wide regions for infiltration, they are also beneficial in places with limited land. This technique can achieve a comparatively high rate of recharge.

Indicators To Consider

Suitability	Performance Ability	Limitations	Maintenance
- Water depth - 6m - Infiltration Rate -150 mm / hr - Soil mix - sand + loam + Textures - Planting mix - Bioswales mix "Bioswales Mix" - Pg 107 - Maintenance lvl - Medium - Community engagement - Medium lvl of acceptance	DELAY ● STORE ● FILTER ● RECHARGE ○ Legend ● Highly Effective in all conditions ● Moderately/ Conditionally Effective ○ Not Effective / Not Applicable	- Description neededGa. Idici incta etus, tem autem iligendita cor moluptias autem quas si am ipid quibus eos et qui conse ex everferio odiciis ut quiatut sequia quodita tiorum quat. - Rit, comnis alit, cupa eiciaec tioreca tenempo riatestendae sin nostiunti commoditius as ex exere aliquid quid untium	- Removal of debris/litter from the system - Clearing of inlets, culverts and outlets from debris and sediment. - Check "4.2.1. General Site Maintenance" for more details - Check - Pg 152 for more details

Table 2.6. Schedule of Rates - 0.9 diameter

Components	SOR number	Quantity	Units	UnitRate
Recharge well		1	Nos.	Rs 70,000
Excavation		11.4453	Cmt	Rs 230
Rcc rings with perforation		2.4021	Sqm	
Perforated RCC cover slab		1	Nos.	
Gravel		2.5434	Cmt	Rs 1,,200

Components	SOR number	Quantity	Units	UnitRate
overflow pipe		1	Rmt	Rs 1,200
Recharge Well provided in Open Spaces		15	Nos.	Rs 70,000

References



Fig. 2.62 Reference Images of Recharge wells

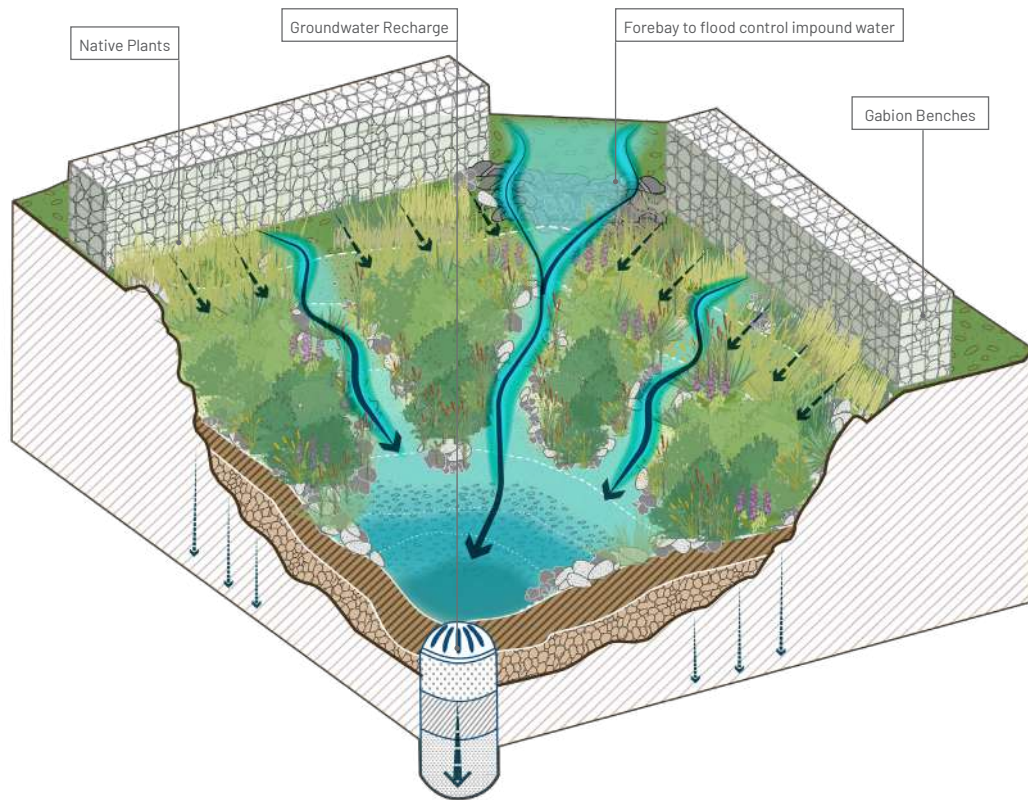


Fig. 2.63. Axon showing recharge wells Details

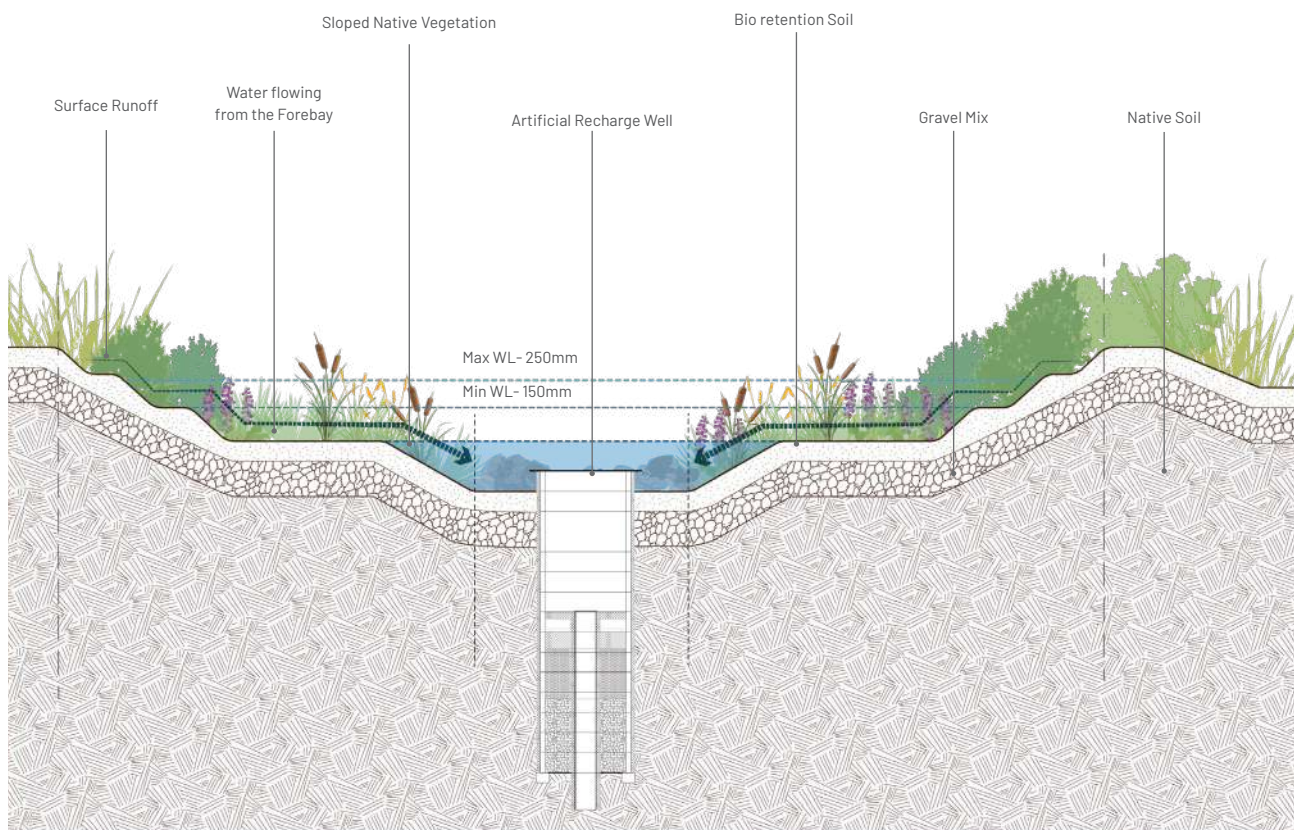


Fig. 2.64 Section of Recharge wells



T.3. Raingarden – Buildings

Rain gardens are vegetated areas created to collect runoff from impermeable surfaces like parking lots, walkways, and roofs. In case of runoff from the roofs, water from the buildings are slowly released back into the existing sewer system via under drain pipe conveyance through vegetation, and infiltrated into the ground. Rain gardens are small, often planted spaces that blend in with the surrounding landscape elements. They are typically filled with a range of native grasses and plants.

Indicators To Consider

Suitability	Performance Ability	Limitations	Maintenance
- Water depth – 0.07m to 0.25 - Slope – 4% to 12% - Infiltration Rate – 25-75mm/hr - Soil mix – sand + topsoil + compost - Planting mix – Bioswales mix “Bioswales Mix” – Pg 109 - Maintenance lvl – Medium - Community engagement – Medium lvl of acceptance	DELAY ● STORE ● FILTER ○ RECHARGE ○ Legend ● Highly Effective in all conditions ● Moderately/ Conditionally Effective ○ Not Effective / Not Applicable	- Use of rain gardens is not advised in the site with steep slopes or insufficient rainfall. - Additionally, sites with high groundwater tables and polluted areas should not be used for rain gardens. - Highly susceptible to clogging if the surrounding vegetation is neglected	- Removal of debris/litter from the system - Clearing of inlets, culverts and outlets from debris and sediment. - Immediately after the monsoon is over, take out the stagnant water in the settling chamber. - Check – Pg 152 for more details

Table 2.7. Schedule of Rates – 1m x 1m x 1m

Components	SOR number	Quantity	Units	UnitRate
Excavation		1.50	Cmt	Rs 391
Kerb		3.50	M	Rs 2,948
Water Inlet Grating		0.75	Nos.	Rs 338
Water Outlet Grating		0.375	Nos.	Rs 169
Shrubs		1.50	Sqm	Rs 2,700
Soil		0.45	Cmt	Rs 2,838

Components	SOR number	Quantity	Units	UnitRate
Boulder (300-450mm)		0.38	LS	Rs 56
Gravel		0.90	Cmt	Rs 1,080
Perforated Pipe		1.50	M	Rs 900
Overflow Pipe		1	M	Rs 200
Trees		2	Nos.	Rs 12,000

References



Fig. 2.65 Reference Images of Raingarden (Buildings)

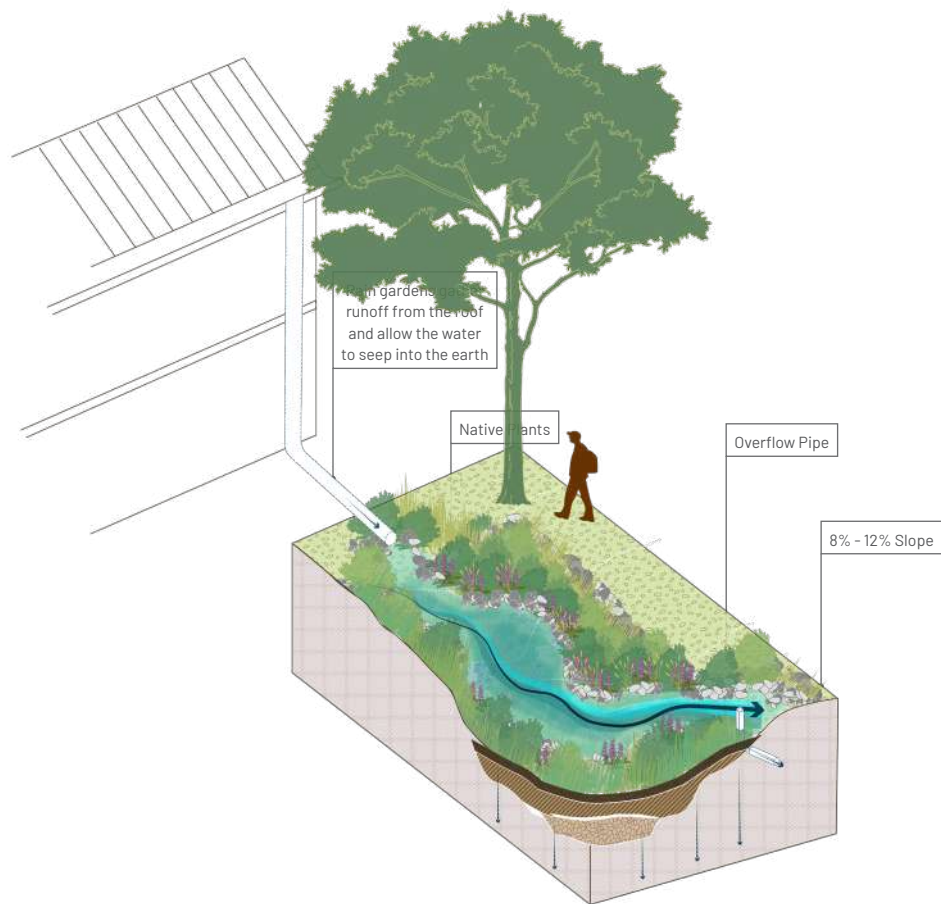


Fig. 2.66 Axon showing Raingarden (Buildings)

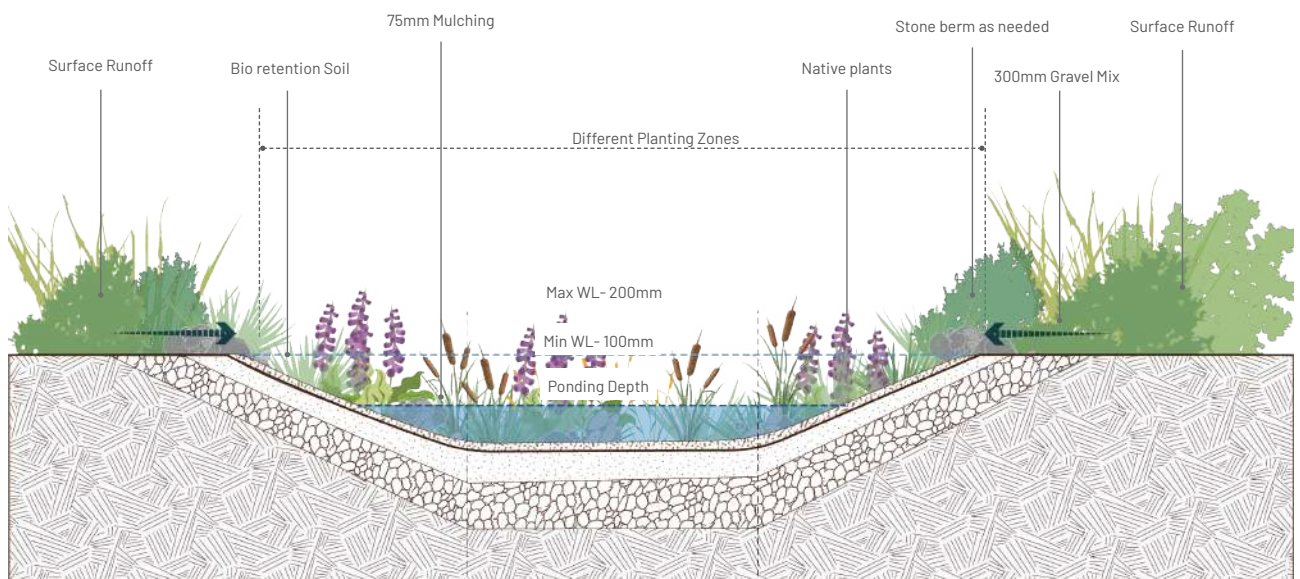


Fig. 2.67 Section showing Raingarden details



T.4. Raingarden – Streets

Rain gardens are vegetated areas created to collect runoff from impermeable surfaces like parking lots, walkways, and roofs. Surface Runoff is the overland flow of water resulting from rainfall before it reaches a water course. It is generated because impervious areas do not allow water to soak into the ground. Rain gardens are usually generated over various impervious surfaces of sponge parks. The runoff water from the streets are channelized in the raingarden and entered through the pipes and used as source water for artificial groundwater recharge.

Indicators To Consider

Suitability	Performance Ability	Limitations	Maintenance
- Water depth – 77 to 203 mm - Slope – 4% to 12% - Infiltration Rate – 25-75mm/hr - Soil mix – sand + topsoil + compost - Planting mix – Bioswales mix “Bioswales Mix” – Pg 109 - Maintenance lvl – Medium - Community engagement – Medium lvl of acceptance	DELAY ● STORE ● FILTER ● RECHARGE ○ Legend ● Highly Effective in all conditions ● Moderately/ Conditionally Effective ○ Not Effective / Not Applicable	- Use of rain gardens is not advised in the site with steep slopes or insufficient rainfall. - Additionally, sites with high groundwater tables and polluted areas should not be used for rain gardens. - Highly susceptible to clogging if the surrounding vegetation is neglected	- Removal of debris/litter from the system - Clearing of inlets, culverts and outlets from debris and sediment. - Immediately after the monsoon is over, take out the stagnant water in the settling chamber. - Check – Pg 152 for more details

Table 2.8. Schedule Of Rates – 1.5M x 1M x 1M

Components	SOR number	Quantity	Units	UnitRate
Excavation		1.50	Cmt	Rs 391
Kerb		3.50	M	Rs 2,948
Water Inlet Grating		0.75	Nos.	Rs 338
Water Outlet Grating		0.375	Nos.	Rs 169
Shrubs		1.50	Sqm	Rs 2,700
Soil		0.45	Cmt	Rs 2,838

Components	SOR number	Quantity	Units	UnitRate
Boulder (300-450mm)		0.38	LS	Rs 56
Gravel		0.90	Cmt	Rs 1,080
Perforated Pipe		1.50	M	Rs 900
Overflow Pipe		1	M	Rs 200
Trees		2	Nos.	Rs 12,000

References



Fig. 2.68 Reference Images of Raingarden (Streets)

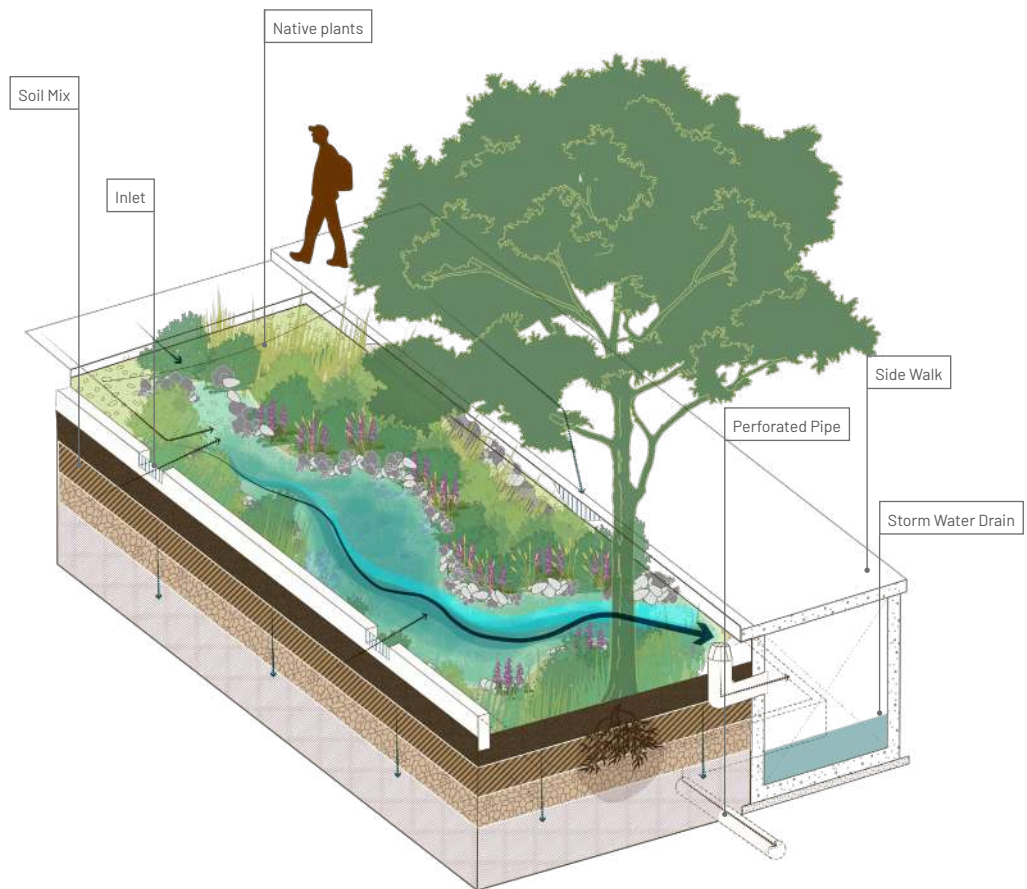


Fig. 2.69 Axon showing Raingarden(streets)

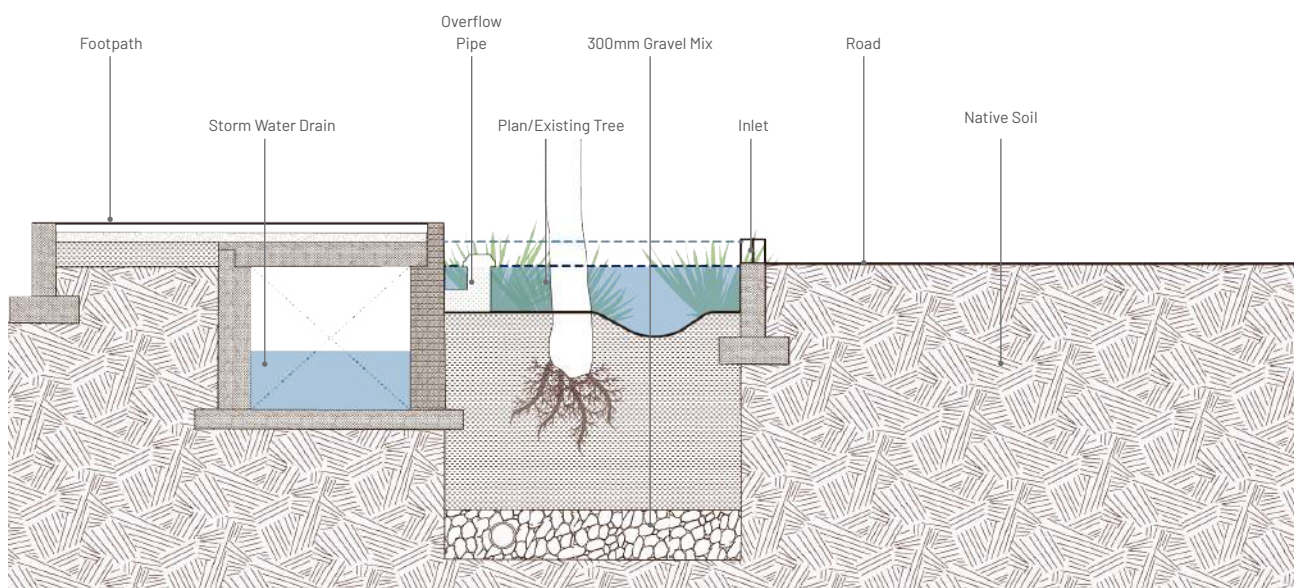


Fig. 2.70 Section showing Raingarden (Streets) details



T.5. Retention Pond

Even though retention ponds might seem like basically another water feature, it has far more benefits. Permanent components designed to contain water flow for a specific amount of time are called retention ponds. In response to a flood, the pond's water level fluctuates, reducing risk and protecting the neighborhood from flood damage and expensive repairs. By temporarily retaining water during strong storms, retention ponds help reduce peak storm water runoff rates and enhance the quality of urban runoff.

Indicators To Consider

Suitability

- Water depth - 1m to 2.5m
- Slope - >15%
- Infiltration Rate - NA
- Soil mix - sand + topsoil + compost
- Planting mix - Bioswales mix
"Bioswales Mix" - Pg 109
- Maintenance lvl - Medium
- Community engagement - Medium lvl of acceptance

Performance Ability

- DELAY** ●
- STORE** ●
- FILTER** ●
- RECHARGE** ○

Legend

- Highly Effective in all conditions
- Moderately/ Conditionally Effective
- Not Effective / Not Applicable

Limitations

- Retention ponds can only hold a finite amount of water
- Over time, sediment can accumulate in the bottom of the retention pond, reducing its storage capacity and effectiveness.
- in areas with high groundwater tables or impermeable soils, retention ponds may not effectively infiltrate stormwater runoff into the ground.

Maintenance

- Conduct routine inspections of the retention pond.
- Clear any trash, litter, or organic debris (**Pg 152**)
- Periodically remove sediment that accumulates in the bottom of the to maintain its storage capacityCheck **"4.3. Operation and maintenance - Pg 152"** for more details

References



Fig. 2.71. Reference Images of Retention pond

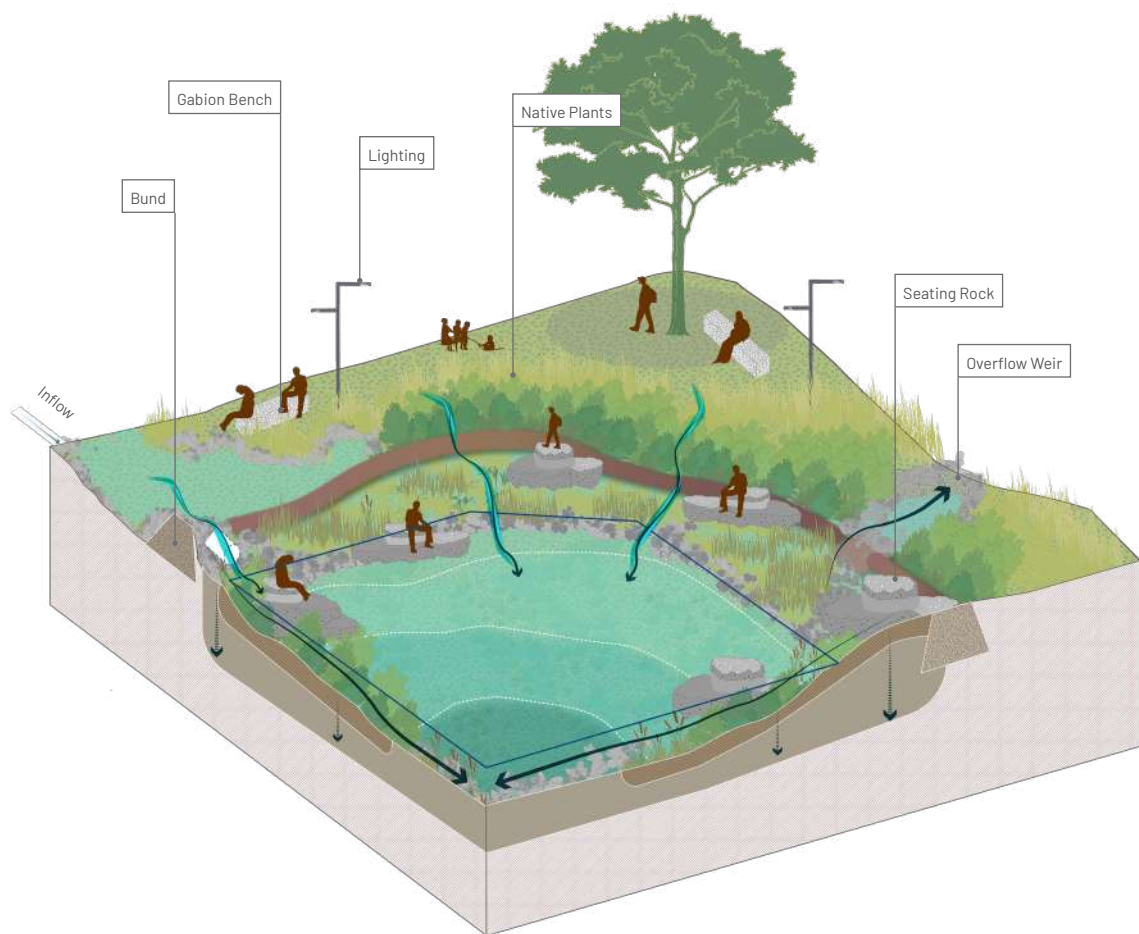


Fig. 2.72. Axon showing Retention pond

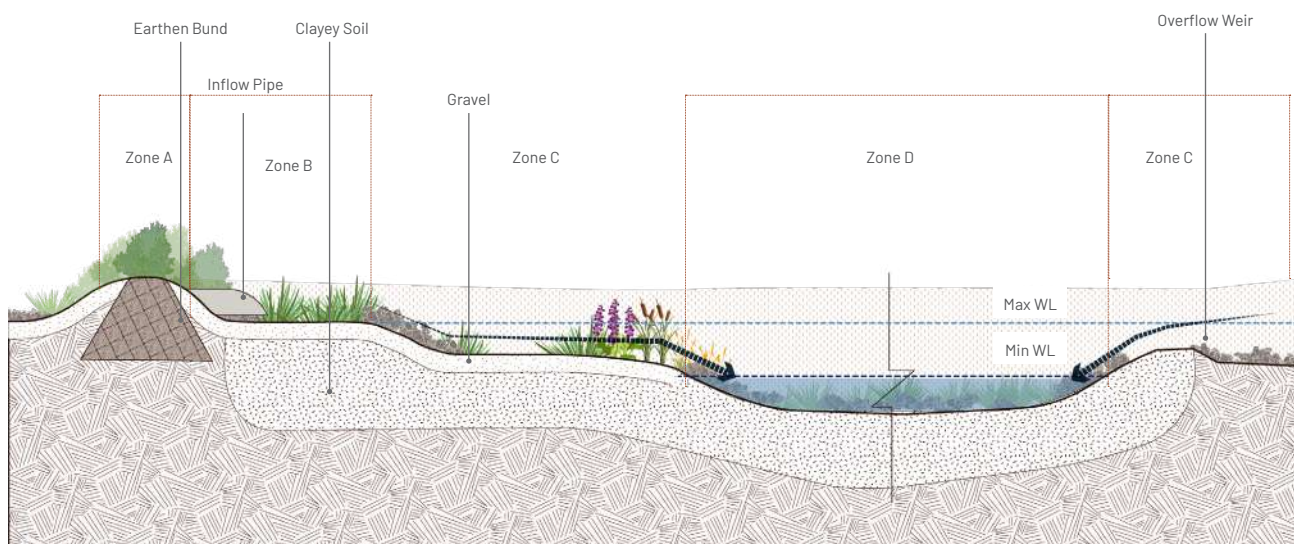


Fig.2.73 Section showing Retention ponds details



T.6. Infiltration Basin

An infiltration basin is a type of shallow pond where rainfall penetrates through the ground. In addition to helping to remove pollutants from storm water, this control is effective in boosting groundwater recharge, which in turn increases baseflow to neighboring flows. Certain underlying soil requirements of infiltration basins may make them impractical in certain places. To make sure they don't fail, pretreatment design and routine maintenance and inspection protocols are essential. Onsed que non cum quiaeratus.

Indicators To Consider

Suitability	Performance Ability	Limitations	Maintenance
- Water depth - 1m to 2.5m - Slope - >15% - Infiltration Rate - 75 - 100 mm/hr - Soil mix - sand + topsoil + compost + gravel - Planting mix - Bioswales mix "Bioswales Mix" - Pg 109 - Maintenance lvl - Medium - Community engagement - Medium lvl of acceptance	DELAY ● STORE ● FILTER ● RECHARGE ● Legend ● Highly Effective in all conditions ● Moderately/ Conditionally Effective ○ Not Effective / Not Applicable	- Infiltration basins may not always effectively remove pollutants from stormwater runoff. . - If not properly designed or maintained, infiltration basins can provide breeding grounds for mosquitoes, increasing the risk of vector-borne diseases	- Inspect and maintain outlet structures to ensure they are functioning properly and allowing for controlled discharge of water from the infiltration basin. (Pg 152) - Periodically remove sediment that accumulates in the bottom of the infiltration basin to maintain its storage capacity and infiltration rates. (Pg 153)

References



Fig. 2.74. Reference Images of Infiltration Basin

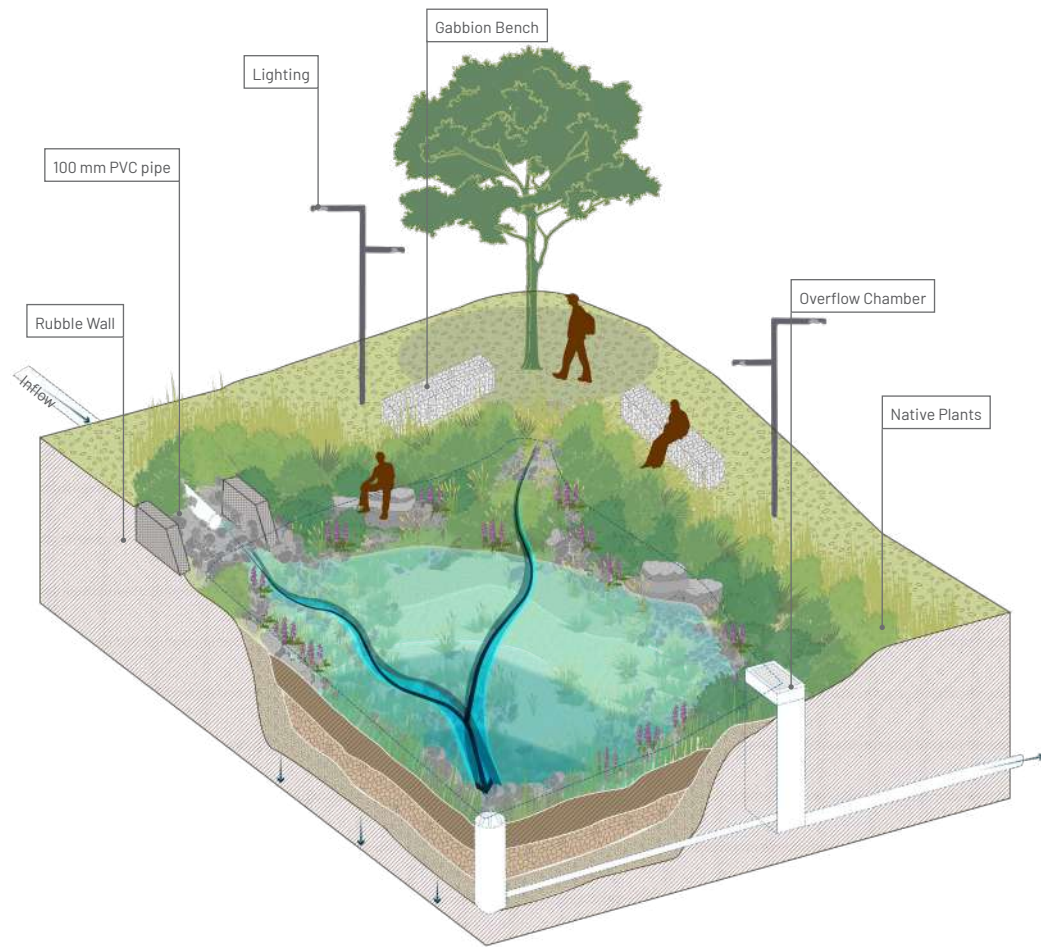


Fig. 2.75. Axon showing Infiltration Basin

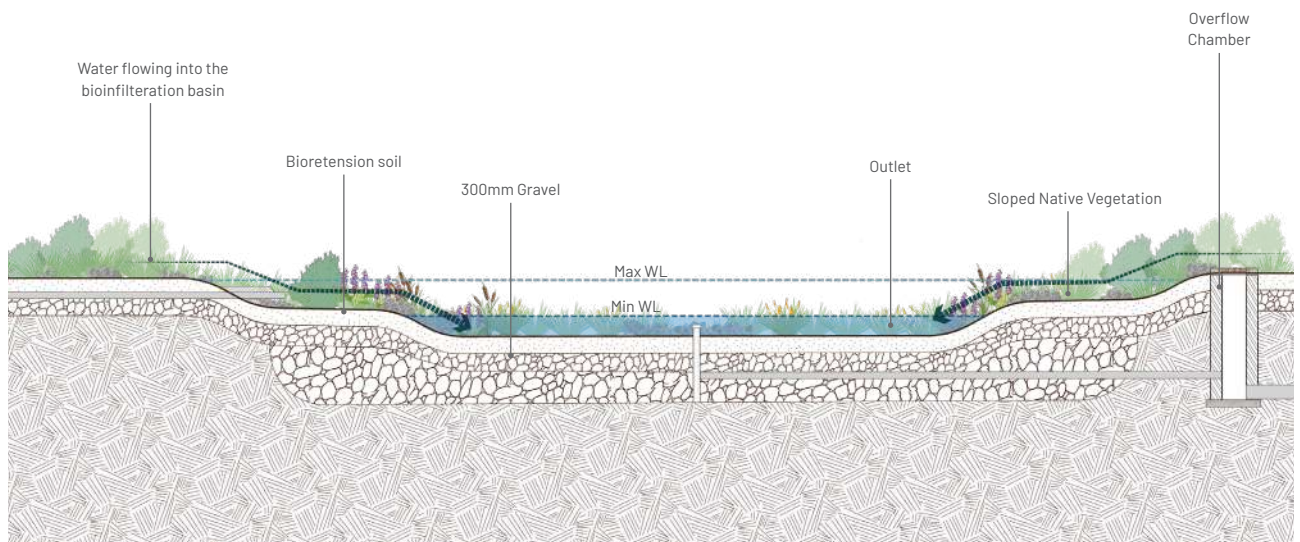


Fig. 2.76. Section showing Infiltration basin details



T.7. Sunken Court

A sunken plaza, also known as a sunken courtyard or sunken square, is a unique architectural feature where a portion of the ground level is excavated or lowered to create a depressed area within an outdoor space. Sunken plazas offer distinctive design opportunities and functional benefits, often serving as gathering spaces, performance venues, or landscaped areas within urban environments.

Indicators To Consider

Suitability

- Water depth - 1m to 2.5m
- Slope - >15%
- Infiltration Rate - 76.2 /hr
- Soil mix - sand + topsoil + compost
- Planting mix - Lawn mix
"Lawn Mix" - Pg 108
- Maintenance lvl - Medium
- Community engagement - Medium lvl of acceptance

Performance Ability

- DELAY** ○
- STORE** ●
- FILTER** ○
- RECHARGE** ●

Legend

- Highly Effective in all conditions
- Moderately/ Conditionally Effective
- Not Effective / Not Applicable

Limitations

- Sunken plazas are prone to drainage problems, especially during heavy rainfall
- Maintaining a sunken plaza can be more challenging compared to ground-level spaces.
- Sunken plazas may present accessibility challenges for individuals with mobility impairments or disabilities.

Maintenance

- Removal of debris/litter from the system (**Pg 152**)
- Monitor and remove sediment buildup in any drainage channels or catch basins to prevent clogging and ensure proper water flow.
- Repair any cracks, uneven surfaces, or damage to pavement or hardscape features (**Pg 154**)

References



Fig. 2.77. Reference Images of Sunken court

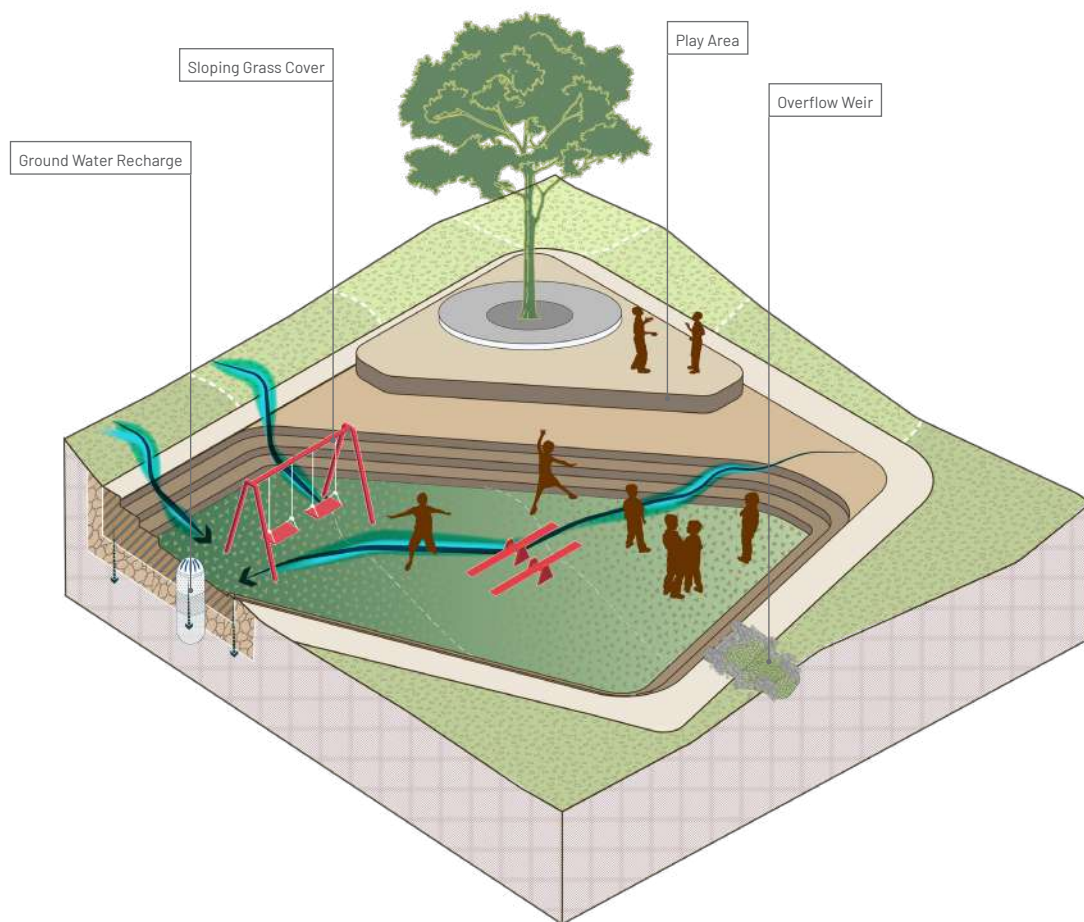


Fig. 2.78. Axon showing Sunken Plaza

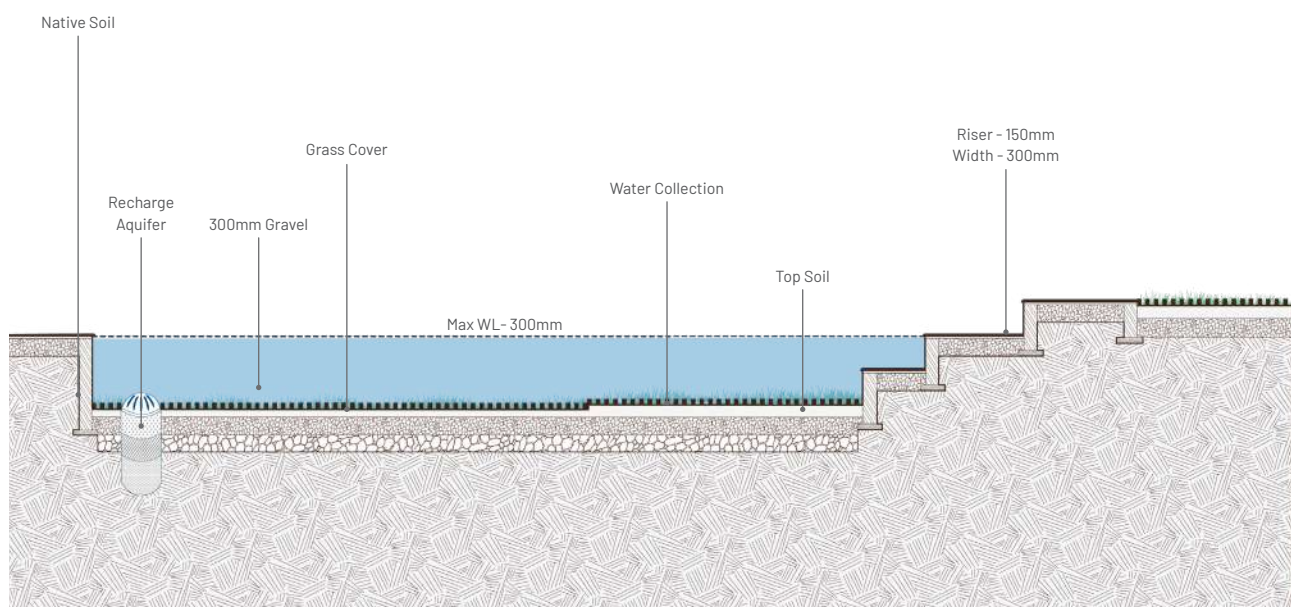


Fig. 2.79. Section showing Sunken Plaza Details



T.8. Water Plaza

Water plaza is a type of public space or urban feature that incorporates water elements as a central design element. It typically consists of an open area or plaza where water features such as fountains, pools, or interactive water installations are integrated into the landscape. Water plazas serve multiple purposes, including aesthetic enhancement, recreation, storm water management, and ecological function.

Indicators To Consider

Suitability

- Water depth - 1m to 2.5m
- Slope - >15%
- Infiltration Rate - NA
- Soil mix - NA
- Planting mix - Lawn mix
"Lawn Mix" - Pg 108
- Maintenance lvl - Medium
- Community engagement - Medium lvl of acceptance

Performance Ability

- DELAY** ○
- STORE** ●
- FILTER** ○
- RECHARGE** ●

Legend

- Highly Effective in all conditions
- Moderately/ Conditionally Effective
- Not Effective / Not Applicable

Limitations

- Water plazas may present accessibility challenges for individuals with mobility impairments or disabilities.
- Constructing and maintaining a water plaza can be expensive, requiring investments in infrastructure, landscaping, water features, and ongoing maintenance.

Maintenance

- Clean and sanitize the water plaza, surfaces, and amenities regularly to prevent the buildup of algae, mold, or bacteria. **(Pg 152)** for more details
- Monitor and adjust water levels in the plaza's features as needed to maintain proper water depth and prevent overflow or drainage issues

References



Fig. 2.80. Reference Images of water plaza

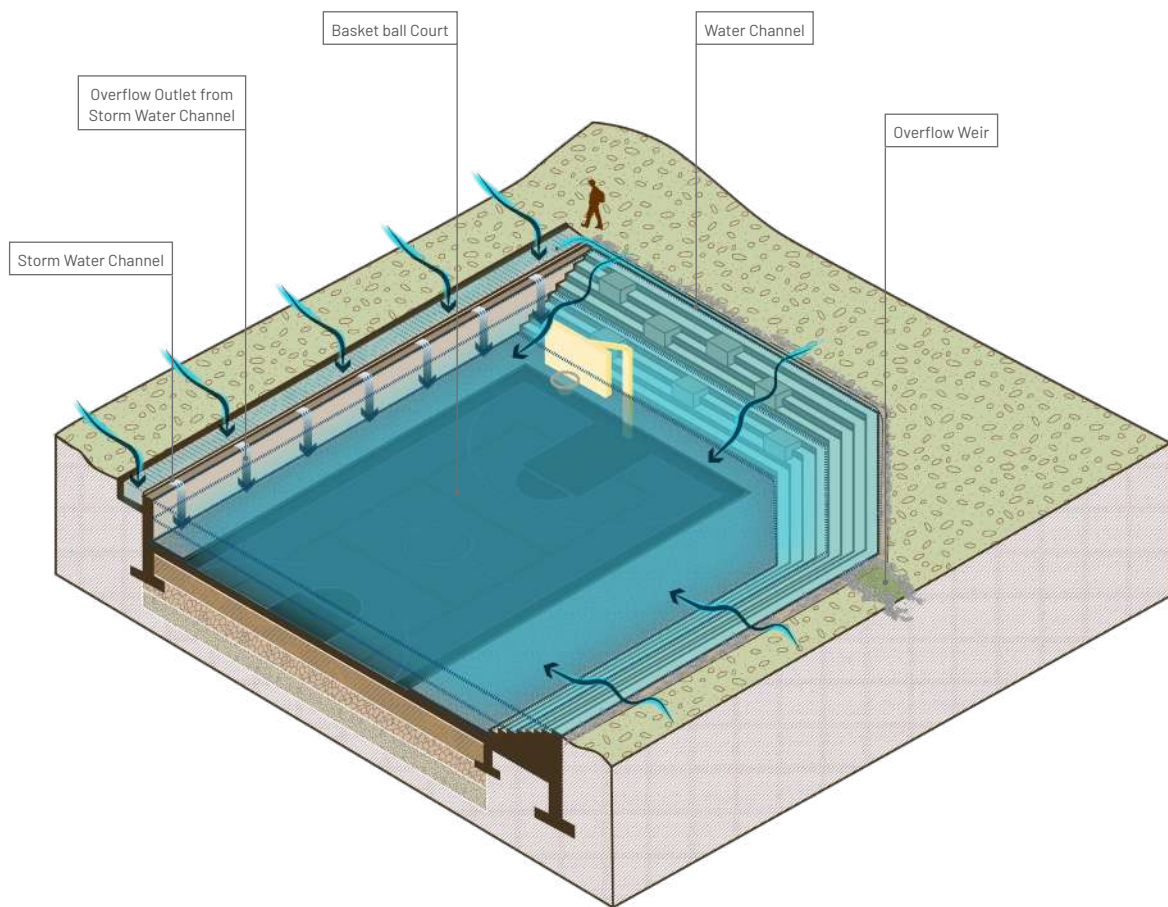


Fig. 2.81. Axon showing Water plaza details

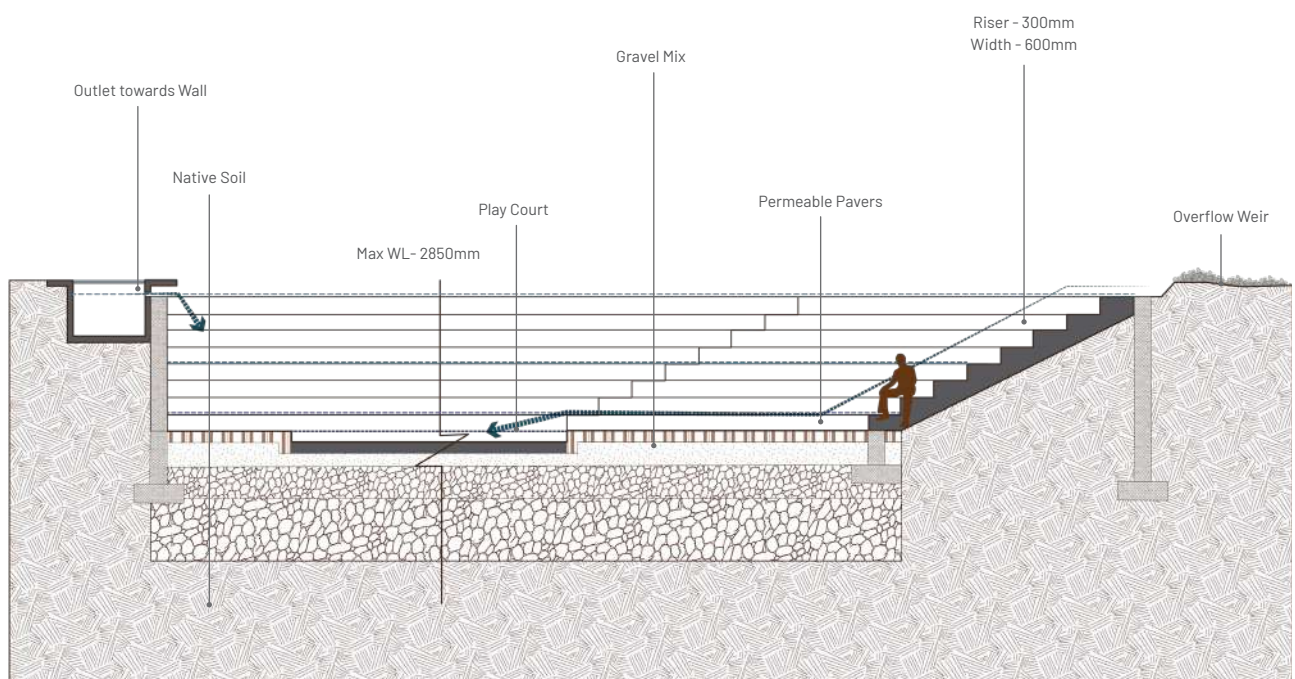


Fig. 2.82. Section showing water plaza details



T.9. Constructed Wetlands

Constructed wetlands are engineered systems designed to mimic the natural processes of wetlands for the purpose of wastewater treatment, storm water management, and ecological restoration. These systems use a combination of vegetation, soil, and microbes to remove contaminants and improve water quality. Constructed wetlands typically include a substrate layer consisting of sand, gravel, or organic material where beneficial microbes can thrive

Indicators To Consider

Suitability

- Water depth - 1m to 2.5m
- Slope - >15%
- Infiltration Rate - 76.2 /hr
- Soil mix - wetland soil + clay lining
- Planting mix - Bioswales mix
"Wetland Mix" - Pg 109
- Maintenance lvl - Medium
- Community engagement - Medium lvl of acceptance

Performance Ability

- DELAY** ●
- STORE** ●
- FILTER** ●
- RECHARGE** ○

Legend

- Highly Effective in all conditions
- Moderately/ Conditionally Effective
- Not Effective / Not Applicable

Limitations

- Wetlands can provide breeding grounds for mosquitoes and other pests, increasing the risk of vector-borne diseases and nuisance to nearby residents.
- They can also pose flood risks if improperly managed or if their hydrology is altered.

Maintenance

- Monitor water levels and flow patterns within the wetland to ensure they meet the requirements of wetland species.
- Removal of debris/litter from the system **(Pg 152)**
- Manage wetland habitats to provide suitable breeding, feeding, and nesting areas for native wildlife species

References



Fig. 2.83. Reference Images of Constructed wetlands

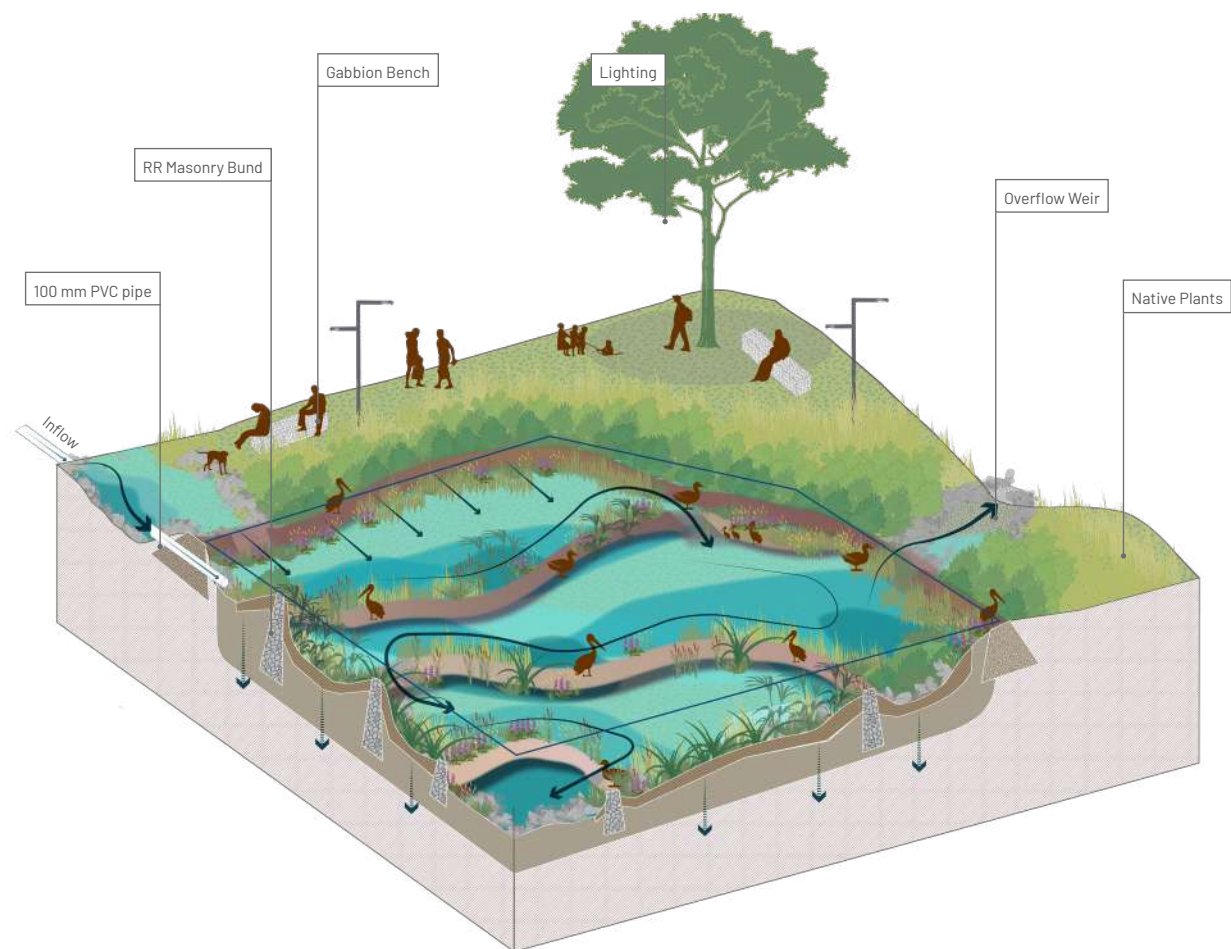


Fig. 2.84. Axon showing Constructed wetlands

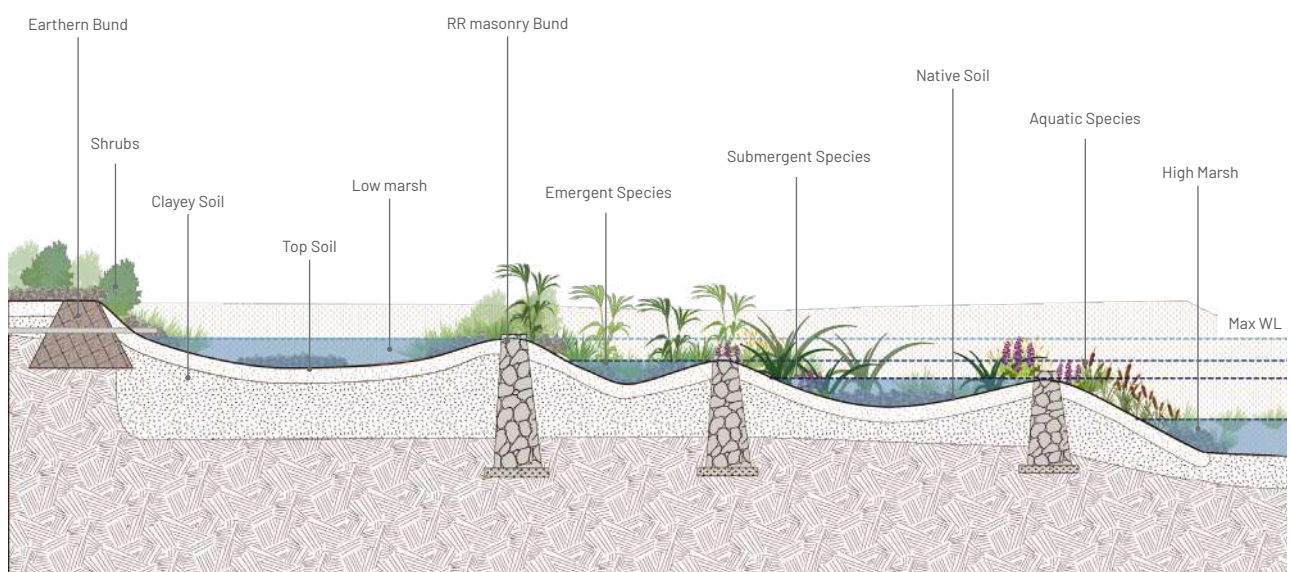


Fig. 2.85. section showing constructed wetlands details



S.3. Vegetation and Planting

This section outlines the essential requirements for creating an effective landscape plan, from site assessment to design for Sponge Parks. It also goes over important considerations that should be made when choosing a plant palette for Sponge Parks. Refer Planting list section of this document for specific information. There may be several environmental conditions within a site, created by variations in light availability, graded slope, hydrology, and storm water flow. This will break the site up into niches and appropriate species must be selected for each niche.

Removal

- Survey existing vegetation for removal of invasive species in & around the project area that might be harmful for an efficient functioning of the proposed planting in the Sponge Park.
- **Refer B.4.1 Tree construction protection** for further details

Relocation

- Develop a plan for relocation (if necessary) of a healthy, desirable plant depending on the different wetness zones as per the designed Sponge park.

Plantation

- Plantation is based on the functioning of Sponge park & plant mix developed for the same. Refer planting mix (**Pg 107**) & **B.4.5.plant list** for understanding the recommended species, spacing, irrigation & maintenance requirements.

Maintenance

- Develop a plan for maintenance of the existing vegetation and providing them a healthy growth condition.
- **Refer 4.2. plant maintenance regimes**

Table 2.9. Planting Strategy

Strategy	Description
Massings	Plant grasses, perennials, and shrubs in groups or massings, with members of the same species, for easier maintenance and a powerful visual impression.
Edge Techniques	A traditional way to indicate the change in terrain for the users of the park to analyze the pedestrian and vehicular entry of the park.
Diversity of species	A multi-layered combination of indigenous trees of different species helps establish a viable community and enhance habitats.
Sightlines	To preserve public safety and sight lines, the landscape plan should choose a variety of species while also keeping the park safe.
Micro climate	Within a system, a single plant or massing can influence nearby plants or massings and provide a small-scale micro climate.
Sunlight	The three light conditions that a plant prefers are full sun, moderate shade, and full shadow. It is typical to have full sun in an urban setting.
Hydrology	Different plants can tolerate different amounts of downpours; some can sustain prolonged periods of flooding, while other plants react negatively to prolonged flooding.



Fig. 2.86. Reference images of Planting

Planting Mixes

Plants adapt to their environment by seeking light, moisture, and nutrients. They form communities and influence softscape design in sponge parks, where strategic planting enhances maintenance, aesthetics, and habitat quality.

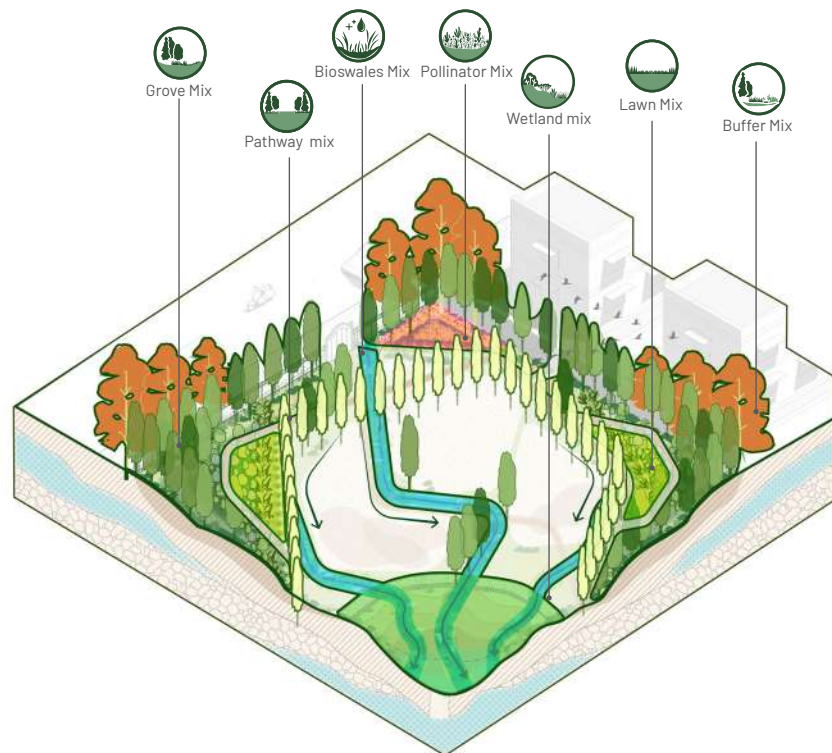


Fig. 2.87. Axon showing various plant mixes in the sponge park

Table 2.10. Different Planting mixes

Planting Mix	Description	Application
 Buffer Mix	A robust, multi-layered, densely planted species in combination of trees, shrubs & creepers to buffer from the noise & air pollution.	Along the park edge for compound wall (between the park & the road) and any of the 2 zones within the park as required
 Pathway Mix	A multi-layered combination of indigenous trees of different species helps establish a viable community through the trails	Along all the pathways
 Grove Mix	A planting mix consisting of old growth climax stage species with different understory species. The species present are distributed in two ways – they occupy different areas of ground (they are distributed horizontally), and their canopies occupy different levels above the ground (they are distributed vertically).	Minimum one Grove mix in a Sponge Park
 Pollinator Mix	An intense combination of diverse flowering plants creates one-of-a-kind sensory experiences in certain public spaces. This planting mix can have non-invasive exotic plants, which require supplementary maintenance.	Intermediate pockets with pollinator mix to create habitats
 Lawn Mix	Throughout the sponge park, a multilayered mixture containing multiple grass species is dispersed to facilitate easy water percolation towards groundwater during floods.	Near the usable / functional areas such as playcourts, kids play area, open areas
 Bioswales Mix	A diverse array of moist soil-loving plants arranged in layers, chosen for their individual soil moisture tolerance levels	Across the Sponge Park for conveyance of water from highest point to lowest point
 Wetland Mix	A diverse range of species that are tolerant to drought and love water, mostly marking the locations of seasonal water bodies.	Lowest point of the site

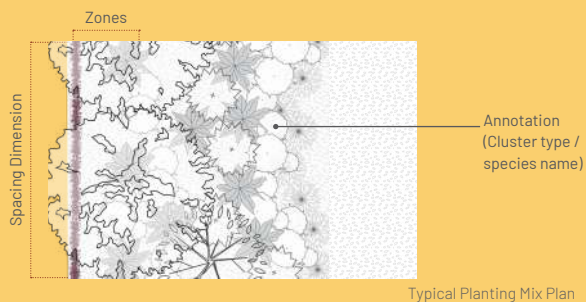
How to read Plant mixes ?



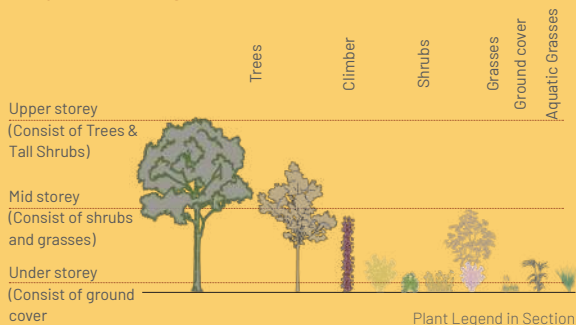
Name of the Plant Mix

- This section gives the clear description of the titled plant mix.
- This provides an in-depth explanation regarding how to plant the specified mix.
- This gives detailed instructions on where to plant the designated combination.
- Chapter to be read with maintenance chapter & annexure

ii. Typical Planting Plan



iii. Typical Planting section



Composite of species Percentage of various species combination
% Trees + % Shrubs + % Lawn (Annexure pg no.)

Maintenance level Maintenance needed for plant mix
(Maintenance pg no.)

Irrigation Demand Amount of watering needed for the plant mix

Spacing & Massing Plant spacing is depends on a number of variables

Lighting Lighting required that is adequate for humans & less harmful to the flora & fauna

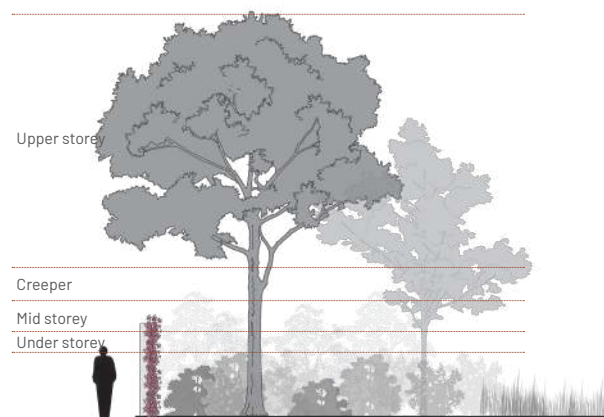
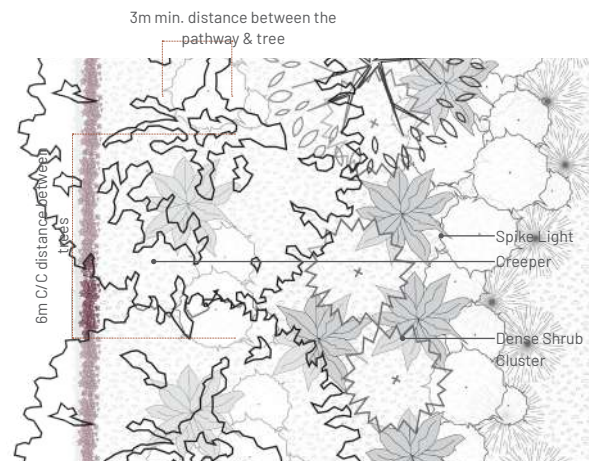
Plant Species Required species for the mix. To be refer with plant list (Annexure pg no.)

Types of Plant mixes



Buffer Mix

- A robust, multi-layered, densely planted species is a combination of trees, shrubs & creepers.
- It is used exclusively along the periphery of the park to provide a climatic buffer (heat mitigation, noise & air pollution) that comes from the neighbourhood. Its width varies from 6 - 9 m. It provides visual connect with park but blocks physical accessibility for safety.
- It not a public amenity but serves as an ecologically rich continuous green corridor.



Composite of species 30% Trees + 50% Shrubs + 20% Creeper

Maintenance level

Irrigation Demand

Spacing & Massing Trees at min. 6m C/C.

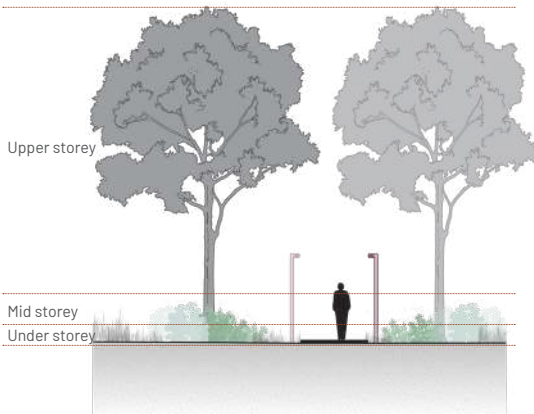
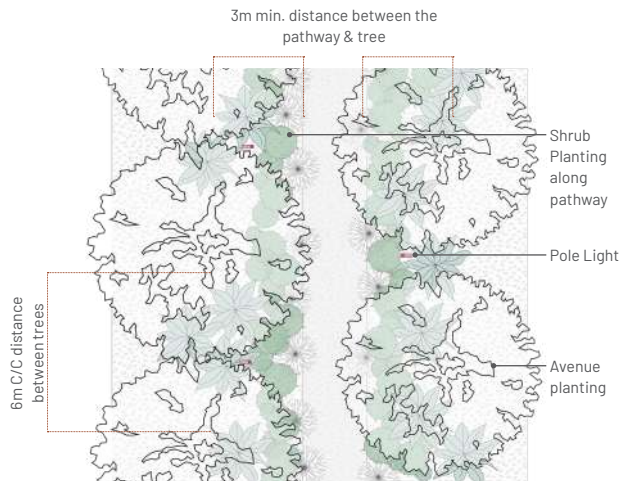
Lighting Lighting the biofence edge for safety

Plant Species *Pongamia pinnata*, *Murraya paniculata*, *Passiflora edulis*



Pathway Mix

- A layered combination of indigenous trees of different species helps establish a viable community through the trails.
- Plantation of avenue trees with shrubs to shade the pathway & add to the aesthetic.
- A minimum of 3m distance has to be left from the pathway so that the tree growth can spread without harming the pathway.



Composite of species 40% Trees + 30% Shrubs + 30% Grasses

Maintenance level ● ● ● ○ ○

Irrigation Demand ● ● ● ○ ○

Spacing & Massing Trees to be planted at 6m C/C

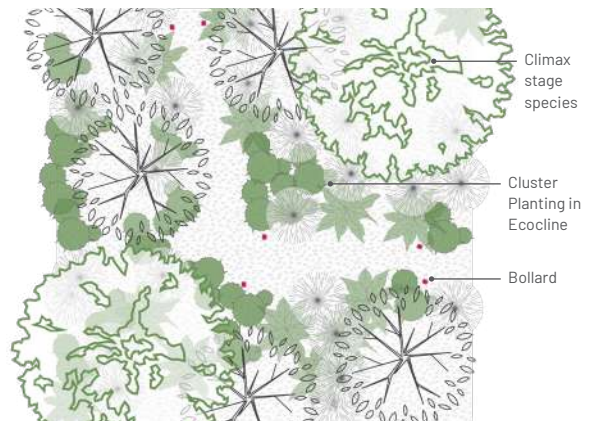
Lighting Pole light along the pathway

Plant Species *Azadirachta indica*, *Alpinia purpurea*



Grove Mix

- A layered combination of indigenous trees of different species helps establish a viable community through the trails.
- Plantation of avenue trees with shrubs to shade the pathway & add to the aesthetic.
- A minimum of 3m distance has to be left from the pathway so that the tree growth can spread without harming the pathway.



Composite of species 40% Trees + 40% Shrubs + 20% Grasses

Maintenance level ● ● ○ ○ ○

Irrigation Demand ● ○ ○ ○ ○

Spacing & Massing Plant spacing is depends on a number of variables

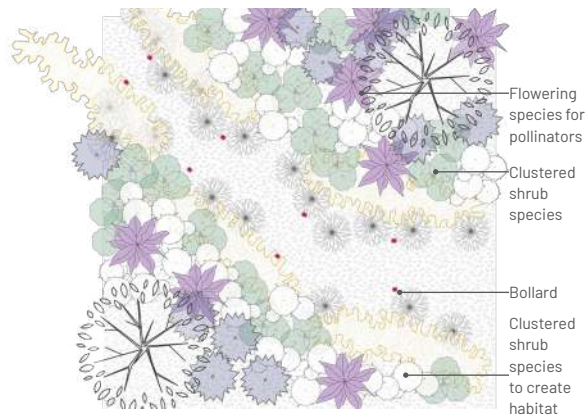
Lighting Bollard lighting at the entrances and centre

Plant Species *Ficus hispida*, *Senna auriculata*, *Ocimum sanctum*



Pollinator Mix

- An intense combination of diverse flowering plants creates one-of-a-kind sensory experiences in certain public spaces. This planting mix can have non-invasive exotic plants, which require supplementary maintenance.
- This plant mix will attract a lot of pollinators due to their colours & fragrance. This mix is dominant by various shrubs planted in different levels based on their height & aesthetic.

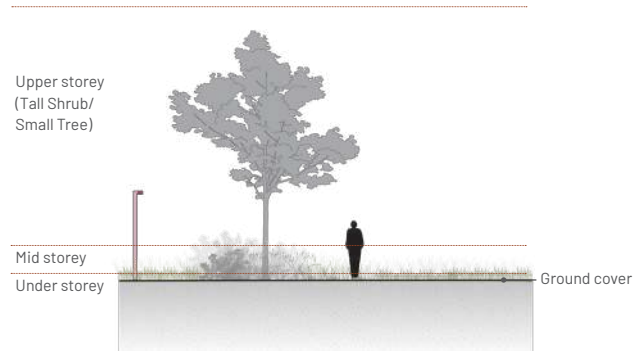
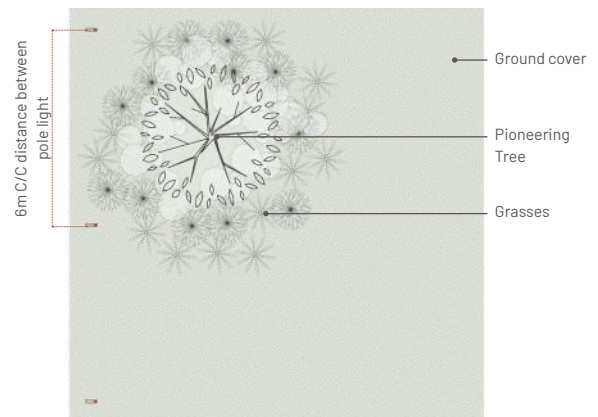


Composite of species	25% Trees + 50% Shrubs + 25% Grasses
Maintenance level	● ● ● ○ ○
Irrigation Demand	● ● ● ○ ○
Spacing & Massing	Plant spacing is depends on a number of variables
Lighting	Bollard light along the pathway
Plant Species	<i>Hibiscus tiliaceus</i> , <i>Barleria cristata</i>



Lawn Mix

- Throughout the sponge park, a multilayered mixture containing multiple grass species is dispersed to facilitate easy water percolation towards groundwater during floods.
- This mix is the most useable area for the public. It would show a seasonal character where the grasses will become dry during summer & regenerate during monsoon.
- It will also need maintenance to avoid any successive species from growth so as to maintain its character.



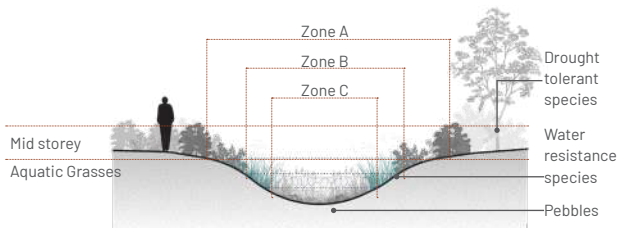
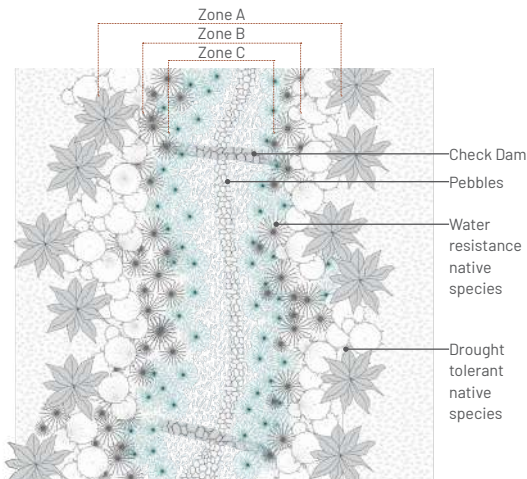
Typical planting Mix section

Composite of species	20% Trees + 20% Shrubs + 60% Lawn
Maintenance level	● ● ● ○ ○
Irrigation Demand	● ● ○ ○ ○
Spacing & Massing	Plant spacing is depends on a number of variables
Lighting	Pole light on the periphery of the lawn area
Plant Species	<i>Cynodon dactylon</i>



Bioswales Mix

- A diverse array of moist soil-loving plants arranged in layers, chosen for their individual soil moisture tolerance levels.
- It has 3 zone - Zone A has drought tolerant species that has minimal impact from water inundation.
- Zone B has water resistance species that can survive during flooding, while zone C are species that thrive in high moisture areas.



Composite of species 10% Trees + 40% Shrubs + 40% Grasses

Maintenance level ● ● ● ○ ○

Irrigation Demand ● ○ ○ ○ ○

Spacing & Massing Plant spacing is depends on a number of variables

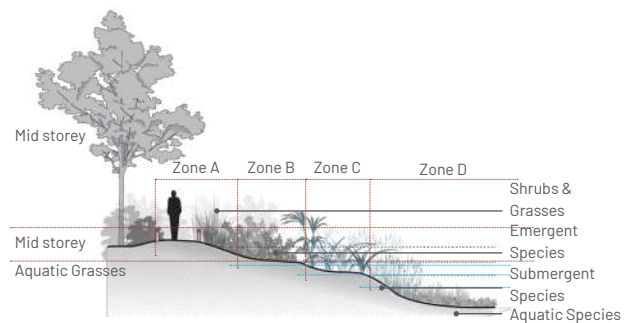
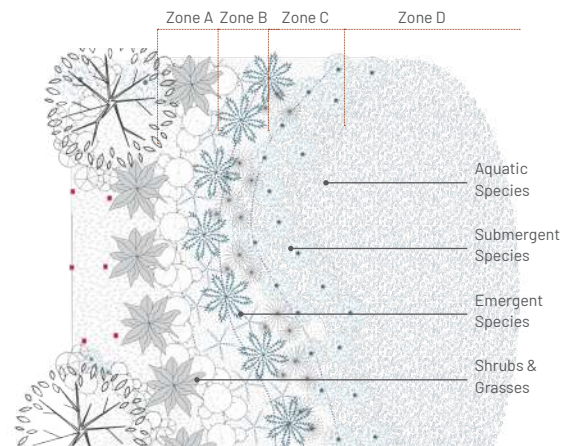
Lighting -

Plant Species *Canna indica*, *Eclipta prostrata*



Wetland Mix

- A diverse range of species that are tolerant to drought and water inundation, mostly marking the locations of seasonal water bodies.
- This mix has 4 zones with shrubs & grasses on ground level, emergent, submergent & aquatic species in the water body.
- These species filters & stores the storm water, creates habitats for aquatic species & a community amenity.



Composite of species 15% Trees + 25% Shrubs + 60% Grasses

Maintenance level ● ● ● ○ ○

Irrigation Demand ● ○ ○ ○ ○

Spacing & Massing Plant spacing is depends on a number of variables

Lighting Bollard light along the bund edge

Plant Species *Nymphoides ssp.*, *Canna indica*, *Vetiver*



S.4. Amenities and Social Facilities

1. Inclusion And Safety

The objective of intentional planning and development of sponge parks is that they accommodate and welcome people of all ages, abilities, and backgrounds, while promoting equitable access, participation, and enjoyment for everyone, regardless of physical or cognitive limitations.

- Ensure that park features, amenities, and layouts are usable by people of diverse abilities and needs without the need for adaptation or specialized equipment.
- Application of inclusive pathways, entrances, seating areas, and amenities to eliminate physical barriers and promote equal access for everyone in sponge parks
- Design parks to be safe and comfortable for all users, including children, seniors, individuals with disabilities, and caregivers.
- Play environments in sponge parks are created that offer diverse and inclusive play opportunities for children of all abilities, including sensory-rich experiences, adaptive equipment, and accessible play structures.
- Calm and quiet places are created within the park for individuals who may require sensory retreats or relaxation
- Ensure compliance with accessibility standards and regulations, or equivalent guidelines in other regions, to uphold legal requirements for equitable access.

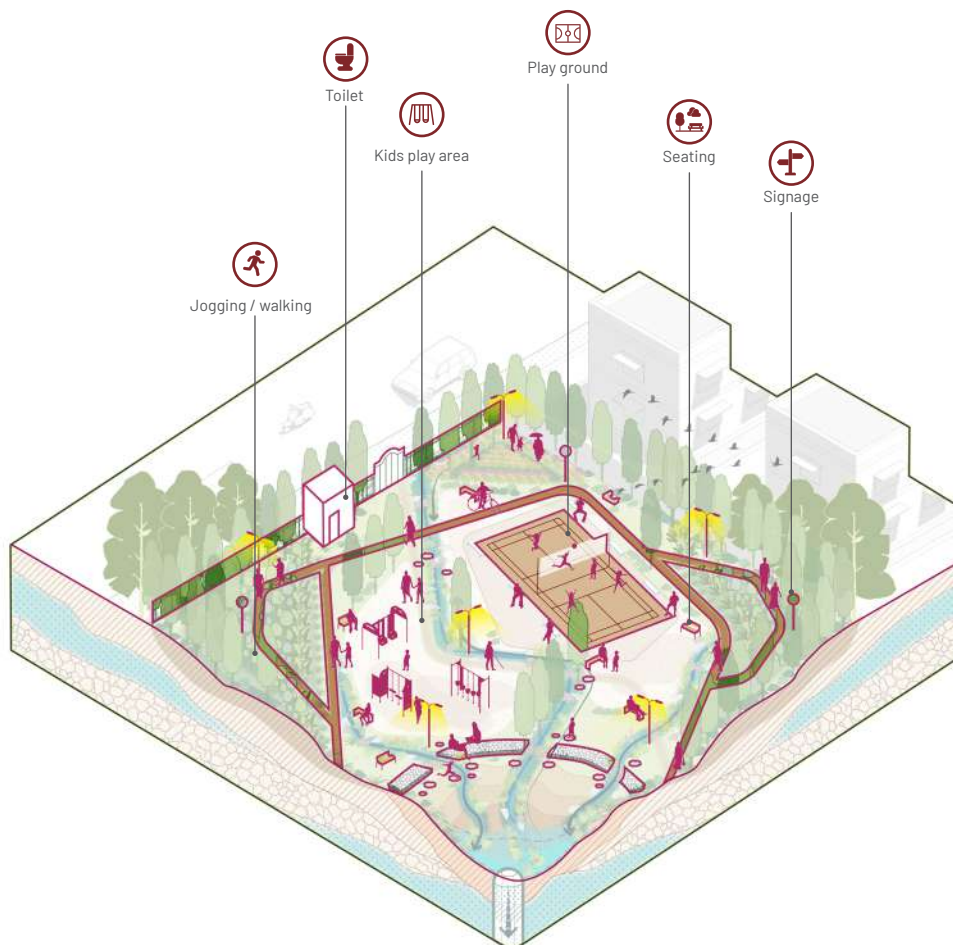


Fig. 2.88. Axon showing various social amenities in the sponge park

Table 2.12. Different social amenities

Amenities	Typology	Descriptions	Advantages	Adjacencies
Entrances 	   	Entrances are the portals to nature play and learning, with naturalized entrance designs can convey positive messages to attract visitors and put them at ease.	- Creates sense of arrival and departure - Acts as transition zone - Serves as a gathering and socializing setting	Entrances can be designed next to relaxation spaces like seating and shady structures
Pathways 	   	Pathways function as a space's arteries, regulating human energy flow along primary, secondary, and tertiary scales navigating throughout the sponge park.	- Provide flat terrain that is easy to navigate and has an accessible surface. - Offer less direct, narrow routes - Slanted enough to retain a sense of exploration	Pathways connect to different components of the sponge parks and also acts as a setting boundaries
Signage 	   	A key aspect of pathway settings can be signage. They facilitate a sense of inquiry and revelation by offering hints and data to improve the learning process.	- Provide communication system of information that can be easily read and understood by people - communicating clear directions inside the park.	Should be displayed at every entry level of the park as well in some cases of spots which act as children temporary exhibits.
Kids Play area 	   	A play area is a space created, usually outside, to give kids an environment that encourages play.	- Improves the physical, social and emotional wellbeing - Enhances and attracts more children to come to the sponge parks	The kids play area should be ideally placed near seatings or shade structures
Gym 	   	The gym is a free time where community members can use the gym to run laps, and engage in fitness stations, and other activities.	Exercises in an open gym provide you greater flexibility and freedom during your workout, which can help you get fitter and feel better overall.	The gym could be placed adjacent to the kids play area with the jogging and walking trail crossing across it.
Seatings 	   	Seatings in the park draw people and activity while improving people's sense of social comfort.	- Seatings provide social comfort - It can aid in promoting impromptu social gatherings and activities.	Seatings should be placed in the sponge park where more of social interactions happens
Lighting 	   	Lighting in parks plays a crucial role in enhancing safety, accessibility, usability, and aesthetics, especially during evening hours	- Aids safety and security to the park - Brings in clear accessibility through the sponge park even during nights	Lighting should be done near pathways, water features and special components
Jogging Walking Trails 	  	Pathways for recreational activities such as running, walking, jogging, and biking	Brings in more interaction among the people	Trails should be set around the park
Toilets 	  	Seatings in the park draw people and activity while improving people's sense of social comfort.	- Seatings provide social comfort - It can aid in promoting impromptu social gatherings and activities.	Places that have activity are good places to set up a seating especially where people observe each other
Play grounds 	  	Seatings in the park draw people and activity while improving people's sense of social comfort.	- Seatings provide social comfort - It can aid in promoting impromptu social gatherings and activities.	Places that have activity are good places to set up a seating especially where people observe each other

1. Accessibility and Legibility

Accessibility of a sponge park is designed with features that ensure equitable access and usability for people of all ages and abilities, including those with disabilities or mobility challenges. Creating an accessible sponge park environment involves application of design considerations, and implementation of features that promote inclusivity and accommodate diverse needs.

Indicators for better accessibility of sponge parks

- The pathways and trails that are wide, smooth, and free of obstacles to accommodate wheelchairs, strollers, and individuals with mobility aids
- Integrating sponge parks with the benches, picnic tables, or seating areas that are stable and have sufficient space around them to accommodate wheelchairs and assistive devices.
- Ensure that restrooms, changing facilities, and amenities are accessible to people with disabilities, including features such as grab bars, accessible sinks, and spacious layouts
- Incorporate safety features such as emergency call stations, accessible emergency exits, and clear evacuation routes that are accessible to all park users.
- Ensure that pathways and gathering areas remain well-lit and free of hazards to enhance safety for nighttime use.



Fig. 2.89.Reference - Accessibility Compliance

2. Diverse Programming and Spaces

A key aspect of pathway settings can be signage. They facilitate a sense of exploration and revelation by offering hints and data to improve the learning process. In order to achieve the requirements for functional legibility, the layout, typographic style, and materials utilized should all mesh well with the surrounding environment.

Signs are a vital source of information for caregivers seeking directions to destinations and pathways. Some common types of signage are wayfinding signage, advertising signage, safety signage, informational signage or educational signage, regulatory signage, identification signage and digital signage. In the proposed sponge parks informational signage / education signage boards are placed to present general information about the facilities provided as well as permanent features of the site.

Advantages

- Establish a system of information communication that is simple enough for people of all ages, cultural backgrounds, and skill levels to read and understand.
- Clear directions to various locations (settings) and useful information that satisfies strict functional requirements, such as text size for accessibility and wayfinding, should be communicated.



Fig. 2.91.Gender inclusive programming for women and children



Fig. 2.90.Reference - Clear signage with directions



Fig. 2.92.Reference - Shaded, well-lit gathering spaces within large open spaces

3. Gender Inclusive Adventure / Nature Play

- Play equipments for all development ages with options that are accessible to handicapped children
- Playgrounds with universal motifs and natural features to encourage gender-neutral nature play



Fig. 2.93.Reference - Nature play structure



Fig. 2.94.Reference - Nature play structure

Lighting for Safety and Biodiversity

a. Pathway Lighting

- Install low-level bollard lights or pathway luminaires along walkways and trails to guide pedestrians and enhance visibility at ground level.
- Use solar-powered or low-voltage LED fixtures for eco-friendly pathway lighting.

b. Amenities Lighting

- Use pole-mounted lighting to provide illumination for gatherings and recreational activities in open areas, plazas, playgrounds, and picnic areas.
- Select lighting fixtures with broad beam angles to provide uniform illumination over vast spaces.

c. Water Feature (BGI) Lighting

- Use spotlights to add dramatic effects and improve the aesthetic appeal of water features, like retention ponds, constructed wetlands
- Use color-changing lighting to create eye-catching displays and to perceive seasonal sense.

d. Special feature (BGI) Lighting

- For certain park features like waterplaza, sunken courts, or event areas, take into account specialty lighting.
- Include movable or temporary lighting options for activities and events over the seasons.

e. Natural Lighting Integration

- To create a well-balanced evening atmosphere, preserve natural darkness and enhance park lighting with natural illumination from nearby urban areas.



Fig. 2.95 .Reference - Biodiversity



Image Credit - Anna Tower Park

3 IMPLEMENTING SPONGE PARKS

- 3.1. Financing Sponge parks
- 3.2. Procurement of Sponge parks (S, M, L, X)
- 3.3. Constructing Sponge Parks

3.1. Financing Sponge Parks

3.1.1. Financing Adaptation in India

India requires urgent investment in climate adaptation to support economic growth and sustainable development. The government has made efforts to finance adaptation actions, but national investment needs are significant and expected to increase.

1. Key Findings:

- India lacks a unified framework for climate risk assessment, particularly focusing on future climate projections and dynamic hazard-exposure-vulnerability interactions.
- Harmonizing existing assessments could provide a consistent basis for climate risk understanding and guide adaptation investments.
- There is no systematic method to evaluate how development programs address climate risks, hindering the distinction between adaptation and development efforts and tracking adaptation-specific funding.
- Despite systemic challenges, there are national and state-level plans, policies, and institutions for climate adaptation, although progress varies among states.
- Based on State Action Plans on Climate Change (SAPCCs), six states alone have an annual adaptation investment need for 2021-30, highlighting substantial state-level adaptation requirements.
- The upcoming Finance Commission for the 2026-27 period should consider including adaptation-related interventions in the criteria for distributing funds to state governments.
- Introduce time-bound climate-incentivized borrowing limits that reflect state-specific climate risks and vulnerabilities to increase financing accessibility for more vulnerable states.
- Develop comprehensive green finance data to understand investment needs based on sectoral targets, national missions, and action plans for climate change, facilitating effective solutions and progress measurement.
- Establish a template for tracking and tagging adaptation-related expenditure to enhance transparency and inform decision-making.
- Utilize financial mechanisms like Public-Private Partnerships

(PPPs) and blended financing, offering assurances of minimum returns or revenues to attract private capital for climate adaptation.

- Create a Climate Risk Exposure and Adaptation Projects database and project preparation facilities to reduce search and transaction costs for private financiers, encouraging investment in adaptation projects.

2. Sources of State Adaptation - Related Finance

i) Role of Finance Commission (FC)

- The Finance Commission (FC), an established constitutional body that convenes every five years, proposes the allocation of taxes between the central and state governments, as well as their distribution among individual states.
- The transfers allocated by the FC include tax devolution and other forms of grants.
- Tax devolution, determined by the FC, represents the primary method of unconditional fiscal transfers to the states.

ii) Climate change considerations in recent FC transfers to states

- The 14th Finance Commission (2015-16 to 2019-20) and the 15th Finance Commission (2020-21 to 2025-26) have included climate change considerations, particularly through forest conservation, as criteria in determining tax devolution to states.
- Additionally, the 15th Finance Commission recommended the establishment of two funds i.e. National Disaster Risk Management Fund (NDRMF) and State Disaster Risk Management Fund (SDRMF) to enhance support for disaster preparedness in vulnerable areas, supplementing the existing Disaster Response Fund.
- Fiscal transfers to state governments under the SDRMF are influenced by factors including states risk profiles, which are determined based on the Disaster Risk Index, evaluating the likelihood and severity of events such as cyclones, droughts, and floods, as well as the states vulnerability levels.

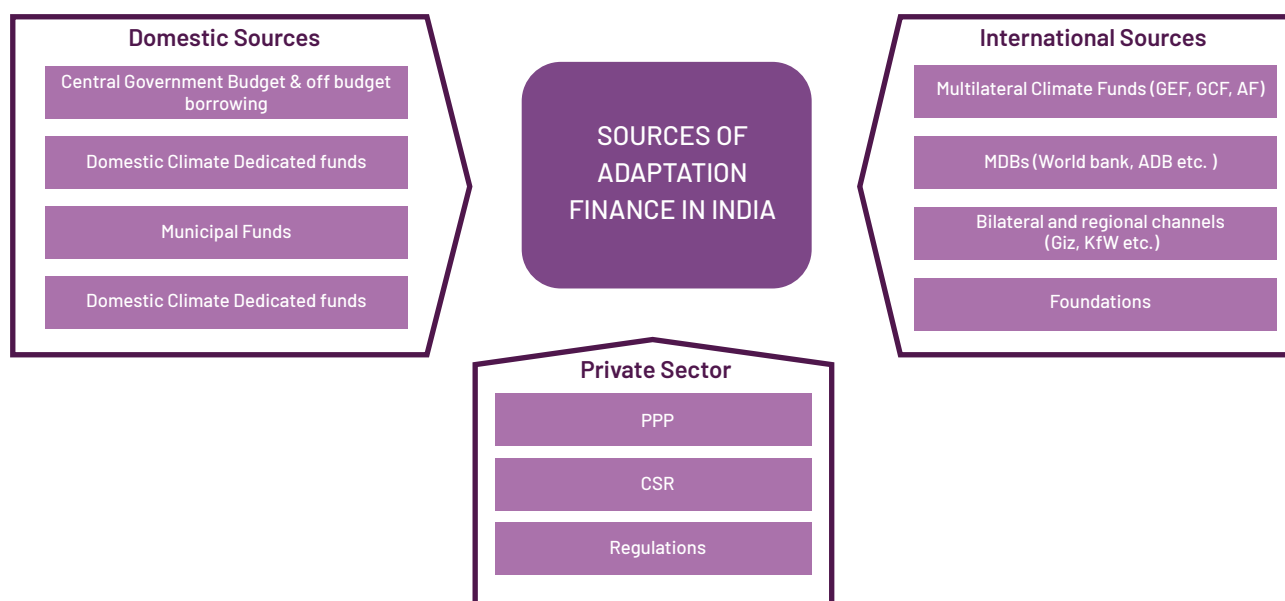


Fig 3.1. Reference - Absence of erosion protection before vegetation

3.1.2. Evaluation of Funding and Financing

This section identifies and evaluates the following creative funding and financing models that can help accelerate investment in infrastructure projects that incorporate resilient design features. The list includes:

1. Multilateral Bonds
2. Municipal Bonds
3. Central government grants
4. State Grants
5. Green / Climate bonds
6. TIF
7. P3s
8. Regional Resilience Trust Funds
9. Impact development fees

1. Multilateral Bonds

- A multilateral funding bond refers to a financial instrument issued by a multilateral development institution or organization to raise funds for development projects and initiatives.
- These institutions, such as the World Bank, Asian Development Bank (ADB), or International Monetary Fund (IMF), provide financial support to multiple countries and regions for various purposes, including infrastructure development, poverty reduction, climate action, and economic stability.

a. Opportunities:

- Multilateral bond funding provides access to a large pool of capital from global investors, including institutional investors and sovereign wealth funds, which can significantly increase the resources available for development projects.
- Multilateral institutions typically benefit from favorable credit ratings, allowing them to issue bonds at lower interest rates compared to individual countries or private entities. This results in lower borrowing costs for member countries accessing these funds.
- Multilateral bonds diversify funding sources for development projects beyond traditional grants and concessional loans, offering flexibility in financing arrangements.
- Bonds issued by multilateral institutions often have longer tenures, providing stable and predictable financing for long-term development initiatives, such as infrastructure projects.
- Multilateral bond funding supports projects with significant development impact, including poverty reduction, climate adaptation, healthcare, education, and sustainable infrastructure, contributing to global development goals.

b. Challenges:

- The creditworthiness of projects or countries benefiting from multilateral bond funding can affect investor perception and the cost of financing, particularly in cases where projects are located in regions with perceived higher risk.
- Heavy reliance on external financing, including multilateral bonds, can increase debt levels for recipient countries, potentially leading to debt sustainability concerns if not managed effectively.
- Multilateral bond financing may involve complex borrowing conditions, including specific eligibility criteria, policy conditions, and reporting requirements, which could pose challenges for borrower countries.
- Borrowing in foreign currencies exposes countries to exchange rate fluctuations, which can affect debt servicing costs and overall financial stability.
- Multilateral bond funding competes with other financing needs and priorities within recipient countries, requiring careful prioritization and coordination to maximize development impact.

- Multilateral bond financing requires robust governance frameworks and accountability mechanisms to ensure transparent use of funds and effective project implementation, which can pose challenges in some contexts.

2. Municipal Bonds

Municipal bonds offer opportunities for funding infrastructure projects without impacting the issuing jurisdiction's overall revenue, but challenges such as debt limitations, referendum requirements, and project alignment with climate resilience goals exist and can affect their use.

a. Opportunities:

- Municipal bonds provide a source of capital for substantial infrastructure projects, leveraging specific revenue streams tied to the financed project.
- Debt service payments for revenue bonds are covered by the revenue generated from the project, ensuring no net impact on the issuing jurisdiction's overall revenue.
- Municipalities have significant experience issuing revenue bonds, making them a familiar and accessible financing option.

b. Challenges:

- Local jurisdictions may face challenges issuing additional debt if they already have significant outstanding debt or a poor credit rating, potentially limiting access to revenue bond financing.
- There is no guarantee that projects financed by revenue bonds will align with climate resilience goals, as these bonds can only finance projects with specific revenue streams.

3. Central Government Grants

Central government grants offer substantial financial support for climate resilience projects, but the application process can be resource-intensive and uncertain in terms of funding outcomes, making them more accessible to larger jurisdictions with greater capacity.

a. Opportunities:

- Central government grants can cover up to 75% of project costs, providing significant financial assistance that can amount to millions of dollars for climate resilience projects.
- Local government staff are generally experienced and comfortable with applying for federal grants, leveraging these opportunities for project funding.

b. Challenges:

- Identifying and applying for federal grants requires significant staffing resources, posing challenges for small governments with limited capacity.
- There is no guarantee that jurisdictions will receive grant funding, and even if awarded, the disbursement process can be lengthy, making these grants suitable primarily for non-time-sensitive projects.

4. State Grants

State grants allow local governments to access state funds for projects, reducing the financial burden on local resources.

a. Opportunities:

- State grants enable local governments to invest in infrastructure projects without fully financing them themselves.
- These grants can be beneficial for projects that may not

secure national-level funding but are competitive at the state level.

b. Challenges:

- State grants often come with restrictions on how funds can be used.
- There's no guarantee of receiving funding, and disbursement of awarded grants can be slow, making them non time sensitive project

5. Green/Climate Bonds

- Structurally similar to General Obligation (GO) bonds and backed by the taxing authority of the municipality.
- Public authorities' ability to issue debt is constrained by debt ceilings and credit ratings.

a. Opportunities:

- Green/climate bonds can generate significant revenue and are relatively straightforward to issue.
- They serve as effective marketing tools for projects, presenting them as environmentally friendly initiatives and enhancing the city's image and reputation.

b. Challenges:

- Green bond issuance requires certification from a third-party rating agency, increasing the cost of capital.
- Certification is a marketing tool that attracts investors interested in green investments and requires annual updates to investors about project details.
- Although green bonds theoretically offer lower yields than traditional municipal bonds, current investor demand may not reflect this advantage.
- However, this may change as international investors face requirements to invest in responsible investments, increasing demand for green bonds.

6. Tax Increment Financing (TIF)

- TIF captures any property tax revenue increases within specific geographic boundaries for a designated purpose.
- TIF districts can issue debt based on projected property value increases, using revenue generated from increased property values to pay for incurred debt.
- TIF can contribute to "climate gentrification," displacing long-term residents as property values rise.
- Rising property values in TIF districts may attract wealthier residents, altering neighborhood demographics and potentially exacerbating housing affordability issues.

a. Opportunities:

- TIF programs are relatively easy to implement, especially in existing business improvement districts.
- TIF is widely used in Florida to fund streetscaping and could also finance capital projects like storm water management, enhancing district resilience

b. Challenges:

- TIF effectiveness depends on rising property values, which may not occur in climate-vulnerable areas.
- Revenue generated by TIF is uncertain due to potential property value fluctuations, especially in vulnerable areas.
- Opposition from residents due to potential property tax rate increases may impede TIF implementation, requiring voter approval.
- TIF diverts property tax revenue from general funds, impacting overall jurisdictional budgets. However, this may change as international investors face requirements to invest

in responsible investments, increasing demand for green bonds.

7. Public Private Partnerships (P3s)

- P3s are agreements between public and private entities where the private entity undertakes tasks like construction, financing, operation, maintenance, and management of a facility or system.
- A key difference from traditional contracts is the integration of design and construction responsibilities under a "design-build" model.

a. Opportunities:

- P3s transfer project risk to the private sector, often managing it more cost-effectively, lowering long-term costs, and improving service quality.
- They can enable projects in cash-strapped areas by reducing the need for upfront government capital.
- Combining construction and operation under one entity can yield efficiencies, and P3s can deliver innovative projects outside the public authority's expertise.

b. Challenges:

- Private financing is contingent on projects having a revenue stream, limiting the types of viable projects.
- Governments have access to cheaper capital through tax-exempt bonds compared to the private sector.
- Coordination among multiple authorities for large-scale projects can be complex.
- P3 contracts require substantial expertise for negotiation and administration, posing challenges for smaller jurisdictions.

8. Regional Resilience Trust Funds

- Regional resilience trust funds are managed by political appointees and can provide loans or grants for infrastructure projects that mitigate climate risk and benefit the region.
- They are typically initially capitalized using real estate transfer taxes, insurance surcharges, or other mechanisms and aim to become self-sustaining over time

a. Opportunities:

- These funds become self-sustaining, requiring no further public funding after initial capitalization.
- They can provide significant capital for large infrastructure projects and allow cities and public authorities to apply for financing similar to existing loan funds.
- Property owners could access funds for retrofitting projects tied to property deeds, facilitating transferability to new owners.

b. Challenges:

- Establishing a regional entity for the trust fund may involve legal and governance complexities
- The fund must operate independently with a mandate from participating jurisdictions, requiring substantial negotiation among interested governments.
- There may be a collective action problem as contributors to the fund may not receive direct proportional benefits, potentially raising fairness concerns across participating areas.

The above information is sourced from "Financing Climate Resilience Manual"

Evaluation of Funding and Financing Models criteria:

1. Potential to Generate Revenue/Attract Capital:

- Examines whether the model can raise sufficient revenue or attract capital to fund infrastructure projects.
- It also considers if the model relies on revenue/capital generation or alternative mechanisms for project financing.

2. Feasibility:

- Assesses how easily the model can be implemented, considering technical challenges and political complexities that may affect feasibility.

3. Fairness/Efficiency:

- Focuses on whether the funding or financing model ensures that beneficiaries of investments also bear the associated costs.
- It considers whether externalities are internalized to promote fairness and efficiency.

4. Equity:

- Considers whether the distribution of costs aligns with the ability to pay, aiming to avoid exacerbating inequalities through resulting projects.
- This criterion emphasizes fairness and equitable outcomes in project implementation.

Table 3.1. Evaluation of Funding and Financing Alternatives Summary

Creative funding & financing models	Potential Generate Revenue and attract capital	Technical and Political Feasibility	Fairness and Efficiency	Equity
Multilateral Bonds	High	Medium	Low	Low
Municipal Bonds	High	Medium	High	Low
Central government Grants	Medium	Medium	Low	Medium
State grants	Medium	Medium	Low	Low
Green / Climate bonds	Medium	High	Low	Low
TIF	Medium	High	High	Low
P3s	High	Medium	High	Low
Regional Resilience trust funds	High	Medium	Medium	High
Impact development fees	High	Medium	High	Medium

3.1.3. Engaging the Private Sector in BGI and financing

1. Construction and O&M cost reduction benefits

- Cost-benefit analyses (CBA) highlight the advantages of green infrastructure (GI) over grey infrastructure (conventional methods). They show that GI projects generally have:
 - Reduced built capital costs (equipment, installation).
 - Lower land acquisition costs.
 - Decreased external costs imposed on others.
 - Lower operation, repair, maintenance, and replacement costs.
- A survey covering 479 case study areas in the US and Canada revealed that over 44% of respondents believed GI reduced costs, while 31% stated GI costs were comparable to grey infrastructure.
- Life cycle assessments (LCA) are valuable for evaluating all costs (construction, operation, maintenance, disposal) of specific GI interventions.
- They facilitate comparisons between green and grey infrastructure, support economic cases for GI, and measure return on investment.
- An LCA study in India found that although the initial cost of a green building was nearly 8% higher than traditional construction.
- The most common BGI options used by governments, donors, and climate practitioners are outlined.

2. Recommendations

a. Mainstream Green Infrastructure Into Planning Documents

i) Develop a Long-Term GI Plan:

- Create a comprehensive long-term plan for green infrastructure (GI) based on existing planning documents.
- This plan should set goals, prioritize infrastructure investments, address current issues like flooding and aging infrastructure, involve relevant departments/agencies in decision-making, update codes and regulations, identify skill gaps, and outline funding sources for GI projects.

ii) Integrate GI into Department/Agency-Level Plans:

- Ensure that elements of the citywide GI plan are incorporated into department-level policy and action plans.
- This integration should ensure specific GI interventions are planned and budgeted for by departments responsible for areas like Planning, Transportation, Water & Sewerage, Parks and Recreation, and Housing/Buildings.

iii) Include GI in Infrastructure Investment Planning:

- Incorporate GI into city infrastructure investment plans to allocate sufficient funds for GI initiatives alongside other infrastructure projects.

iv) Establish a Monitoring and Evaluation System for GI:

- Develop a monitoring and evaluation system specific to GI interventions within existing infrastructure monitoring systems.
- This system should include indicators assessing climate risk reduction, mitigation benefits, and ecological services provided by GI to support continued GI development and investment.

b. Update Codes To Include Green Infrastructure And Enforce new Regulations

i) Updating Building Codes and Regulations:

- Essential for GI success. Without mandates, little incentive

for change.

- Developing cities must lead in applying standards to public spaces.

ii) Develop and Enforce Storm water Retention Standards:

- Municipalities should require retaining specific precipitation amounts on-site.
- Properties must manage precipitation to prevent storm water entering sewers.

iii) Require GI for Managing Runoff:

- Update regulations to mandate GI use for managing runoff from impervious surfaces.
- Examples include landscaping requirements for parking lots and disconnection of downspouts from sewers.

iv) Institute Storm water Management Fees:

- Implement fees based on impervious surface area to cover storm water management costs.
- Larger landowners pay higher fees, providing revenue for storm water management and GI projects.

v) Introduce Discharge Permit Process:

- Use permits to regulate surface water discharge, including GI requirements for commercial and large developments.
- Aligns with NPDES program goals to reduce runoff and pollutants.

3. Communicate And Demonstrate The Benefits Of BGI

i) Informing Residents and Businesses about BGI:

- Conduct assessments to study feasibility and cost savings in the local context.
- Implement demonstration projects to show how GI works practically.
- Communicate project results to improve public acceptance and buy-in for regulatory changes.

ii) Building an Evidence Base:

- Conduct economic and environmental analysis to compare green and gray infrastructure locally.
- Use Cost-Benefit Analysis (CBA) during investment planning to compare costs and benefits.
- Assess non-climate benefits like ecological services, biodiversity conservation, and public amenities.

iii) Demonstrating GI Benefits through Pilot Projects:

- Partner with donors or establish Public-Private Partnerships (PPPs) to develop and test GI initiatives.
- Partnerships reduce risk, accelerate implementation, and provide valuable experience. Successful pilot projects serve as models and build the business case for broader GI adoption.

iv) Disseminating Information about GI:

- Develop community involvement strategies and awareness initiatives for inclusive public engagement.
- Create communication campaigns articulating GI benefits and opportunities.
- Engage businesses and establish public-private networks for effective communication.

Table 3.2. BGI Components and Benefits

Task	Description	Climate Resilience Benefits	Carbon Sequestration & Air Quality Benefits	Water Management Benefits
Bioswales	Vegetated linear depression or trench designed for the collection, conveyance, infiltration and filtration of storm water runoff.	- Increased groundwater infiltration - Reduced heat island effects from grey infrastructure - Flood mitigation - Reduced pressure on existing water management infrastructure - Improved biodiversity and wildlife habitats	- Carbon sequestration from vegetation. Reduced energy needs for managing storm water (e.g., pumping, treatment) - Removal of air pollutants such as ozone, nitrogen dioxide, sulfur dioxide and particulate matter. Water pollution abatement through filtration of storm water runoff	- Reduced runoff from precipitation - Increased groundwater infiltration - Flood mitigation. Reduced erosion during storms - Reduced pressure on existing water management infrastructure - Reduced sedimentation of streams and rivers. Water pollution abatement through filtration of storm water runoff
Bio retention areas	Storm water treatment process for removing pollutants and sediment from storm water using a system of ponding areas with vegetation, soil, sand gravel and organic materials,	- Increased groundwater infiltration - Reduced heat island effects from grey infrastructure - Flood mitigation - Reduced pressure on existing water management infrastructure - Improved biodiversity and wildlife habitats	- Carbon sequestration from vegetation - Reduced energy needs for managing storm water (e.g., pumping, treatment) - Removal of air pollutants such as ozone, nitrogen dioxide, sulfur dioxide and particulate matter and Water pollution abatement through filtration of storm water runoff	- Reduced runoff from precipitation - Increased groundwater infiltration - Flood mitigation - Reduced erosion during storms - Reduced pressure on existing water management infrastructure - Reduced sedimentation of streams and rivers - Water pollution abatement through filtration of storm water runoff
Native Landscaping	Landscaping that uses native plants – including trees, shrubs, ground cover and grasses – indigenous to the geographic area being planted.	- Reduced heat island effects from paved areas - Increased groundwater infiltration, Flood mitigation - Reduced water demand for irrigation - Improved biodiversity and wildlife habitats	- Carbon sequestration from planted materials and vegetation - Reduced energy needs for managing storm water (e.g., pumping, treatment) - Reduced energy needs for irrigation	- Increased groundwater infiltration - Flood mitigation - Reduced pressure on existing water management infrastructure - Reduced water demand for irrigation
Urban Wetland	Urban or periurban transitional areas between terrestrial and aquatic ecosystems where the water table is usually at or near the surface or the land is covered by shallow water	- Improved watershed management - Increased groundwater infiltration, Flood mitigation - Reduced heat island effects from paved areas - Reduced pressure on existing water management infrastructure - Improved biodiversity and wildlife habitats	- Improved watershed management - Increased groundwater infiltration, Flood mitigation - Reduced heat island effects from paved areas - Reduced pressure on existing water management infrastructure - Improved biodiversity and wildlife habitats	- Reduced erosion during storms - Reduced flooding from storm surges - Improved watershed management - Increased groundwater infiltration - Reduced pressure on existing water management infrastructure - Water pollution abatement through filtration of storm water runoff
Rainwater Harvesting	Collection and storage of rainwater through a variety of techniques such as cisterns (tanks), check dams, ponds, open wells and groundwater aquifer recharge shafts.	- Increased water security and reduced impact of droughts - Flood mitigation - Increased ground water infiltration - Reduced pressure on existing water management infrastructure - Improved agricultural yields when linked to irrigation systems - Reduced saltwater intrusion and Reduction of spikes in water prices for individuals and companies	- Reduced energy needs for managing storm water (e.g., pumping, treatment) - Reduced energy needs for water provision and irrigation	- Reduced runoff from precipitation - Flood mitigation - Increased ground water infiltration - Reduced pressure on existing water management infrastructure - Reduced water demand from municipal water sources

3.2. Procurement for Sponge parks

Procuring Services and Goods

Sponge Parks can provide a wide range of benefits when they are planned, designed, implemented and maintained well. However, there can be wide range of complex challenges that have to be addressed at various stages of the lifecycle in order for Sponge Parks to fulfill their environmental functions and social needs.

This manual has considered size as a relatively good proxy for complexity for the sake of simplicity. As such, the manual is meant to provide enough guidance for GCC to plan and design small (S) Sponge Parks for tendering where only the procurement of a contractor is needed to construct the Sponge Park and maintain it for 2 to 5 years as per the contract. After this point the Sponge Park comes under the maintenance purview of GCC's Parks Department or from another procured maintenance contractor. While small and simple Sponge Parks only require procurement

for construction, the realisation of more complex parks will require procurement at multiple stages of the lifecycle (Refer to Figure 3.2.)

Consulting services for the Project Planning of a large number of Sponge Parks within the prioritisation framework of the GCC as provided in this manual can be a good use of procurement to identify bankable projects based on comprehensive geotechnical, hydrological, environmental, and social assessments. This procurement can also engage social experts and planners who can engage local communities for feedback (Refer to Table 3.3). The GCC currently does not have the technical capacity for extensive studies or community engagement to carry out this exercise without a qualified consulting firm or a consortium of experts.

With large and special case Sponge Parks, the complexity of integrating social facilities and blue-green infrastructure components



Fig 3.2. Sustainable infrastructure framework life cycle



Fig 3.3. Procurement need by lifecycle for simple and complex Sponge Park projects

Table 3.3. Procurement Requirements by Infrastructure Lifecycle and Sponge Park Typology

Lifecycle	Expertise	Open Tender		Empanelled / Invited	
		LCS	QCBS	LCS	QCBS
1. Project Planning	Surveyors, Hydrologists, Geologists, Urban / Landscape Planner, Social Scientists	• S, M	• S, M, L, X		
2. Concept Design through Detailed Design	Landscape Architects, Architects, Urban Designers, Hydrologist, Civil, MEP, Drafting		• L, X		• M, L
3. Construction	Contractor, Field Engineers, Site Manager, Landscape Architect, Project Manager, Construction Workers				
4. Operation and Maintenance	Contractor, Horticulturist, Gardeners, Cleaners, Repair Crew			• M	• M, L, X

catering to the community needs and hydrological demands of the surrounding catchment area will require multidisciplinary expertise in the Concept Design phase. Multidisciplinary consulting firms with expertise ranging from landscape architecture to hydrology to civil engineering can provide services that cover Concept Design and Detailed Design with good for tendering documents that are used to solicit bids from Construction contractors.

A different contractual engagement based on project cost can engage the multidisciplinary firm to oversee the implementation and provided good for construction drawings as needed. Since the capacity of local contractors to implement BGI components is limited, the manual recommends having landscape architects and civil engineers monitor construction progress.

Quality Based Empanelled Providers and Sustainable Procurement

The manual recommends the GCC set up an **empanelment of consultants, contractors, and vendors** who can deliver on the quality and specifications that Sponge Parks demand for the specific lifecycle stages of design (concept and detailed), construction, and operation and maintenance. This can include consulting firms with prior experience in public open spaces and nature-based solutions and vendors who can meet the

Sustainable procurement incorporates economic, environmental, social sustainability considerations throughout the lifecycle of the project. As per the World Bank's guidance on investment project financing, sustainable procurement develops the market's capacities to deliver innovative and sustainable solutions like Sponge Parks and leads to cost savings on a long-term basis by applying a lifecycle approach to procurement.

This requires identifying the priorities of financing or implementing authorities, understanding the expected sustainability benefits of the project, selecting a procurement process design that ensures the selection of qualified service providers or vendors that prioritise sustainability, evaluating bids from a quality of sustainable solutions and whole-of-life cost perspective, setting up KPIs to measure sustainability outcomes, and assessing the sustainability outcomes and benefits achieved from the procurement process,

3.3. Construction for Sponge parks

3.3.1. General Construction notes

1. General Constructions issues

a. Programming BGI Construction:

- Consider BGI construction throughout site development.
- Subsurface drainage is usually first, but final BGI construction should occur later to avoid sedimentation and over-compaction issues. Method statements and pre-construction planning are essential for successful BGI completion.

b. Pollution and Sediment Control:

- Prevent construction runoff from entering BGI or flowing off-site.
- Construction runoff is sediment-laden and can clog and pollute BGI components. Avoid using certain BGI (e.g., pervious surfaces) for managing construction runoff.

c. Access and Storage Areas:

- Paved areas are typically constructed early for access and storage.
- If using pervious surfaces, construct pavement at the end of development to prevent clogging.

d. Skills and Awareness:

- Contractors and workers should understand BGI components and appropriate construction practices.
- Conduct "toolbox talks" to increase awareness among workers.

e. Infiltration System Protection:

- Use hardcore for structural purposes below impermeable layers, but avoid if infiltration is intended.
- Implement exclusion zones for construction traffic over infiltration surfaces to prevent compaction.

f. Landscaping Practices:

- Prioritize aesthetics and attention to detail in BGI landscaping.
- Consider seasonal planting requirements and prevent overland sediment wash-off.

g. Erosion Control:

- Fully stabilize vegetated BGI with planting or temporary erosion protection before allowing runoff flow.

h. Construction Inspection and Handover:

- Include inspections at key stages and completion to ensure BGI are constructed per design.
- Produce as-constructed drawings and conduct surveys to verify design levels.

i. Specifications and Bills of Quantities:

- Highlight key aspects impacting BGI operation and performance in project specifications. Tailor specifications and bills of quantities based on the construction contract

2. Construction Programming

Effective construction programming for BGI involves careful planning and sequencing of activities to protect the environment, BGI components, and promote successful vegetation establishment. This approach minimises erosion, sedimentation, and the need for post-construction rehabilitation works.

a. Importance of Effective Construction Programming:

- Protect the receiving environment and BGI components during construction.

- Preserve natural infiltration characteristics of site soils and subsoils. Ensure proper conveyance and storage of runoff without erosion or sedimentation.
- Promote healthy vegetation establishment and habitats.
- Accommodate necessary inspections during construction.

b. Construction Access and Initial Activities:

- Exercise care to avoid damaging infiltration surfaces, trees, and designated buffer zones.
- Install sediment basins and traps before major earthworks/groundworks to contain sediment.
- Use runoff control measures to divert water and prevent damage to drainage systems.

c. Earthworks/Groundworks and Erosion Control:

- Start clearing and earthworks only when erosion control measures are in place.
- Apply surface stabilisation measures promptly to prevent erosion during development.
- Delay construction of pervious surfaces and landscape works until later stages.

d. Stabilisation and Rehabilitation:

- Stabilise disturbed areas with temporary measures and apply permanent stabilisation promptly.
- Remove unstable sediment from traps and incorporate it into topsoil.
- Rehabilitate infiltration and filtration surfaces exposed during construction.

e. Commissioning and Rehabilitation:

- Commission permanent BGI components after construction completion.
- Rehabilitate temporary BGI components used for drainage or other purposes.
- Minimise the need for rehabilitation by careful construction planning.

f. Planning and Sequencing:

- Outline all land-disturbing activities needed for the project and sequence erosion control practices.
- Pay attention to site access, material storage, interim site drainage, and surface protection.

g. Challenges with Small Sites and Permeable Surfaces:

- Small sites with extensive permeable surfaces require careful planning to avoid damage.



Fig 3.4. Reference - Absence of erosion protection before vegetation

3. Construction method statements

The construction method statement for BGI serves to guide safe and compliant construction practices, address unique BGI requirements, and ensure effective communication and training for successful implementation. This document plays a crucial role in managing construction risks and achieving quality standards in BGI projects.

a. Purpose of Construction Method Statement (BGI):

- Formalize responsibilities for completing BGI work.
- Define approach, processes, and program for constructing and stabilizing BGI.
- Identify any unique items or methods required for BGI construction.

b. Components of BGI Construction Method Statement:

- Nature of work details, including site plans and full scheme drawings.
- Consents, reinstatement requirements, and access points.
- Site-specific ecological issues and water quality considerations.
- Proposed strategy for sediment control and site drainage during construction.

c. BGI Construction Safety and Compliance:

- Ensure safe systems of work and address health and safety hazards.
- Manage risks associated with BGI construction, which may differ from conventional practices.

d. Impact of Other Construction Activities on BGI:

- Highlight requirements to protect BGI components during construction.
- Ensure adherence to specific BGI requirements, like maintaining drop from hard surfaces to grassed areas.

e. Role of Construction Method in Inspection and Quality Assurance:

- Guide adoption bodies in planning construction inspections. Implement comprehensive quality assurance to ensure minimum workmanship standards.
- Communicate BGI design requirements and operational aspects to site staff and subcontractors.

f. Communication and Training for BGI Construction:

- Emphasize differences from traditional construction activities to avoid common risks like surface clogging.



Fig 3.5. compaction of sub-grade below pervious construction intended to infiltrate water

4. Erosion Control

The importance of erosion control during construction activities, outlining factors influencing erosion, erosion control procedures, and specific erosion protection techniques to mitigate soil disturbance and maintain BGI effectiveness.

a. Factors Influencing Erosion During Construction:

- Soil Disturbance: Any disturbance of natural soil and vegetation can increase erosion due to exposed loose soil.
- Erosion Factors: Soil type, geology, vegetative cover, topography, climate, and land use influence erosion potential.
- Role of Vegetation: Roots bind soil, leaves reduce raindrop impact, and ground cover traps rain, reducing runoff velocity.
- Water Erosion Factors: Runoff velocity, volume, soil type, vegetation cover, machinery, and de-watering outlets affect land erosion.

b. Erosion Control Procedures:

- Limit erosion amount and rate on disturbed areas to maintain BGI effectiveness.
- Stabilize exposed soil with temporary or permanent covers and water conveyance facilities.
- Conduct land disturbing activities to reduce soil erosion and sediment movement.
- Minimize total exposed soil and duration of accelerated soil erosion during construction.
- Establish cover on disturbed areas promptly after final grading.
- Design water conveyance facilities to limit flow to non-erosive velocities.
- Remove sediment from runoff water before leaving the site.
- Stabilize disturbed areas with vegetative cover quickly.
- Establish erosion protection techniques.

c. Erosion protection techniques

- Use vegetation to reinforce soil and reduce runoff velocity.
- Employ geotextiles, geocellular confinement, and erosion control fabrics.
- Implement reinforced grass systems to protect against erosion and traffic loading.
- Utilize gravel trenches to intercept runoff and infiltrate or divert it.
- Design flat sites / slack gradients to reduce runoff velocity.

Table 3.4. Maximum Allowable velocities based on soil type

Soil Type	Maximum allowable velocity m/s	
	Seeded	Turfed
Sand	0.6	0.9
Silt loam, sandy loam, loamy sand	0.6	0.9
Silty clay loam, sandy clay loam	0.75	1.2
Clay, clay loam, sandy clay, silty clay	0.9	1.5

5. Sediment Control

Sediment control techniques such as straw bale barriers, silt fences, and sediment basins are employed during construction to manage sediment runoff effectively, based on site characteristics like catchment area and slope.

a. Principles of Sediment Control:

i) Runoff and Sediment:

- Sediment in runoff tends to settle as runoff rates decrease during rainfall events, but it can be resuspended and moved downstream with subsequent runoff.

ii) Erosion Control Impact:

- Effective erosion control can reduce sediment supply on-site, but sediment trapping and management are still necessary.

b. Sediment Control Techniques:

i) Common Controls:

- Include straw bale barriers, geo-textile silt fences, and sediment basins during construction.
- Selection Criteria: The choice of control system depends on catchment area size and site slope.

ii) Straw Bale Barriers and Silt Fences:

- Used for smaller sites.
- For larger areas, runoff should be directed through diversion ditches to temporary sediment basins. Proper installation and maintenance are crucial for performance.

iii) Geo-textile Silt Fences:

- Act as temporary barriers along contours at the base of disturbed areas.
- Durable if installed and maintained correctly. Not suitable for concentrated flow paths; consider more robust filters if concentrated flow conditions exist.

iv) Sediment Basins:

- Designed to trap sediment and facilitate easy removal. Proprietary systems or other facilities may also be used.
- Consideration should be given to sediment resuspension during storm events.

v) Maintenance and Rehabilitation:

- Sediment basins and treatment systems require complete clean-out and rehabilitation post-construction.
- Permanent features in BGI design need careful management to prevent sediment contamination.

Table 3.5. Sediment control system design criteria

	Allowable Maximum Limits		
	Drainage catchment area (hectares)	Drainage catchment slope length (m)	Drainage catchment slope gradient
Sediment control facility			
Straw bale barrier or silt fence	0.6–1.2 per 100 linear metres	50	1:2 (50%)

6. Pollution Control

a. Pollution Prevention:

- Detailed guidance from Masters-Williams et al (2001) and EA (2012) emphasizes controlling pollution loads from surface water runoff and managing materials and fuel spills with containment techniques.
- Pre-planning of construction site layout to minimize impacts on water bodies, including proper waste disposal, storage, and fueling areas. Environmental pollution protection plan outlining drainage routes, discharge systems, spillage kits, and incident response.

b. Construction Pollution Sources and Controls:

i) Sediment:

- Address sources like excavated or exposed ground with measures such as silt fences, runoff diversion, and interception devices.
- Manage stockpile erosion through protective coverings and proper location away from drainage systems.
- Control plant and wheel washing to prevent contaminated discharge into watercourses.
- Design haul roads to minimize runoff and manage dust through regular spraying and sweeping.
- Limit excavation in riverbeds, employing diversion strategies and protective booms.
- Implement techniques like grass areas or gravel strips to reduce suspended solids in de-watering operations.

ii) Oils and Hydrocarbons:

- Mitigate hydrocarbon pollution through machinery maintenance, drip trays, and regular inspections for leaks.
- Use designated refueling areas with spill kits and proper storage facilities.
- Secure tanks and install booms along watercourses to prevent oil and hydrocarbon contamination.

Table 3.6. Maximum Allowable velocities based on soil type

Sources	Potential Problem Indicators
Storage tanks	leaking valves, leaking pipe work corrosion, Monsoon damage, vandalism, leaking bund
General operation and maintenance	removal of waste, refuelling leaking pumps, browsers, generators, plants, machinery disposal of waste oil
Accidents/incidents	spillages (greatest risk at refuelling) overturning (drums and buckets), mechanical failure eg. rupture of pipes, inadequate bunded area, vandalism

7. BGI Construction Inspections

a. Inspections during BGI Construction and Operation:

- Regular inspections are essential during BGI construction and once operational to ensure proper construction and adherence to design criteria.
- The inspections aim to verify correct construction, assess design assumptions, and address any changes or ground condition variations.
- Independent inspection by the approval body or designer is preferred over contractor self-certification.
- A construction checklist is provided in annexure for reference.

b. Types of Inspections:

- Pre-excavation inspection to manage construction runoff and prevent SuDS clogging.
- Excavation inspections for ponds, infiltration devices, swales, etc.
- Inspection of infiltration surfaces before any construction overlay.
- Monitoring pipework installation.
- Earthworks, pavement, or filter material inspections and testing during placement.
- Level check of prepared SuDS components before planting.
- Final inspection post-surfacing or planting to ensure compliance and identify defects.

c. Contractor Awareness and Final Inspection:

- Contractors must be informed about inspection requirements to avoid invalidated work.
- Final inspection occurs at the end of the maintenance period (typically one year) to confirm compliance with design specifications.

d. Verification Report and Monitoring:

- The approving body or designer provides a verification report post-construction, detailing inspections, design variations, non-compliances, and corrective actions.
- Monitoring during the initial year of operation may be necessary to optimize SuDS performance based on site-specific needs and design sensitivity.

Table 3.7. Summary of issues to be considered by responsible

Designers	Site Managers	Construction supervisors & Operators
• Avoid using infiltration or pervious surfaces in area likely be required for construction traffic • Design to allow drainage of site during construction • Dissemination of information to contractors to ensure suds are constructed correctly • Design for ease of construction.	• Effective programming Prepare construction method statements • Dissemination of information to supervisors and operatives to ensure that BGI construction • Arrange construction access so that it will not adversely affect suds performance • Arrange for effective silt and pollution control during construction. • Arrange for prompt planting and establishment of landscaped BGI features • Ensure that appropriate erosion controlArrange for construction checks and inspections at appropriate times.	• Understand requirements for construction and ask for information from site manager if not clear • Do not compact areas for infiltration • Ensure that required erosion, pollution and silt control is in place before starting work • Minimise exposed areas of bare soil • Avoid placing construction materials on completed BGI (eg. topsoil on pervious surfaces).

3.3.2. Construction Requirements of BGI

1. Swales

a. Pre-construction Protection:

- Grass swales should be clearly marked and protected with signage and silt fencing to prevent disturbance during site work.
- No unnecessary vehicular traffic should be allowed near the swale during construction.

b. Construction Practices:

- Excavation equipment should operate from the side of the swale, not the base, to prevent soil compaction.
- If compaction occurs, affected soil should be replaced with a blend of topsoil and sand to promote infiltration and biological growth.

c. Accuracy in Construction:

- Ensure precise construction of swale levels and slopes to avoid issues like runoff bypassing inlets, ponding, or flow channelling, which can compromise flow conditions.

d. Post-construction Management:

- Swales should not receive runoff until vegetation is fully established and sediment loads from construction are minimized.
- Techniques like flow diversion, erosion control blankets, or seeding should be used.

e. Rehabilitation:

- If sediment accumulates in the swale during construction, it should be cleared and the swale fully rehabilitated before the drainage system is put into operation.

f. Planting and Establishment:

- Plant swales during optimal times for successful establishment without irrigation.
- Use temporary stabilization methods like erosion control matting or blankets.
- Re-seed or replant areas with less than 30% coverage after four weeks.

g. Construction Safety:

- Develop a construction phase health and safety plan compliant with regulations to identify and mitigate construction risks effectively.



Fig 3.6. Reference - Construction of Bioswales

2. Bio retention Ponds

a. Construction of Bio retention Areas:

- Ideally constructed at the end of development to minimize erosion and sediment generation.
- Establish dense vegetative cover over the contributing pervious catchment area before accepting runoff.
- If construction runoff is unavoidable, protect bio retention areas using silt fences or straw bales.

b. Addressing Bio retention Issues:

- Issues like blinding, compaction, and failure during construction are common.
- One approach is to use a temporary impermeable cover over the filter medium during construction to collect sediment, which is removed once planting is complete.
- Temporary covers are more effective than sediment fences or straw bales.

c. Monitoring Points for Construction:

- Avoid over-compacting soils beneath bio retention areas to maintain infiltration capacities.
- Use backhoe excavators for larger areas and hand excavation for smaller systems.
- Apply mulch before planting, avoiding piling around plants to prevent disease and pests.
- Ensure geotextiles are not clogged or torn during construction.
- Test filter medium before placement to meet required criteria.

d. Establishment and Maintenance:

- Quickly establish planting in bio retention systems.
- Regular watering, weeding, and replanting during the establishment period to ensure plant survival.
- Maintain even surface levels to prevent ponding and clogging.

e. Health and Safety:

Develop a construction phase health and safety plan to address all construction risks.



Fig 3.7. Reference - Construction of Bio retention ponds

3. Infiltration Systems

a. Careful Planning and Implementation:

- Many infiltration system failures result from poor design, inappropriate soils, and careless construction.
- Construction must be carefully planned and executed to avoid adversely affecting infiltration system performance.

b. Construction Timing:

- Infiltration basin construction ideally occurs after site stabilization to minimize the risk of premature system failure due to sediment-laden runoff.
- If construction during site development is unavoidable, initial excavation should stop 450 mm above the basin floor until after stabilization.

c. Management of Construction Runoff:

- Infiltration basins should not be used to manage construction runoff or trap construction sediments.
- Avoid laying topsoil in saturated conditions, which can be challenging with tight construction schedules.

d. Construction Techniques:

- Use equipment with light-pressure tracks to perform excavation and leveling, preventing compaction of the basin floor.
- Carefully prepare the basin base to an even grade without significant undulations.
- Avoid smearing or compacting surface soils within the basin during construction.
- Till the basin floor to a depth of 150 mm after final grading to maintain a well-aerated, porous surface texture.

e. Backfilling and Slope Finishing:

- Control backfilling around inlet and outlet structures to minimize settlement and erosion risks.
- Use fertile, porous topsoil of sufficient depth for healthy vegetation growth on side slopes.

f. Immediate Stabilization Post-Construction:

- Immediately stabilize the base and side slopes of the basin with dense water-tolerant grass coverage to prevent erosion.
- Implementing these practices during infiltration basin construction helps optimize system performance and longevity.



Fig 3.8. Reference - Construction of Infiltration ponds

4. Constructed wetlands

a. Structural Preparation:

- Bottom and side slopes, including any benches, should be carefully prepared to ensure structural integrity.
- Embankments must be checked to meet design criteria and retain surface water runoff without significant erosion.

b. Backfilling and Soil Quality:

- Control backfilling around inlet and outlet structures to minimize settlement and erosion.
- Use fertile, porous soil of sufficient depth on side slopes to support healthy vegetation growth.

c. Impermeable Liner Protection:

- Take care to avoid damaging impermeable liners during construction if used for the pond.

d. Erosion Prevention and Planting:

- Utilize erosion prevention materials that allow for plant establishment.
- Plan planting over multiple years to monitor establishment rates and adjust densities accordingly.

e. Construction Runoff Management:

- Ponds should not be used to manage construction runoff unless there are plans for complete rehabilitation to original design levels before handover.

f. Health and Safety:

- Detailed construction activities and their scheduling are covered in above section
- Develop a construction phase health and safety plan to address all construction risks



Fig 3.9. Reference - Construction of Wetlands

3.3.3. Construction Requirements of Trees

a. Sediment Accumulation Management:

- Clear sediment from construction work on tree pits or planters before adoption by the maintenance organization.

b. Soil Handling and Placement:

- Handle tree soils and structural soils carefully to avoid damage or compaction during construction.
- Place soil when it is friable and non-plastic, with moisture content at least 5% below the soils plastic limit.
- Avoid placing soil during frozen conditions or heavy rainfall.

c. Soil Mixing and Compaction:

- Prevent mixing tree soil or structural soil with other materials like sub-base or debris.
- Minimize handling to preserve soil structure and avoid compaction by trampling or machinery traffic.

d. Fertilizer Use and Considerations:

- Consider using slow-release fertilizers advised by tree specifiers to aid establishment, balancing against surface water pollution risks.

e. Structural Soils and Compaction:

- Structural soils serve as load-bearing sub-base for pavements and should be compacted to appropriate density as per pavement design.



Fig 3.10. Reference - Placement of Trees

3.3.4. Soil Requirements

The use and management of natural soils, or the consideration of manufactured soils due to the scarcity of natural soil, is important for BGI (Blue-green infrastructure). Soils play a crucial role in drainage and provide essential nutrients for healthy plant growth, which is vital for achieving rapid establishment and ground cover in BGI.

a. Bioengineering

- The utilization of bioengineering methods and various soil reinforcement treatments along BGI can be valuable for implementing effective BGI.
- These techniques are particularly beneficial for stabilizing banks next to watercourses that experience occasional high or fast flows, or for retaining soil on steep slopes.
- However, its advisable to avoid these methods immediately adjacent to proposed BGI or water bodies.
- To achieve shallower gradients near water edges within a BGI framework, steeper gradients may be necessary elsewhere.
- Bioengineering integrates soft landscaping with durable underground engineering to establish and preserve watercourse formations as intended.
- Solutions may involve geotextiles, cellular confinement systems, and vegetated barrier structures, offering a softer and more natural approach compared to hard landscaping features like sheet piling or concrete banks.
- Gabions are another option, though they do not achieve a completely soft system.

b. Developing Technology

- The development of soil retention technology is ongoing, making it essential to conduct online reviews to explore potential products and applications.
- Currently, soil retention solutions range from natural materials like coir fiber, faggots, and rocks to man-made materials.
- The choice of material depends on the specific site and its intended use, whether to aid in the establishment of BGI or to ensure long-term durability and performance.
- Materials used for establishment purposes are typically biodegradable.
- Natural materials are generally suitable for shallower banks and lower water flows, providing stability during initial plant establishment to stabilize the banks.
- In contrast, durable man-made products are preferable for steeper banks or areas with higher flows and velocity to ensure long-term stability.

c. Soil Reinforcement

- Different levels of reinforcement are required based on slope steepness, susceptibility to water erosion, and desired vegetation type.
- Cellular confinement systems consist of flexible materials arranged in honeycomb or diamond-shaped cells, filled with soil and planted or covered with grass, offering extra strength to prevent soil sliding on steeper slope upto 1:1
- Turf reinforcement mats are strong fiber mats fixed onto slopes for seeding or planting, providing stability for plant establishment on slopes up to 1 in 3.
- Reinforced turf is pre-grown with an incorporated fiber mat, offering immediate results and durability when fixed onto slopes.
- These products vary in suitability depending on slope conditions and desired vegetation establishment.

d. British Standards

- Multipurpose topsoil supports various plant types and is

suitable for most landscaping applications.

- Specific-purpose topsoils, with specific properties like low fertility or acidity, are used for specialized needs, not general landscaping.
- When specifying topsoils, it's important to consider local soil type and intended site use to ensure compatibility with soft landscaping requirements, such as wildflower areas that benefit from low-fertility soils.

e. Textural Classification Of Soil

- The texture of soil refers to the mixture of different particle sizes, categorized by names like loamy sand or clay.
- Soils are classified as heavy (clay/silty) or light (sandy) based on their ease of cultivation.
- Texture is a fundamental property influencing drainage, water storage, workability, erosion susceptibility, and overall suitability for different uses.
- Soil structure, defined by the aggregation of soil particles into peds, varies from small crumbs to large blocks and is more critical in heavy textured soils.
- Clayey/silty soils with poor structure are less permeable and porous compared to sandy soils, limiting their suitability for certain BGI applications.

f. Top soil manufacture

- Multipurpose topsoil used for general landscape purposes can be manufactured by blending compost, sand, and subsoil, offering an alternative where natural topsoil is limited on-site.
- This process is feasible for larger projects with economies of scale, allowing on-site blending of soils.
- Manufactured soils combine existing materials, including remediated soils, with inorganic and organic components like PAS 100:2011 compliant green compost to create general-purpose or specific-purpose soils.
- These soils are also commercially available.
- Guidance from soil or landscape experts is recommended to ensure blended soils support desired plant growth and align with specific BGI requirements.
- PAS 100 is a specification by the Waste and Resources Action Programme (WRAP) for composted materials from licensed facilities that process household and garden waste into usable compost.
- For more details refer 'The Landscape Institute and WRAP (2012)' have also developed a standard specifically for landscape applications.

g. Use of Fertilizers

- The quality of specified topsoil may necessitate certain fertilizers to achieve optimal nutrient levels for healthy plant growth. Soil fertility is indicated by NPK values, representing nitrogen, phosphorus, and potassium levels critical for plant health:
- Nitrogen supports leaf and stem growth.
- Phosphorus is essential for root development.
- Potassium aids in photosynthesis, flower, and fruit development.
- Soil nutrient levels can be determined through soil testing as per BS 3882:2015, with specific fertilizers applied to restore balance and create suitable conditions for plant establishment.
- Organic bulk fertilizers are typically used for new planting, while inorganic fertilizers with the appropriate NPK composition address soil nutrient deficiencies, especially for grass.
- Wildflower areas generally require no additional fertilizers unless specific soil analysis reveals contamination or severe

nutrient depletion.

- When applying fertilizers in BGI, they should be integrated into the soil during cultivation to minimize runoff.
- Care must be taken to avoid over-application, as excess fertilizers can lead to downstream contamination and adverse effects on watercourses.
- Slow-release fertilizers are preferred over soluble fertilizers for sustainable application.

h. Use of Mulches

- Mulches are applied to aid in plant establishment by covering the soil with a layer of material, serving two main functions:
- Preventing weed seeds from germinating and competing with plants for essential resources.
- Reducing water evaporation from the soil during dry periods, promoting plant growth.
- During the critical plant establishment phase in BGI, prioritizing plant maturity over soil evaporation is key.
- Once plants are established, their root systems efficiently draw moisture from the soil, outweighing any water loss due to evaporation from the surface.
- In BGI landscape schemes, chipped or pulverized tree bark is common for mulching planting beds.
- However, this is unsuitable for areas with water flow or outlets as bark can block drainage systems.
- Gravels, pebbles, or biodegradable materials like jute matting are effective alternatives that won't accumulate or block outlets.
- These materials should be secured with pins or pegs and will eventually be covered by developing plants, making them ideal for creeping plants.



Fig 3.11. Reference - Bioengineering of the soil



Image Credit - People's Park Chennai

4 MAINTAINING SPONGE PARK

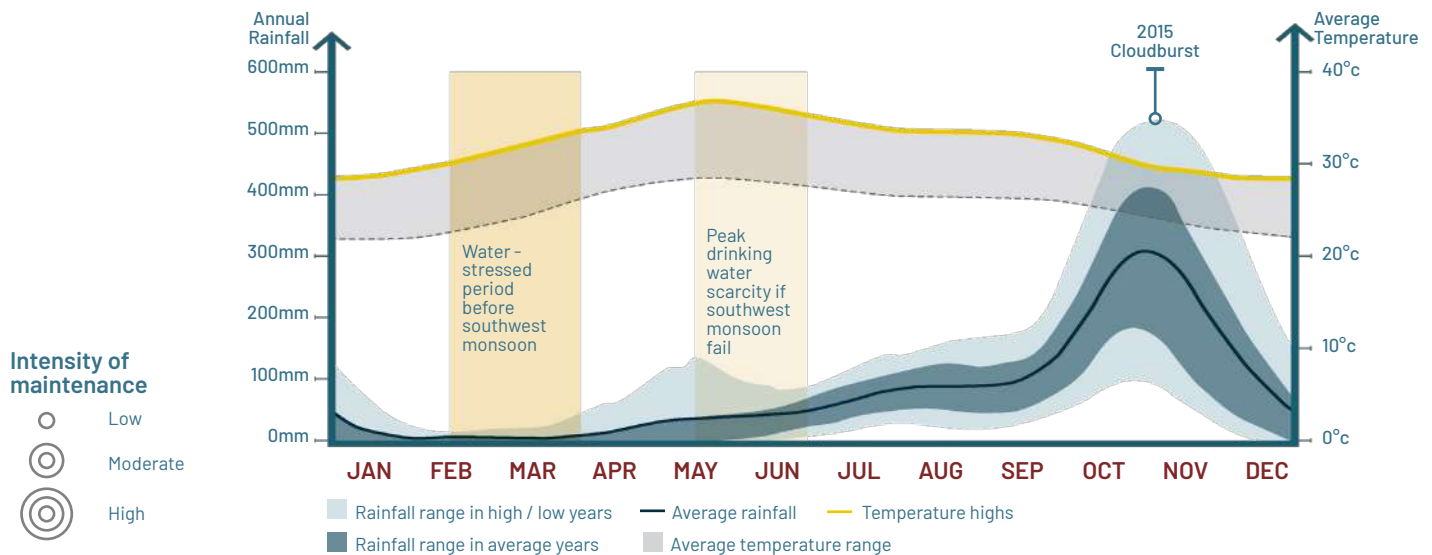
- 4.1. Sponge Park Maintenance Framework
- 4.2. Plant Maintenance Regimes
- 4.3. Operating And Maintaining Parks

4.1. Sponge Park Maintenance Framework

4.1.1. Prioritising Maintenance by Season and System

Maintenance is critical to ensure the continued functionality of blue-green infrastructure and the services provided by the planting in Spone Parks season after season. The four Sponge Park systems have varying degrees of dynamism in terms of how they are impacted by changes in climate or shocks from floor and

drought events. The framework of Regular, Reactive, Semi-Annual, and Annual maintenance regime following the seasonal shocks and stresses of Chennai's climate is depicted below. This section follows this framework to provide detailed guidelines on maintenance regimes and actions by Sponge Park systems



		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Soil and Grading 	Regular / Reactive	○	○	○	⊗	⊙	○	○	○	○	⊙	⊗	⊗
					Retain soil moisture through summer					Erosion control during monsoon			
	Semi-annual / Annual	■			■								■
		Amend / Enhance Soil			Mulching						Earth work repair		
Hydrology and Blue green 	Regular / Reactive	○	○	○	○	○	○	⊙	⊙	⊙	⊗	⊗	⊗
											Leaf litter control & BGI repair		
	Semi-annual / Annual	■					■			■			
		Post monsoon BGI repair					Post peak summer BGI repair			Annual mechanical cleaning			
Vegetation and Planting 	Regular / Reactive	○	○	⊙	⊗	⊙	⊗	○	○	○	⊙	⊙	⊙
					Adequate irrigation at evenings during peak summer						Post monsoon trees repair		
	Semi-annual / Annual	■			■		■			■			■
		Planting			Netting		Pruning			Pruning	Composting dead vegetation		
Amenities and Social Facilities 	Regular / Reactive	○	○	○	○	○	○	○	○	○	⊙	⊙	⊙
	Semi-annual / Annual	■											
		Post monsoon repair											

4.1.2. Maintenance Regimes of Sponge Parks

The components of the sponge parks in particular may be exposed to harsh temperature fluctuations, pollution, large amounts of silt and rubbish accumulation, and an antagonistic weed population, all of which can make the habitat for plants difficult. For the sponge parks to remain viable and functional over the long term, a strict

and efficient maintenance program is essential. For more detailed information about Maintenance. This section provides an overview of maintenance events as well as a brief summary of routine and reactive maintenance tasks that are advised to be followed for the better performance of the sponge parks.

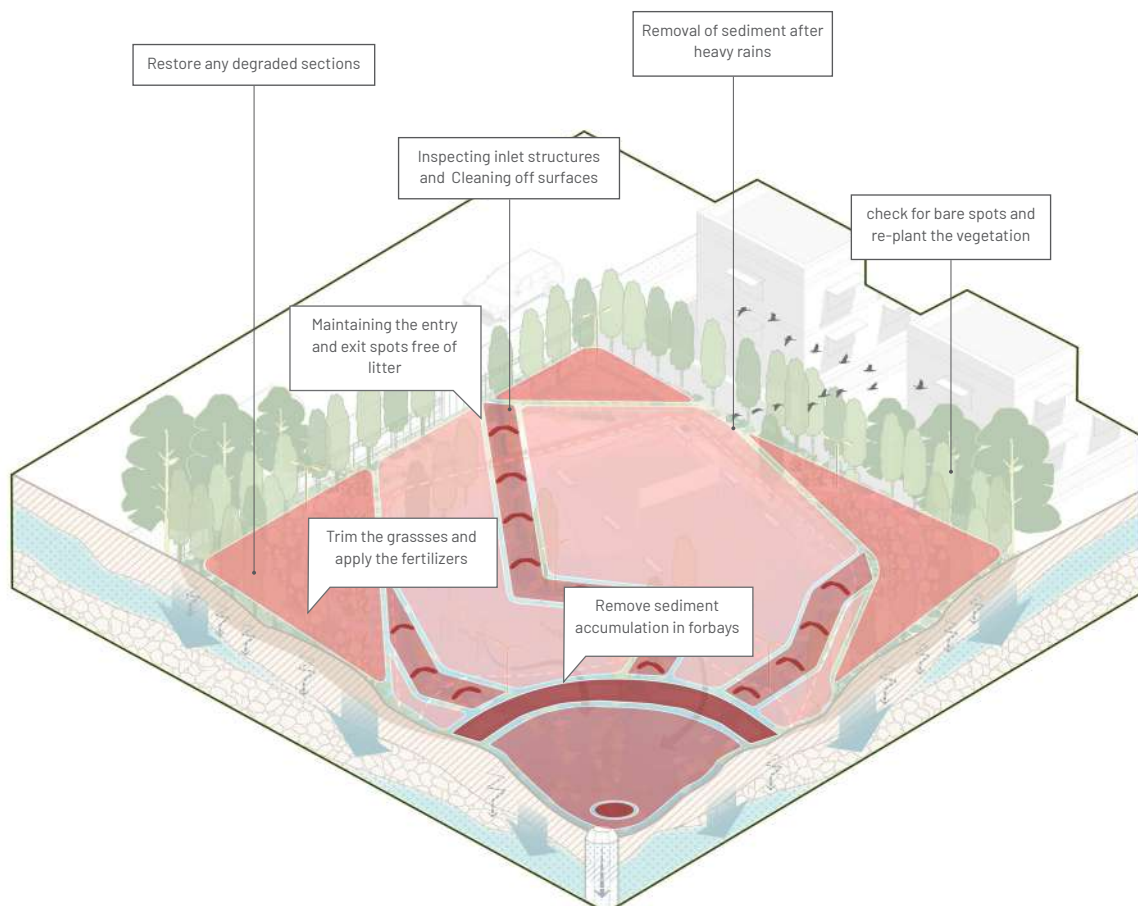
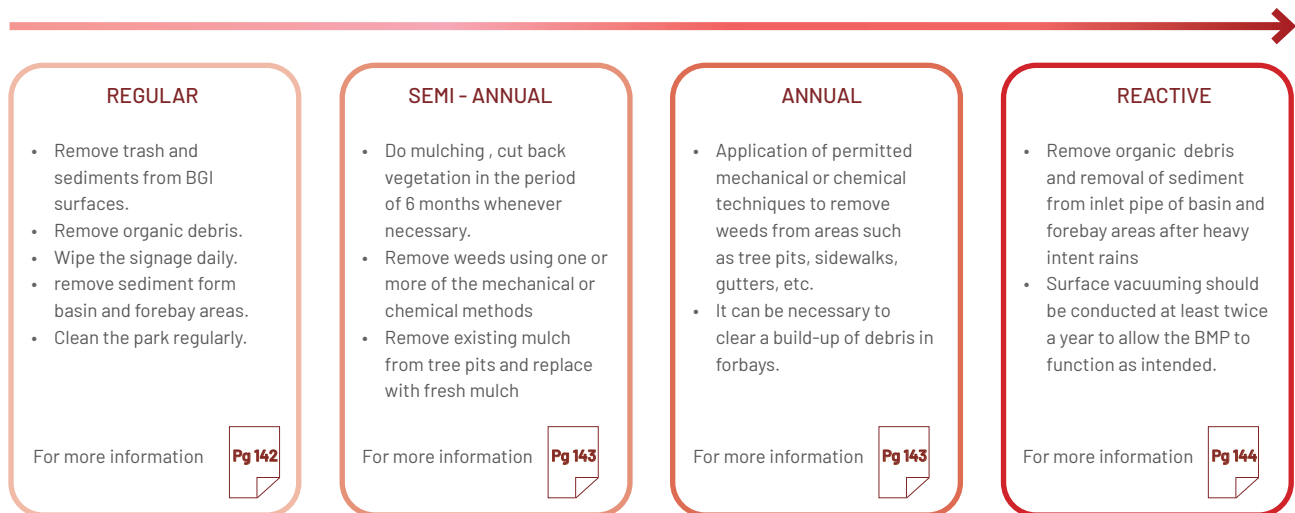


Fig 4.1. Axon showing different maintenance of the sponge parks

4.1.3. Maintenance of BGI Components

To ensure the long-term sustainability and functioning of the BGI, an effective maintenance regime must be set in place. BGI are dynamic systems that depend on healthy vegetation to delay, infiltrate, store and cleanse the storm water runoff. Especially under harsh urban conditions such as pollution, weeds and dumping of solid waste, a rigorous program is important to sustain them to be effective and aesthetic. The following are a set of guidelines to maintain vegetation, specifically listed for each BGI - Rain Garden, Bioswales, Tree Planting, Soil Amendment and Infiltration basin.

Maintenance Of Recharge well - Refer fig 4.2 and 4.3

Conduct frequent inspections of the raingarden to check for any signs of damage, erosion, or sediment accumulation. Remove weeds and unwanted vegetation from the raingarden regularly to prevent them from competing with native plants for nutrients and water. Apply a layer of organic mulch, such as wood chips or shredded bark, to the surface of the raingarden to help retain moisture, suppress weed growth, and improve soil structure. Monitor water levels in the the raingarden to ensure proper drainage and infiltration. Periodically test the soil in the raingarden to assess nutrient levels and pH balance.

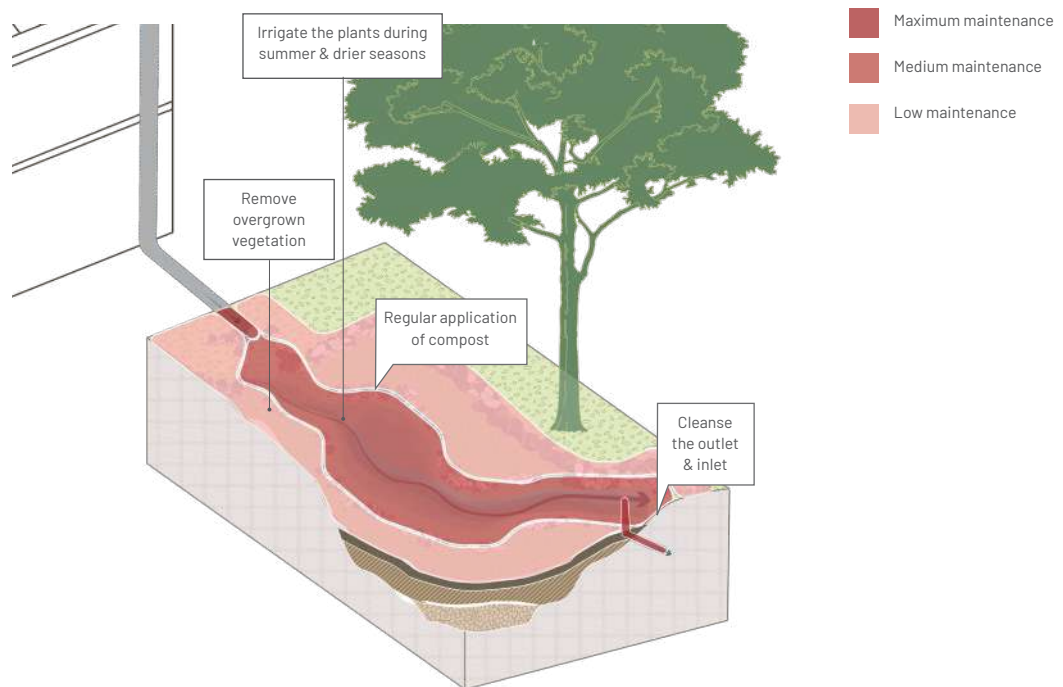


Fig 4.2. Maintenance of Raingardens (Buildings)

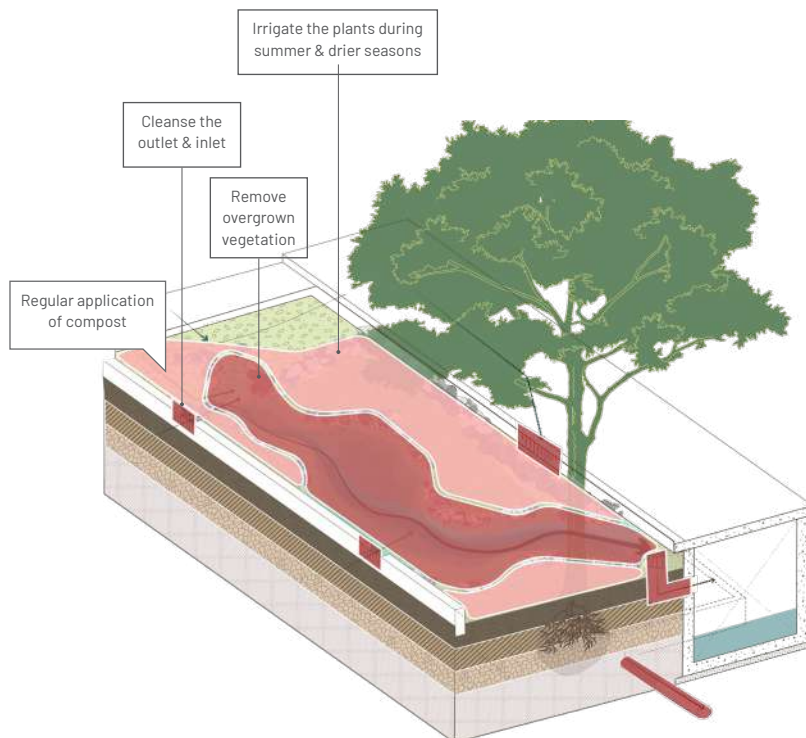


Fig 4.3. Maintenance of Raingardens (streets)

Maintenance Of Bioswale - Refer fig 4.4

Conduct routine inspections of the bioswale to check for signs of erosion, sediment accumulation, and damage. Monitor vegetation growth in the bioswale and remove any weeds or invasive species that may compete with native plants. Clear any trash, litter, or organic debris that accumulates in the bioswale to prevent blockages and ensure proper water flow. Apply a layer of mulch, such as wood chips or shredded bark, to the surface of the bioswale to help retain moisture, suppress weed growth, and protect soil from erosion. Inspect and maintain outlet structures, such as weirs or culverts, to ensure they are functioning properly and allowing for controlled discharge of water from the bioswale.

Maintenance Of Recharge well - Refer fig 4.5

Conduct routine inspections of the recharge well and its surrounding area to check for any signs of damage, clogging, or sediment accumulation. Inspections should ideally be performed quarterly or at least twice a year. Remove any debris that may have accumulated on the surface of the recharge well or in the inlet structures. Periodically clean out sediment and debris that have settled at the bottom of the recharge well. Control vegetation growth around the recharge well to prevent roots from invading and obstructing the well structure. Check and clean inlet structures, such as catch basins or grates, to prevent them from becoming blocked by debris.

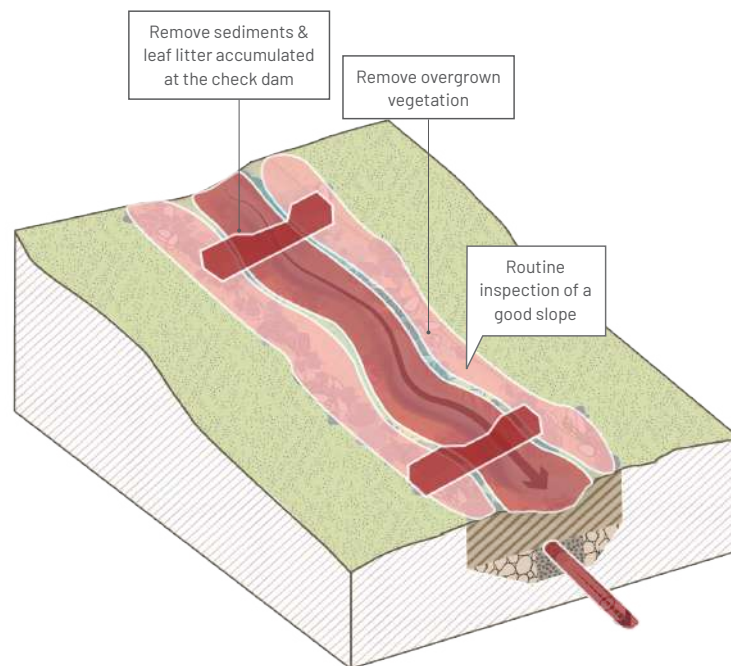


Fig 4.4. Maintenance of Bioswales

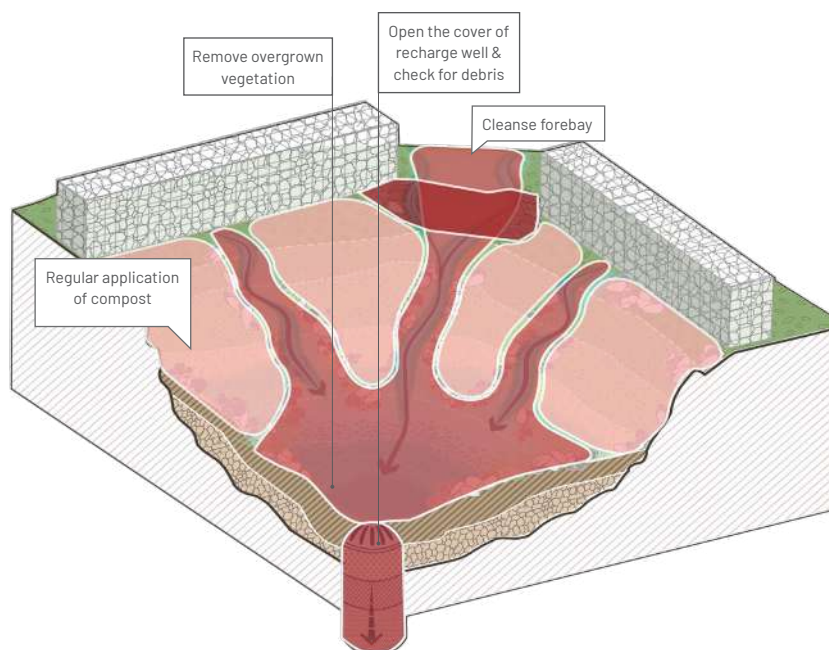


Fig 4.5. Maintenance of Recharge wells

4.1.4. Routine Maintenance of BGI

Table 4.1. Daily and Monthly Maintenance Routine

Schedule	Task	Applicable Toolkits	Descriptions	Preconditions	Protocol
Daily	General Care	Applied to all BGI	Clear SMP surfaces (such as sidewalks, gutter lines, tree pits, etc.) of debris and/or silt.	If present within BGI (sponge) Toolkits	4.3.1
			Remove organic debris (eg.. leaves, feces, etc.) from BGI surfaces	If present within BGI (sponge) Toolkits	
			Wipe down signages	Dust, grime or residue on signs	
			Remove tags, strings, and expired no parking signage	If present within BGI (sponge) Toolkits	
		Wetlands, Bioswales, Raingardens	Remove settlement of debris from basin and forebay areas	If present within BGI (sponge) Toolkits	
Monthly	Erosion Repair	Applied to all BGI	Fill eroded areas, place erosion fabric, and, if necessary seed	If minor (<20 square), nonrecurring erosion is present within BGI components	4.3.2
	Concrete repair	Applied to all BGI	Repair hairline/cosmic cracks	If present within BGI (sponge) Toolkits	4.3.3
			Replace loose, missing or displaced brick, stone or paver	If present within BGI (sponge) Toolkits	
	Settling	Applied to all BGI	Fill in sinkholes or slits with stone, then fill with dirt and mulch, if needed.	If sinkholes within BGI components are 24 inches deep or less	4.3.4
	Weeding	All vegetated BGI	Use a combination of mechanical and chemical weed removal techniques.	If present within BGI (sponge) Toolkits	4.2.1
	Mowing	Rain garden, Retention basin, wetlands, Bioswales	Mow turf grass	As directed by owner/operator	4.2.2
			Mow grasses to a height of 3-4 in.	If height of vegetation is > 4 in above ground surface elevation	
	Dead & Damaged Vegetation Removal	All vegetated BGI	Remove dead vegetation, trees or shrubs from BGI area as well as prune the vegetation	If damaged, diseased, and/or dead branches; suckers present within the BGI (sponge) Toolkits	4.2.3
	Cutting Back Vegetation	All vegetated BGI	Cut back dense vegetation	If the height of the dense vegetation at sidewalks is > 4, as measured from the top of the curb elevation	4.2.4
	Pest & Disease Management	All vegetated BGI	Treat vegetation to remove, destroy, or minimize pests and disease	If harmful insects (e.g., bag worms, wax scale, caterpillars, aphids, etc.); galls, mildew or fungus are present	4.2.5
			Remove small animal carcasses	If small animal (e.g., rat, bird, cat, etc.) carcasses are present within the BGI (sponge) Toolkits	
	Mulching	Tree trench, green gutter	Apply mulch to tree pits	If gap between top of sidewalk and top of mulch is > 1 in.	4.2.6
		All vegetated BGI	Move mulch away from a tree's base or a shrub with woody stems.	If mulch is within 3 in. of trunk	

Table 4.2. Semi annual and annual Maintenance

Task	Applicable Toolkits	Description	Conditions	Frequency	Protocol
General care	Applied to all BGI	Remove trash and/or sediment from all BGI surfaces & wipe down signage	If trash and/or sediment is present within the BGI area	3 times per year in April, July, and October	4.3.1
Weeding	All vegetated BGI	Remove weeds using one or more of the mechanical or chemical methods	If weeds are present within the BGI area	3 times per year in April, July, and October	4.2.1
Structural pruning	All vegetated BGI components	Complete selective pruning to improve tree architecture	none	Annually during the period from December to the end of February	4.2.4
Cutting Back of Vegetation	All vegetated BGI components	Cut back herbaceous vegetation from previous growing season	If the height of herbaceous Vegetation exceeds 6 in.	Annually during February and march	4.2.4
Dead & damaged vegetation removal	All vegetated BGI	Remove dead herbaceous vegetation or shrubs from the BGI area	If dead vegetation is present within the BGI area	3 times per year in April, July, and October	4.2.3
Mulch Care	Tree trench, storm water tree	Remove existing mulch from tree pits and replace with fresh mulch	none	Annually during February march and April	4.2.6
	Rain garden/ Retention Basin	Apply mulch to the perimeter of landscaped beds > 2 years old and to entire bed for soft sites < 2 yrs old	none	Annually during February march and April	
Pest & Disease management	All vegetated BGI components	Treat vegetation to remove, destroy, or minimize pests and disease and Remove animal carcasses	If harmful insects galls, mildew or fungus are present within the BGI	As needed	4.2.5
Soil Amending	All vegetated BGI components	Tree/shrub appears unhealthy, unrelated to drought; soil issues observed. Amend soil as needed following annual nutrient test performed by the owner/operator	Soil tests report the need for soil amendment; Consult owner/operator	Depending on soil test results	4.2.7
Planting & Seeding	All vegetated BGI components	Bare areas in planted beds > 20 sq m during the growing season	Consult landscape architect or horticulturist and owner/operator for plant selection	Replace plant(s)	4.2.8 & 4.2.9
	Rain garden/ basin, wetland, swale, green gutter	Bare areas in meadow areas or seeded areas (> 20 sq m) during the growing season		Perform seeding in spring (March 1 - May 15)	
Vacuum Cleaning	All BGI components with subsurface features	Vacuum clean trash sediment/ organic debris from subsurface access	If trash/sediment/organic debris present within structures	Once a year, Most preferably post monsoon	4.3.6
Inlet Pretreatment Device Maintenance	All BGI components with subsurface features	Empty and clean surface pretreatment devices	If trash, sediment, and/or organic debris is present in pretreatment devices	Once a year, Most preferably post monsoon	4.3.6
		Install permanent pretreatment devices	If pretreatment devices are not present		
Bolt & lock care	All BGI components with subsurface features	Clean and grease appurtenances	When bolts or locks is opened	Once a year, Most preferably post monsoon	4.3.5
Trees	All BGI components with the trees	Place water bag(s) on unhealthy tree	If tree leaves appear brown or wilted	Annually in April, or after planting	4.2.10
Herbaceous vegetation	All BGI components with the trees	Water herbaceous vegetation and shrubs	If there has been a period of 4 or more days without rain	Every 4 days from April to end of October	

4.1.5. Reactive (Additional) Maintenance of BGI

1. Description

- • Reactive maintenance tasks Table 4.3 are additional tasks beyond the regular maintenance listed in Table 4.1 and 4.2.
- • Reactive maintenance tasks may be required in response to specific observations related to site safety, BGI performance or aesthetics during regular maintenance by the operator.
- • Reactive tasks may require consultation with the professionals such as engineers, scientists, landscape architects, horticulturalists or others.
- • Reactive tasks require approval or validation of the operator before work can be performed. Some observations listed in the Table 4.5 could pose potential safety hazards to the public and to maintenance personnel.
- • When issues are spotted, the member responsible should immediately secure the site and contact the operator.
- • The list of possible responses is not all-inclusive and other reactive maintenance tasks or investigations not listed in this table or manual may be required in response to observations.

2. Observations

- • Certain observations listed in Table 4.3 may pose significant safety risks to the public and maintenance personnel, such as large sinkholes or widespread settling.
- • In the event that safety concerns are identified, maintenance staff must promptly secure the site and notify the owner/operator. It is important to note that the observations listed in Table 4.3 are not exhaustive, and maintenance personnel should remain vigilant in identifying potential issues.

3. Possible Responses To Observations

- • Table 4.3 outlines potential actions that can be taken in response to observations. This list is not exhaustive, and there may be other reactive maintenance tasks or investigations not explicitly mentioned in this table or manual that could be necessary based on specific observations.
- • Initiating reactive maintenance tasks in response to observations requires approval from the owner/operator, unless prior approval has been granted to initiate specific response actions for certain observations.

Table 4.3. Reactive Maintenance

Issue	Observation	Securing site	Possible response	Additional Study	Protocol
Sedimentation	Sedimentation over an area > 250 sq m in size		Sedimentation over an area > 250 sq m in size	Consult engineer to determine possible design solutions	4.3.1
Erosion	Recurring erosion located downslope of energy dissipater		Construct or extend energy dissipater	Consult engineer to correctly analyze for optimal performance	4.3.2
	Recurring erosion not associated with energy dissipaters		Perform erosion repair	Consult engineer to determine possible design solutions	
Settling	Sinkholes > 24 in. depth	●	Perform void/sinkhole repair	Assess area using dye testing or geotechnical investigate cause of soil loss	4.3.4
Clogging	Standing water within SMP infiltration /storage area more than 72 hrs after a rain event (except storm water wetlands)		Perform soil management; debris removal, and/or pipe jetting/vactoring/de-watering	Engage with engineer to find out potential design solutions. Additionally, geotechnical Investigations may be required.	4.3.6
	Standing water in inflow inlets above the height of the distribution pipe for more than 72 hrs after a rain event		Perform emergency pipe cleaning	Perform pipe inspection to assess condition prior to cleaning	
	Standing water on pervious pavement, or pavement pores that appear caked with fine sediment or debris		Perform restorative cleaning	Perform infiltration testing if infiltration rate is < 10 in./ hr pavement may require restorative maintenance	
Dead and missing vegetation	Large trees in urban areas are dead , have large broken limbs (>6 in. dia.) otherwise pose safety risk	●	Remove trees/shrubs or dead limbs	Consult arborist for tree removal	4.2.3
	Trees or shrubs that were present at previous Maintenance event are missing		Replace trees/ shrubs	Not applicable	
	Tree branches growing close to overhead utility cables		Pruning trees in accordance to utility line clearance regulations	Consult a certified arborist	
Concrete, Pavement, or Masonry Damage	Structural failure or damage & repair large cracks	●	Repair/reconstruct structure and cracks if present in BGI	Perform additional investigate of root cause of missing components	4.3.3
	Loose, missing, or displaced brick, stone, or paver areas > 4 sq m.	●	Replace and/or reset the missing masonry parts	None	
	Pervious or conventional asphalt or concrete is severely degraded or shows significant dents or scars	●	If large concrete cracks present within the BGI	If large concrete cracks present within the BGI	
Pests	Mosquito infestation or roach infestations, or wasps		Report and apply control measures	None	4.2.5
Missing components	Bypass of storm water observed at inlet or curb cut during storm events		Perform inlet drainage modification	None	4.3.3
	Missing clean out covers	●	Contact the owner/operator about replacements	None	N/A
	Public access/safety risk is N/A observed by the owner/ operator		Install permanent fencing	Consult a construction Contractor to perform repairs	

4.2. Plant Maintenance Regimes

4.2.1. Planting Mix Maintenance



Buffer Mix : This mix needs some maintenance regularly in terms of pruning shrubs, maintaining the climber to maintain the sightline (**Refer 4.2.5**). Leaf litters need not be cleaned; will act themselves as mulch and reduce water velocity.



Lawn Mix : Except the invasive plants, other plants and herbs should not be removed from the space; to avoid exposing the soil to evaporation. Grasses and other small herbs are seasonal; so, they will dry in summer & flourish naturally after rains. (**Refer 4.2.2, 4.2.3**)



Pathway Mix : This mix needs the maximum maintenance. The leaf litter, flowers or twigs have to be cleared regularly so that the pathway is accessible & visible for movement. (**Refer 4.2.2, 4.2.5, 4.2.11**)



Bioswales Mix : Overgrown vegetation is to be avoided as this may cause friction force to rise sharply and greatly reduce the flow capacity of the swales. Routine inspection of a good slope so that there is no hindrance to the conveyance of storm water runoff

(**Refer 4.2.2, 4.2.4, 4.2.8**)



Grove Mix : Maintenance is needed in the initial period (2-5 years) but eventually it will become a self sufficient mix that will need occasional maintenance. The plants needs to grow naturally in this mix with initial care. Leaf litters need not be cleaned; will act themselves as mulch and reduce water velocity. (**Refer 4.2.7, 4.2.8**)



Wetland Mix : Unweed invasive herbs and shrubs once in a month. Irrigate the plants during summer and drier seasons. Regular application (once in a month) of compost or farmyard manure is required. (**Refer 4.2.2, 4.2.4, 4.2.8**)



Pollinator Mix : This mix needs maintenance in terms of regularly irrigating, pruning, dweeding and soil amendment so that the desired intent can be achieved. (**Refer 4.2.2, 4.2.5, 4.2.6, 4.2.8**)

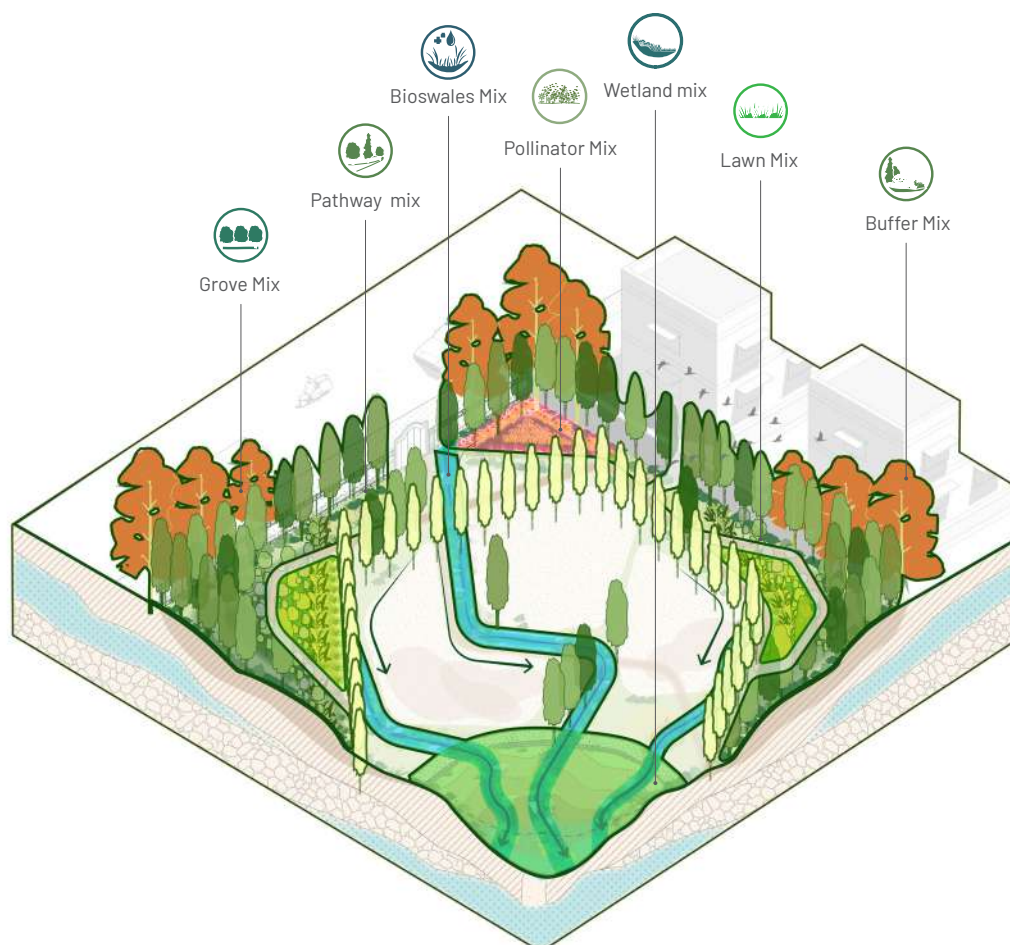


Fig 4.6. Planting mix Maintenance

4.2.2. Weed Control

The steps and specifications for weed management with mechanical and chemical techniques are covered in this section:

- Mechanical: Hand-pulling woody and herbaceous weeds
- Chemical treatments include basal bark treatments, foliar treatments, cut stem treatments, and pre-emergent treatments.

In this section, "weeds" are defined as follows:

- Plants listed on the Invasive Plant List. Refer annexure
- Volunteer species that do not conform to the owner/operator's definition of the SMP's aesthetic

1. Standard Operating Procedure

a. Hand pulling of mature annual and tap-rooted herbaceous plants and tree seedlings : (refer fig 4.1)

- If needed, use a shovel or spade to loosen the soil around the plant's root mass.
- Remove the entire plant, including the root mass, to prevent re-sprouting.
- Shake off soil from plant roots.
- Smooth the surrounding soil using a shovel or rake to fill in the hole, and cover with shredded hardwood or root mulch. Bag and dispose of plant material properly at an approved off-site location, ensuring no plant pieces remain on-site.

b. Hand pulling of aquatic weeds: (refer fig 4.2)

- In areas of intentional continuous ponding, remove aquatic weeds using an aquatic weed rake.
- Bag and dispose of the plant material properly at an approved off-site location, ensuring no plant pieces remain on-site.
- Prepare herbicide solution according to manufacturer's specifications before arriving on-site.
- Apply the herbicide following manufacturer's instructions and recommended safety procedures:
- Avoid using open containers on-site during application to minimize herbicide spillage.
- In case of herbicide spillage, follow appropriate safety protocols for cleanup and notification of relevant parties
- Take caution to prevent herbicide agents from spreading to other areas.
- Follow manufacturer's and safety specifications for pesticide cleanup and disposal.

Procedures for specific chemical treatments:

c. Cut stem treatments:

- Cut stems horizontally at or near ground level, ensuring cuts are level, smooth, and free of debris.
- Immediately apply the appropriate translocated herbicide to the outer 20% (cambial area) of the stump.

d. Foliar treatments:

- Apply the appropriate translocated or contact herbicide using a low-pressure backpack sprayer, applying at rates of one gallon or less per minute.
- Use a flat spray tip or adjustable cone nozzle to apply herbicide to leaves and stems of target plants, using a consistent back-and-forth motion to cover foliage fully without causing runoff.
- Allow herbicide treatments to dry for at least 3 hours at an air temperature above -15C to ensure adequate absorption and translocation.
- In areas with significant public use, consider closing off the treatment area until the herbicide has completely

dried. The need for area closures should be determined before application and reviewed/approved by the owner/operator.

e. Basal bark treatments:

- Apply herbicide with a backpack sprayer using low pressure with a straight stream or flat fan tip.
- For vegetation with a basal stem diameter of less than 77mm, apply a translocated herbicide-oil mixture on one side of the basal stem up to 153mm from the base, ensuring the mixture almost encircles the stem within an hour.
- For stems larger than 77mm in basal diameter or with thick bark, treat both sides of the stem up to a basal height of 305mm - 610mm (0.3 m to 0.6m)

f. Pre-emergent treatments:

- Apply pre-emergent herbicide in early spring, late summer, or early fall, or immediately after cultivation.
- Remove weed residues, prunings, and debris thoroughly before treatment.
- Apply granular pre-emergent herbicide using a small handheld spreader or liquid form with a hand-held or backpack sprayer.
- Apply evenly to bare soil, avoiding areas seeded with non-weed species.
- After applying granular herbicide, apply approximately 6.35mm or more of water evenly across the treatment area (manual watering or rainfall is acceptable).



Fig 4.7. Reference - Handpulling method of weeds



Fig 4.8. Reference - Removal of aquatic weeds

4.2.3. Mowing and String Trimming

The following section outlines the requirements for string trimming and mowing

1. Applicability and Requirements

- Where mowing is not feasible due to slope or terrain challenges, use a string trimmer instead.
- During spring and summer mowing or string trimming, take care to minimize impact on ground-nesting birds (avoiding nesting season: March- June).

2. Standard Operating Procedure

a. Mowing warm season grasses:

- Maintain established warm season or wildflower meadows at a height of 150mm - 200 mm to deter woody species and encourage new growth of target grasses and forbs.
- Use a flail-type mower when possible to avoid burying seedlings with mowed material.
- When using a flail mower, mow up and down slopes (perpendicular to the slope) rather than along contours (parallel to the slope) exceeding 15 degrees.
- Clippings from a flail mower are finely chopped and can be left in place without harming plants.
- If a flail mower isn't available, use a conventional tractor, handheld, or walk-behind mower.
- Avoid using walk-behind mowers, riding mowers, or tractors with brush hogs on slopes steeper than 15 degrees. Remove excess clippings and dispose of them off-site.

b. Mowing cool season grass meadows: (refer fig 4.3)

- Maintain cool season meadows at a height of 77mm to 100 mm to deter woody growth and achieve preferred height and aesthetics.
- Use handheld, tractor-mounted, or walk-behind mowers.
- Mow uniformly to the prescribed height without scalping or tearing grasses.
- Avoid mowing within 300 mm of trees or shrubs; cut or remove plants by hand within this zone.
- Remove excess clippings and dispose of them off-site.

c. String Trimming

- Trim herbaceous vegetation to about 100 mm -150 mm (0.1 to 0.15m) above the ground.
- Avoid trimming within 300 mm (0.3) of trees or shrubs; cut vegetation manually in this zone.
- Maintain an even level of trimmed vegetation for a tidy appearance. Dispose of trimmed plant material off-site.



Fig 4.9. Reference - Mowing in the park

4.2.4. Dead and Damaged Vegetation Removal

This section indicates how trees removed from unrestricted areas. Shrubs or herbaceous plants removed if they are taller than 1524mm (1.52m) at the top of the crown can be removed.

1. Applicability and Requirements

Specialty tree removal services are not covered in this manual.

2. Standard Operating Procedure

a. Large shrub Removal

- Use a handsaw or small chainsaw to cut through thick branches.
- Employ a digging spade and fork to loosen and cut roots around the root zone.
- Cut through roots at the base of the stump with a garden mattock.
- Dislodge the stump using a digging spade and fork, or use a stump puller if available.
- Backfill the excavated hole with surrounding soil and apply mulch.

b. Removing Trees: (refer fig 4.4)

- Determine the expected fall line based on the tree's natural growth pattern and angle.
- Remove any dead snags before felling, if feasible.
- Choose an appropriate saw based on tree size (hand saw for trees less than 100 mm DBH).
- Use either a one-cut or two-cut method (undercut) to fell the tree, depending on size and constraints.
- One-cut method: Make a single horizontal cut through the trunk.
- Two-cut method (undercut): Create a V-shaped notch on the intended fall side and then make a backcut on the opposite side.
- Cut the trunk and branches into manageable pieces for removal and disposal.
- Roots may be left or removed at the owner/operator's discretion.
- If roots remain: Cut the stump flush with the ground surface.
- If roots are removed: Use tools to expose and cut roots, then remove and dispose of them.
- Backfill with soil and mulch as needed.

c. Herbaceous Vegetation and Small Shrub Removal:

- Use a hand saw or pruners to cut the base of vegetation.
- Dig out roots with a shovel, being careful not to disturb nearby plants and backfill with topsoil and apply matching mulch (Refer 4.2.7)



Fig 4.10. Reference - Removal of dead plant

4.2.5. Pruning & Cutting Back Vegetation

This section outlines procedures and criteria for trimming, pruning, and thinning woody and herbaceous plants to ensure their health, including the following aspects:

- Non-structural pruning of trees and shrubs
- Structural pruning of trees and shrubs
- Cutting back of herbaceous species

1. Applicability and Requirements:

- Structural tree pruning requires oversight by a Certified Arborist.
- Arrangements should be made with utility companies for the removal of branches near electrical distribution lines, performed only by qualified arborists.

2. Standard Operating Procedure:

a. Pruning of shrubs and trees:

i) Non-structural pruning: (refer fig 4.5)

- Remove dead, damaged, diseased, or dying branches.
- Trim broken branches back to the branch collar.
- Remove low limbs obstructing overhead and line of sight clearances.

ii) Structural pruning:

- Promote proper growth and train young trees for desired clearances.
- Avoid removing more than 25% of total foliage annually or per branch.
- Elevate lower limbs based on tree size and location.
- Remove rubbing and crossing limbs.
- Perform structural pruning once annually during winter dormancy if needed.

b. Cutting back herbaceous species:

- Trim to maintain safe sightlines for pedestrians.
- Keep herbaceous vegetation heights appropriate for visibility.
- Cut back dormant herbaceous species annually.
- Dispose of trimmed material at an approved off-site location.
- These procedures ensure the health and safety of planted areas while conforming to established standards for plant care and maintenance.

4.2.6. Pest and Disease Management

To manage pests and illnesses, this section lays out the protocols and specifications for chemical controls that are either natural, mechanical, biological, or cultural. These include: Insects and fungus as pests, Pest mammals

1. Applicability and requirements

Chemical pest control shall be performed during periods of dry weather (not more than 24 hrs. before or after a rain event) with little or no wind.

2. Standard Operating Procedure

Assess the severity of infestation and damage, and choose the most targeted method of pest control while minimizing harm to beneficial organisms. Begin with the least harmful approaches

a. Large animal carcass removal:

- Notify the owner/operator upon discovering a large animal carcass.

b. Small animal carcass removal:

- Use disposable gloves.
- Use shovels and rakes to collect the animal carcass and place it in a trash bag.
- Seal and dispose of the bag.
- Clean tools with disinfectant solution (e.g., bleach, pine oil).
- If available, apply disinfectant solution to tools and hose down with potable water.
- Replace mulch as needed **(Refer 4.2.7)**

c. Pest insects or fungi: (refer fig 4.6)

- Remove infected leaves, twigs, branches, needles, and cones from around the base of trees and shrubs to eliminate pests or fungi.
- Apply the pesticide following the manufacturer's guidelines and recommended safety procedures.
- Prevent pesticide contact with unaffected vegetation or non-target areas of the plant.
- Adhere to manufacturer's guidelines for pesticide cleanup and disposal.
- For mosquito issues in inlets or catch basins, use Mosquito Dunks or equivalent products to treat standing water areas



Fig 4.11. Reference - Pruning of tree ahead of monsoon



Fig 4.12. Reference - Application of pesticide to remove pests

4.2.7. Mulching

This section sets forth procedures and requirements for mulch application and maintenance.

1. Standard Operating Procedure

a. Mulch Removal

- Use rakes and shovels to remove mulch from tree pits or Blue-green Infrastructure (BGI), ensuring vegetation is not disturbed. Dispose of the mulch at an off-site location.

b. Mulch Application: (Refer fig 4.7)

- Apply mulch to the perimeter of established landscaped beds that are at least 2 years old.
- Spread a 75 mm thick layer of mulch, extending from the edge of the tree pit or Blue-green infrastructure to a radius of 75 mm from the woody stem of each plant.
- Continue adding mulch until the mulched area aligns with the edge of pavement, unless the tree pit is covered by a grate or enclosed with fencing.

c. Mulch Maintenance:

- Use a rake to pull mulch away from trunks and woody stems of shrubs, maintaining a distance of 77mm to avoid disturbing vegetation.



Fig 4.13. Reference - Mulching to protect during monsoon

4.2.8. Soil Management

This section outlines the procedures and requirements for maintaining soil health and function, covering the following aspects like Soil amendment and Decompaction of tree pit soil

1. Applicability and Requirements: (Refer fig 4.8)

- Inorganic fertilizer is excluded unless specifically approved by the owner/operator for special circumstances.
- Soil must meet specified criteria, including fertility and absence of debris, weeds, invasive species, and pathogens.
- Soil amendments are based on soil analysis conducted or requested by the owner/operator.

2. Standard Operating Procedure:

a. Application of soil amendments: (Refer fig 4.9)

- Remove weeds and complete tree and shrub pruning before applying soil amendments.
- Apply amendments evenly over the target area, avoiding clumping and ensuring no damage to vegetation.
- Hand-spread amendments in vegetated areas.
- Till soil amendments into existing turf soil to a depth of 102mm, Reseed disturbed areas as necessary.

b. Decompaction of tree pit soil:

- Use appropriate hand tools or an air spade to break up compacted soil in tree pits, avoiding damage to surface roots. Apply a 77mm layer of compost over roots.



Fig 4.14. Reference - Soil amendment Ph testing



Fig 4.15. Reference - Application of soil amendment

4.2.9. Planting and Transplanting

This section outlines procedures and guidelines for planting and transplanting trees, shrubs, containerized herbaceous plants, and herbaceous plugs within blue-green infrastructure. The work includes tasks such as delivery, storage, handling of plants, appropriate planting seasons, site preparation, planting lists, installation of trees, plants, and shrubs (both containers and seedlings), and protection of new plantings.

1. Applicability and Restrictions:

a. Plant Delivery, Storage, and Handling:

- Plants and trees must meet specific requirements set by the owner/operator regarding genus, species, variety, size, and quality. Plants should be clearly labeled with scientific and common names upon delivery.
- Substandard plants or trees, including those with inadequate caliper size, root ball condition, presence of insects, injuries, or defects, may be rejected by the owner/operator at any stage of the work.
- Vegetation should not be stored in direct sunlight, and roots must be kept moist.
- Protect bark, roots, and branches from damage during handling; avoid using the trunk as a lever or lifting/carrying plants by the trunk or branches.

b. Appropriate planting seasons:

i) Evergreen trees and shrubs:

- Plant during beginning of monsoon season, i.e. June to September
- Ensure that planted vegetation have sufficient time to establish fine root systems and receive adequate watering to prevent winter desiccation. Soil temperatures for monsoon planting should not drop below 16°C.

ii) Ground cover, herbaceous perennials, and plugs:

- Plant in early after the danger of monsoon seasons has passed (typically February to March) or late summer 30 days (typically late April or late May).

iii) Bulbs:

- Plant bulbs when soil temperatures are at 12°C but before the rainy season.

c. Site Preparation and Plant Lists

- Planting pits must not be left open at the end of the day.
- The owner/operator will provide instructions on where to install plants.
- After completing the plantings, a comprehensive list of installed plants must be submitted to the owner/operator.
- This list should include botanical and common names, variety, size (container or caliper), quantity, location within the Blue-green infrastructure, and the source of plant materials.

2. Standard Operating Procedure

i) Installation in erosion control blanket

- Make an incision in the erosion blanket and dig a hole for each plug or plant that matches the depth of the plug or potted plants soil.
- Use a dibble bar with the same diameter as the plug to create holes for plugs by punching through the erosion blanket.
- For container plants, cut the stapled erosion control blanket into a circular shape to match the container's diameter.
- Ensure that no erosion control blanket is in direct contact

with any tree or plant stem.

ii) Installation of trees and shrubs

- Ensure that all planting pits have vertical or outward-angled walls from the bottom upward. After digging, scarify the walls of the pit.
- Dig the planting pit to a depth that is at least 1 to 1.5 times the width of the root mass of the plant to be installed.
- The planting pit should be deep enough so that the bottom of the root flare is level with the final grade.
- Remove any debris from the pit and compact loose soil at the bottom of the pit using your foot.
- When handling the plant, avoid touching the branches, leaves, or stem/trunk.
- Remove the plant from its container and position it straight in the center of the planting pit, carrying the plant by its root mass and avoiding lifting or carrying it by the trunk or branches.
- If the tree or shrub is balled and burlapped, carefully remove a portion of the root ball packing and as much burlap as possible while minimizing disturbance to the tree.
- Cut and discard all ropes around the burlapped ball, remove excess burlap, and remove at least a portion of the wire basket and any nails.
- Remove bamboo staking near the root ball and trunk before planting, if present.
- Backfill the planting pit with soil and tamp it firmly to fill any voids and remove air pockets, being careful not to over-compact the soil. Ensure that the plant remains upright during backfilling.
- The top of the root mass of the trees/shrubs should be level with or slightly raised (no more than half an inch) above the final grade. The root flare should be visible and not covered with soil.
- Water the plants thoroughly immediately after planting to saturate the backfill.
- Apply mulch according to the specifications in **Section 4.2.7**.
- Install stakes on all trees using hardwood stakes and ArborTie or an equivalent approved by the owner/operator. If possible, place one stake at the curb side and the second stake opposite.
- Remove all strings and wire from the plant materials, except for plant name tags, which should be left until inspected by the owner/operator.

iii) For herbaceous containers and plugs:

- Dig the planting pit to a depth that is at least 1 to 1.5 times the width of the root ball.
- Remove the plants and soil from the pots or plug trays and position them in the holes so that the soil level of each plant is level with the surrounding finished grade.
- After planting, fill the soil around the plant completely, firming it and ensuring there are no air pockets.
- Water the plants thoroughly immediately after planting to saturate the backfill. Refer **section 4.2.11**

iv) To protect new plantings:

- Install silt socks over trench drain and curb cut openings to reduce scour, inundation, and sediment delivery impacts of storm water during the early establishment of new plants (remove silt socks after a full growing season).

Refer fig 4.10, 4.11, 4.12 in the next page



Fig 4.16. Reference - Transplanting of tree



Fig 4.17. Reference - Transplanting of Shrub



Fig 4.18. Reference - Planting of trees

4.2.10. Seeding

This section outlines the procedures and requirements for seeding activities.

1. Applicability and Restrictions:

- Seeding should be conducted during appropriate seasons: october to december
- The seed plan will be provided by the owner/operator specifying the seed mix location and composition, including scientific and common names with percentages for each species in the mix. Any changes to the original seed mix must be fully documented.

2. Standard Operating Procedure

a. Seedbed Preparation

- Avoid seeding on frozen ground or when temperatures are 32 F/0 C or lower unless instructed otherwise.
- Apply herbicides well in advance of site preparation under the supervision of a Certified Pesticide Applicator.
- Ensure that all areas to be seeded are well-graded and free of weeds, debris, and other materials that may interfere with seeding.
- Scarify the seedbed using a harrow or rake before seeding.

b. Seeding - General

- Perform seeding only after completing all other work in the area. Avoid applying fertilizer or lime to seeded areas without explicit approval.

c. Seeding - hand broadcast:

- Distribute seed uniformly across the target area in two different directions. After seeding, harrow or rake the site to ensure seed-soil contact.
- Firm the soil around the seed using appropriate equipment, ensuring not to cover the seed with more than half an inch of soil. Immediately water the seeded areas evenly and thoroughly.
- Apply straw mulch within 12 hours to all seeded areas.

d. Seeding - hydroseeding:

- Calibrate seeding equipment to ensure accurate and even application.
- Use equipment capable of applying seed at a specified rate.
- Apply seed uniformly across the entire area using a hydroseeder.
- Apply the seed-water mixture within one hour after adding seed to the tank.
- Follow manufacturer's instructions for equipment use, using approved spraying equipment with fan-type nozzles.
- Apply hydroseed in two steps to ensure good seed-to-soil contact.
- The seeding process should strictly adhere to the specified seed mixtures and rates.
- For hydroseeding, the first step involves applying a mixture of 500 pounds per acre for visual metering, along with tackifier at the recommended manufacturer rates.
- The second step entails evenly applying a second coat containing water, 1,500 pounds per acre of hydroseed mixture, and tackifier at the recommended rates to create an erosion-resistant mulch coating over the entire seeded area.
- After completing the hydroseeding application, thoroughly clean the tank, pumps, and hoses to remove all residual material. Wash the exterior of the equipment to remove any slurry spills.

4.2.11. Watering techniques

This section provides guidelines for watering vegetation.

1. Applicability and Requirements:

Avoid overhead watering on sunny days to prevent leaf scorch.

2. Standard Operating Procedure:

a. Fire Hydrant Operation:

- Use approved center compression lock keys or a hydrant wrench for operating permitted fire hydrants.
- Follow guidelines for opening, operating, and closing fire hydrants with approved backflow preventer assemblies.

b. Watering Tank Operation:

If rain-harvested water or fire hydrant access is unavailable onsite, use a watering tank as the water source.

c. Watering Herbaceous Plants, Shrubs, and Seeded Areas:

- Direct water toward the base of plants.
- Allow water to soak into the ground within each vegetated area, moving slowly through each section.
- Ensure each 100-square-foot section of vegetated area is evenly and thoroughly watered for 5 minutes before proceeding to the next section.
- Use appropriate hose sprinkler attachments, avoiding concentrated flows at planted or seeded areas.

d. Watering Trees:

i) Water Bag Installation, Filling, and Removal:

- Install and fill 15-20 gallon watering bags like TreeGator per manufacturer's recommendations on trees meeting specified criteria.
- Allow water to seep into the ground, then refill the watering bag.
- Remove watering bags in October, wash, and store in a dry place.

ii) Watering Using Manual Methods:

- Water each tree for 5 minutes or until the soil is saturated.
- Apply water gently at the base of the tree using a hose.
- Allow water to soak in and replace any disturbed mulch after watering.



Fig 4.19. Reference - Gator bags installed trees

4.2.12. Irrigation

The irrigation of plants in city is heavily influenced by the seasonal weather patterns experienced in the region. Chennai, located in the tropical climate zone, typically experiences distinct wet and dry seasons throughout the year. Efficient irrigation techniques, such as drip irrigation or using moisture-retentive mulches, can help conserve water and promote healthy plant growth despite the challenging weather conditions. Additionally, monitoring soil moisture levels regularly and adjusting watering schedules accordingly can optimize plant health and water efficiency throughout the year.

1. Monsoon Season (June to September)

- During the monsoon season, which is characterized by heavy rainfall, plants generally require less irrigation.
- The ample rainfall provides natural watering for plants, reducing the need for additional irrigation.
- However, it's essential to monitor soil moisture levels to prevent water logging and root rot in certain plants.

2. Post-Monsoon Season (October to December):

- After the monsoon season, Chennai transitions into a period of reduced rainfall.
- Plants may still benefit from residual soil moisture, but supplemental irrigation may be necessary, especially for plants that require consistent moisture.
- It's crucial to adjust watering based on specific plant needs and prevailing weather conditions.

3. Dry Season (January to May):

- The dry season in Chennai is characterized by hot and dry weather, with minimal rainfall.
- During this period, plants are more susceptible to drought stress and require regular watering to maintain their health and vigor.
- Deep and infrequent watering is recommended to encourage deep root growth and resilience to dry conditions.

4. Pre-Monsoon Season (May to June):

- As the dry season progresses towards the onset of the monsoon, plants may benefit from increased watering to prepare for the upcoming rainy season.
- Adequate irrigation during this transitional period helps plants withstand the heat and ensures they are in good condition to benefit from subsequent rainfall.



Fig 4.20. Reference - Irrigation of the plants

4.3. Operating and Maintaining Sponge Parks

4.3.1. Trash, Sediment & Organic Debris Removal

This section outlines procedures and requirements for removing trash, sediment, and organic debris from pretreatment devices and surfaces of Blue-green infrastructures.

1. Applicability and Requirements:

- After monsoon events, the effectiveness of debris removal may be reduced, and removal efforts may be deferred to the next maintenance event if deemed impractical by the foreman. Debris removal from confined spaces like inlets, pipes & culverts

2. Standard Operating Procedure:

a. Trash, Sediment, and Organic Debris Removal from Pretreatment Devices:

- Install a new pretreatment device if absent in highway inlets or domed risers.
- Remove non-permanently attached pretreatment devices by hand or with specialized tools.
- Use pumps to remove standing water before lifting the device.
- Clean the fabric of pretreatment devices with a scrub brush or pressure washer without damaging it.
- Repairing Damaged Pretreatment Devices:
- Replace filter fabric if damaged beyond 3 inches.
- Stockpile damaged filter fabric offsite for repair.

b. Trash, Sediment, and Debris Removal from Blue-green Surfaces:

- Use hand tools to remove small amounts of debris manually. Use appropriate tools like leaf rakes, blowers, or trash claws to remove larger debris from Blue-green infrastructure areas.
- Mechanized equipment like mini excavators or vacuum excavators may be used for large deposits or hard-to-access areas.
- Avoid using heavy equipment on Blue-green infrastructuresurfaces to prevent soil compaction.
- Protect adjacent elements like trees, slopes, and sidewalks during debris removal.
- Immediately stabilize any bare areas resulting from debris removal within vegetated BGI components.

c. Additional Tasks:

- Clean and wipe down signage using appropriate cleaners and soft rags and remove strings or tags used for temporary signage.
- Report illegal dumping activities to the owner/operator and request removal through appropriate channels.



Fig 4.21. Reference - Cleaning of pretreatment device

4.3.2. Erosion Control and Repair

This section outlines procedures and requirements for managing and repairing minor to moderate erosion, along with guidance for repairing and extending energy dissipaters.

1. Applicability and Requirements:

- Erosion Control Blanket must be 100% jute fiber, handwoven into a one-inch by one-inch net. The jute netting should be undyed, unbleached, consist of uniform single jute yarn, and be 100% biodegradable.
- Sizing of new energy dissipaters must be determined by the owner/operator.

2. Standard Operating Procedure:

- Fill eroded areas with matching material from the surrounding media profile if necessary.
- Use hand tools like hoes or rakes to fine-grade the filled area to match the undamaged surface.
- Install erosion blanket according to the manufacturer's specifications, ensuring proper overlap, anchor trenches, and staple patterns.
- Anchor the upslope edge securely into an anchor trench above the water entry point into the Blue-green infrastructures
- Overlap multiple pieces of erosion blankets to ensure no bare soil is exposed.
- Plant or seed the area if directed by the owner/operator, following specific guidelines for the desired species.



Fig 4.22. Reference - Erosion control technique



Fig 4.23. Reference - Extension of a velocity dissipator

4.3.3. Concrete, Pavement & Masonry Repair

This section details the procedures and requirements for repairing and modifying concrete, pavement, and masonry, including adjusting asphalt grading to improve drainage towards inlets.

1. Applicability and Requirements:

- Schedule concrete work early in the day whenever possible to ensure final setting occurs during working hours.
- Protect newly poured concrete from pedestrian and vehicular traffic using barricades, caution tape, or signage.
- Maintain supervision during the final setting period to prevent vandalism and damage.
- Maintain protective measures during the 5 to 7-day curing period of concrete.
- Concrete, pavement, and masonry repairs should occur during temperatures ranging between 4.5C and 27C.
- Avoid concrete, pavement, and masonry repairs within 48 hours of forecasted rain.
- Ensure the crew includes at least one skilled Mason for technical or advanced concrete, pavement, and masonry repair and modification.

2. Standard Operating Procedure:

Seek guidance from the owner/operator if damaged pavement exceeds 50 ft and accounts for more than 10% of the total pavement surface. Block off unsafe areas for pedestrians or vehicular traffic and notify the owner/operator.

a. To repair broken, loose, or compromised concrete or masonry:

- Cover adjacent areas with a tarp to protect surfaces, soil, and vegetation.
- Remove loose debris from the repair area.
- For hairline or cosmetic cracks, apply a concrete crack repair product following manufacturer recommendations.
- For large or structural cracks, clean the area, fill the crack, and consider saw-cutting concrete and installing forms if necessary.
- Mix and apply mortar to fill the repair area, ensuring smooth joints and removing excess mortar.

b. To replace or reset missing masonry parts (stones, bricks, pavers):

- Remove surrounding stone or brick to provide space for tying in newly constructed masonry.
- Prepare subbase to match surrounding conditions or design specifications.
- Install geo-textile fabric if necessary and prepare mortar or adhesive for stone/brick installation.
- Place and secure stone or brick to match existing surfaces, removing excess mortar or adhesive.

c. To repair small divots in pervious or conventional asphalt (less than 50 ft and less than 10% of total pavement surface):

- Cut damaged areas with an asphalt cutting blade, remove material down to the base stone course.
- Fill the hole with conventional asphalt cold patch and pack it down with a hand tamper.
- Seal patched seams with acrylic sealant as per manufacturer's specifications.
- Block the repaired area from pedestrian or vehicular traffic.

4.3.4. Settling Repair

This section outlines procedures and requirements for addressing minor to moderately settled areas.

1. Applicability and Requirements:

Cease maintenance and immediately notify the owner/operator if the area is deemed unstable.

2. Standard Operating Procedure:

a. If settling has caused a visible depression or sinkhole in the surface:

- Excavate over the settled area to expose any subsurface voids.
- Remove settled asphalt or concrete using saw cutting and jackhammering, disposing of materials off-site.
- Hand-remove pavers or stone and set them aside.
- Carefully remove herbaceous plants, shrubs, and small trees (<3 inches DBH) to avoid root damage.
- Extract turf and associated topsoil.
- Clear around the settled area and excavate using hand tools until reaching the bottom of the depression or void.
- Fill the excavated area with clean fill material (such as 2A Modified subbase) and compact using a hand tamper.
- For softscape areas, cover the excavation with topsoil or planting soil mix to match the existing planting medium and grade.
- Replace mulch as specified in **Section 4.2.7**
- Replant or reseed bare soil areas following guidelines in **Section 4.2.9 and 4.2.10.**
- For hardscaped areas, replace the hardscape subbase and surface to match the existing grade over the repaired area.
- Replace any damaged or disturbed pavers, asphalt, concrete, or stone following guidelines in **Section 4.3.3.**

b. If minor settling exists beneath hardscape areas without visible depression or sinkhole:

- Fill the void area with 2A Modified subbase using appropriate tools like a shovel, pry bar, or hand tamp.
- Replace soil using topsoil as needed at the repair interface.



Fig 4.24. Reference – Settling in a Tree pit

4.3.5. Hardware Care

This section details procedures and requirements for the general maintenance of hardware:

1. Standard Operating Procedure:

a. Cleaning and lubricating bolts:

- Remove nuts and bolts from the structure.
- Clean threading to remove debris.
- Apply appropriate lubricant to nuts and bolts.
- Reinstall nuts and bolts carefully to avoid cross-threading.

b. Broken or seized bolt extraction:

- Completely drill out the bolt with a hardened alloy bit.
- Retap the bolt hole using a tap and die set.
- Grease the new bolt and insert it carefully.

c. Replacing missing or damaged appurtenances:

Replace rods, washers, bolts, caps, and gaskets with equivalent hardware.

d. Replacing missing or damaged safety bars:

- Remove debris from unsecured endwall and outfall openings.
- Install hinged or unhinged metal grates over headwall and endwall openings for pipes larger than 8 inches, following specific procedures in **Section 4.3.1**

i) For hinged metal grate installation:

- Measure and mark hinge fastener locations on concrete.
- Pre-drill holes for fasteners in the concrete.
- Paint the grate if necessary and secure it using bolts.

ii) For unhinged metal grate installation using steel flat stock:

- Measure, mark, and cut steel bars to appropriate lengths.
- Drill holes in steel bars for fasteners.
- Install bolts, nuts, washers, and adhesive to secure the grate to the concrete.



Fig 4.25. Reference - Rainwater harvesting pit cleaning

4.3.6. Decanting and Waste disposal

Decanting

This section outlines the procedure for managing water generated or collected during subsurface maintenance activities.

1. Applicability and Restrictions:

Water containing sediment or chlorine must not be discharged into the MS4 or any structure directly linked to a water body. Decanting is only permitted in Combined Sewer areas.

2. Standard Operating Procedures:

- Collect material removed during maintenance in the truck holding tank and allow it to settle.
- Inspect the collected water for unusual color or odor indicating the presence of oil or chemicals. Immediately report any abnormalities to the owner/operator.
- Transport the water to an approved decanting inlet or manhole.
- Decant or filter the water before discharge into an inlet, following owner/operator instructions. This may involve using inlet filters. Ensure no sediment is discharged into the inlet. Transport solid materials in slurry form to an approved disposal site.

Waste Disposal

This section outlines the procedure for managing nonhazardous waste materials generated or collected during subsurface maintenance activities. It covers proper containment, transport, and disposal of waste materials.

1. Applicability and Restrictions:

The waste disposal location must be pre-approved by the owner/operator.

2. Standard Operating Procedures:

- Collect the material removed during maintenance in the appropriate waste storage container (e.g., traps, bins, vacuum/jetter truck storage, etc.).
- If necessary, decant or filter wet material before disposal as discussed in **Section 4.3.7**
- Inspect the waste material for unusual color or odor that might indicate the presence of oil or chemicals. Report any abnormalities to the owner/operator immediately.
- Transport the waste material to the approved disposal site or beneficial end-use location as directed by the owner/operator.
- Dispose of the waste material according to the instructions of the disposal site.



Fig 4.26. Reference - Tanker decanting septage

4.3.7. Composting

This section outlines the procedure for composting in the parks with the leaf litters.

1. Standard Operating Procedures:

- Gather fallen leaves from the park grounds. Use rakes or leaf blowers to collect the leaves into piles.
- Choose a suitable location in the park for composting. Ideally, the site should be flat and well-drained.
- Clear the area of weeds, debris, or other materials that may interfere with the composting process.
- Construct compost bins using wire mesh, wooden pallets, or other materials. Alternatively, use ready-made compost bins.
- Ensure the compost bin has good airflow to facilitate decomposition.
- Start with a layer of coarse materials like twigs or small branches at the bottom of the compost bin to aid aeration.
- Add a layer of shredded leaf litter on top of the coarse materials.
- Optionally, mix in nitrogen-rich materials like grass clippings or kitchen scraps to accelerate decomposition.
- Keep the compost pile moist but not waterlogged. Water the pile periodically if needed, especially during dry periods.
- Cover the compost pile with a tarp or lid to retain moisture and prevent it from drying out too quickly.
- Periodically turn the compost pile using a pitchfork or shovel to aerate the materials and promote even decomposition.
- Turning the pile every 2-3 weeks will help speed up the composting process.
- Regularly monitor the temperature and moisture level of the compost pile.
- Adjust the carbon (brown) to nitrogen (green) ratio if needed by adding more leaves or nitrogen-rich materials.
- The leaf litter will break down over time into nutrient-rich compost. This process can take several months.
- Harvest the compost when it becomes dark, crumbly, and earthy-smelling, usually after 6-12 months.
- Use the finished compost as a natural soil amendment in the park. It enriches the soil, improves soil structure, and retains moisture.
- Apply the compost around trees, shrubs, flower beds, and other planting areas to promote healthy plant growth.
- Continue to add leaf litter and other organic materials to the compost bin to maintain a steady supply of compost for the park.



Fig 4.27. Reference – Composting of leaf litter in parks



Image Credit - ICF Park

5 IMPROVING SPONGE PARKS

5.1. Monitoring for Repurposing Sponge Parks

5.1. Monitoring for Repurposing Sponge Parks

Monitoring Sponge Parks

The literature on nature-based solutions offers compelling evidence for the benefits of Sponge Parks and the associated BGI components. However, this concept has not been applied at scale in India to build a credible body of evidence for India's specific climatic context and technical capacity. The early implementation of Sponge Parks should assign dedicate budget and resources for the monitoring of multiple aspects to gather data that can be used to do a holistic cost-benefit analysis over the entire life cycle.

From examples in China, Singapore, North America, and Europe, blue-green infrastructure is demonstrably cheaper than gray infrastructure in the long term for the purposes of stormwater management. This includes the long-term maintenance costs associated with it and assigning value to the co-benefits that are generated by BGI unlike gray infrastructure (Refer to Figure 5.1)

In order to conduct a similar cost benefit analysis for Sponge Parks in India, the pilot projects need to monitor ongoing costs towards occassional and remedial maintenance that maybe elevated initially for landscaping needs but come down over time. Additionally, the following benefits of Sponge Parks need to scientifically monitored for the purposes to cost-benefit analysis and to evaluate when the Sponge Park may need upgrading or decommissioning.

1. Monitor Runoff Conveyance and Storage for Flood Mitigation Capacity

For Chennai's context, the ability of Sponge Parks to mitigate flood risk by delaying and temporarily storing stormwater runoff is a major benefit. This benefit can be costed in terms of avoided damages to surrounding assets and communities that are exposed to flooding from storm events. Since gray stormwater infrastructure is required to have a designed capacity to handle runoff from 5 year return period storms only, the immediate benefit of a Sponge Park is to quantify the volume of runoff that it handled during storm events that exceed gray infrastructure capacity. To this end, the following data needs to be monitored during every storm event:

- What volume of runoff does the Sponge Park handle without overflow into stormwater drains during a 2, 5, 10, 25, 50, and 100 year RP storm?
- What flood damages did the conveyance of exceeded runoff through Sponge Parks avoid during extreme storm events?
- Are storm events exceeding designed capacity due to climate change?

2. Monitor Depth to Water Table for Aquifer Recharge Capacity

The second most important function of Sponge Parks for Chennai's context is their ability to mitigate water scarcity risk. To this end, all recharging BGI components need to be monitored for their infiltration rates during storm events and existing or new boreholes to measure groundwater depth can be used to monitoring the following data:

- What is the depth to water table around Sponge Park relative to other areas after monsoon and during peak summers?
- Does the Sponge Park need to infiltrate more water due to climate change?

3. Monitor Groundwater Quality

In some neighbourhoods of Chennai where sewerage or storm water drain connectivity or coverage is inadequate, there is a strong risk of sewage mixing with stormwater. Sponge Parks with recharge functions for runoff beyond park boundaries should not be constructed in such catchments. Additionally, catchments with single source industrial pollutants should also be avoided. However, these conditions can change after implementation so it

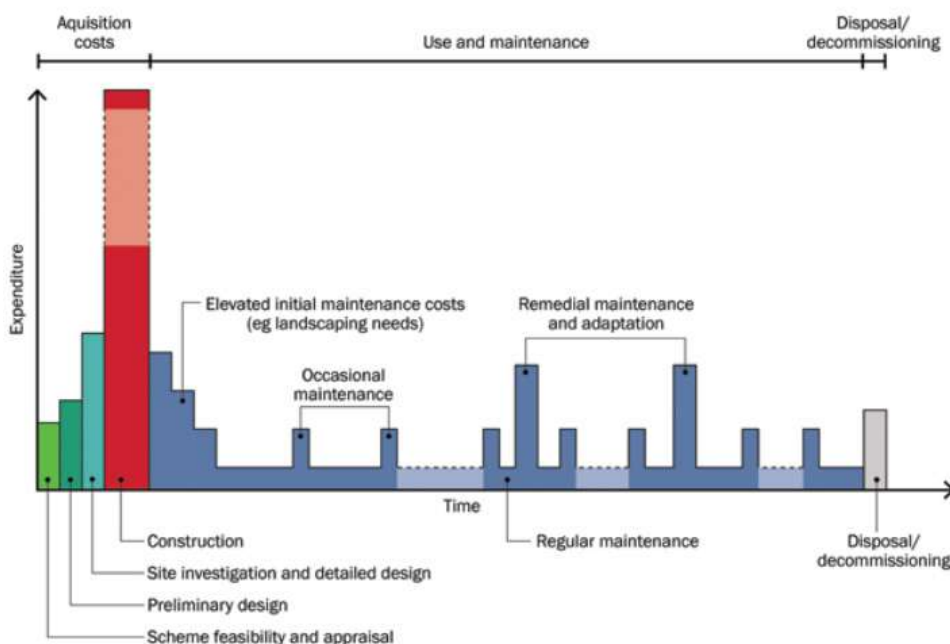


Fig 5.1. Indicative expenditure profile of Sponge Park over lifecycle (Source: CIRIA SuDS Manual 2015)

is important to monitor the following characteristics of groundwater for public health considerations:

- What is the quality of stormwater runoff compared to the runoff filtered by the Sponge Park before recharge?
- What is the quality of the groundwater? If pollution is detected, immediately seal recharge wells and infiltration basins

4. Monitor Ambient Temperature

Extreme heat is growing to become a major climate risk with demonstrable impacts on health, fatalities, and losses in work productivity. For this reason, the Sponge Park manual specifically provides guidelines for urban forests and extensive planting for the purposes of rainwater interception, soil health, as well as their ability to cool ambient temperature through shade and evapotranspiration. In order to quantify these benefits, simple scanners can be systematically deployed during summers to quantify the following:

- How much is the ambient temperature within shaded and unshaded parts of the Sponge Park compared to shaded and unshaded parts over asphalt roads and urban plazas?
- Has urban heat island effect and heat waves increased in the neighbourhood of the Sponge Park?
- If so, increase green canopy cover in Sponge Park

5. Audit Park Activity

The role of Sponge Parks as a recreational open space is elevated through the integration of social amenities with BGI as per the manual guidelines. This role directly benefits community well-being and the health of park users and indirectly improve the

quality of life that can raise real estate values. While the benefit to real estate can be quantified through other datasets, the following should be monitored to quantify the recreational usage of the park and ensure that BGI components do not disrupt social use:

- How many people use the park and at what hours over the weekday and weekend? Is the park used after sunset?
- Has park attendance, programming, and recreational activity increased or decreased after upgrading into Sponge Park?
- If activity has decreased, decommission and rebuild BGI components for increased social activity and visual engagement

6. Monitoring Biodiversity and Landscape Health

Finally, the role of the Sponge Park as an urban habitat is not traditionally valued but monitoring them is crucial to ensure the maintenance regime is well implemented based on the following observations:

- Are plants and vegetation in blue-green infrastructure healthy and well maintained
- Has biodiversity of flora, fauna (bird sightings, pollinator species, insects) increased or decreased over time.
- If decrease in biodiversity or proliferation of invasive species is observed, develop action plan for Sponge Park restoration

By monitoring these indicators, the cost-benefit evidence for Sponge Parks can be built for the Indian context and a scientific basis for the upgrading or decommissioning of Sponge Parks due to climate change or health impacts is also established.

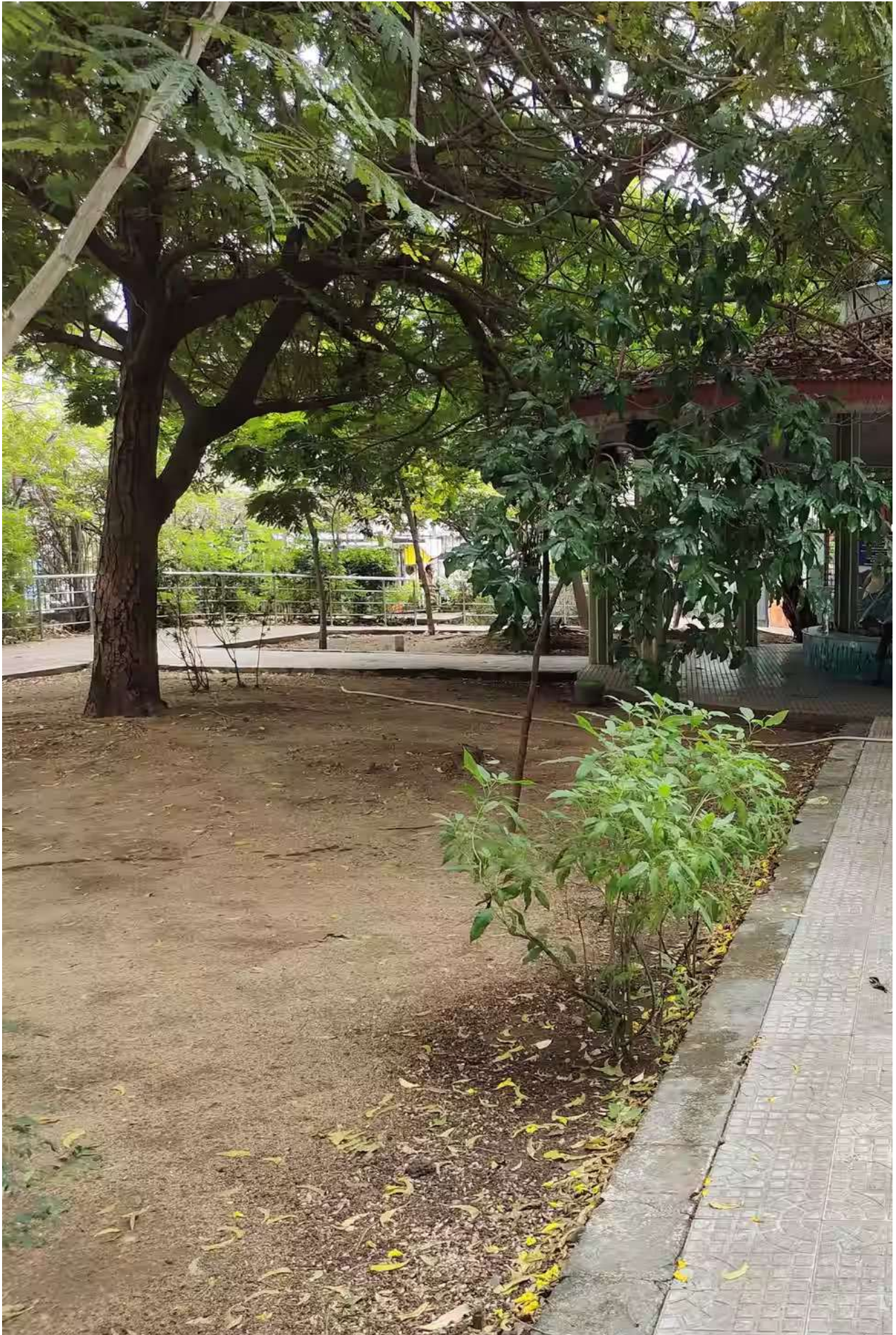


Image Credit - Chennai Corporation Park

ANNEXURE

- A. Detailed Tables for OSRs and Wards
- B. Detailed Guides
- C. Interviews
- D. Workshop Proceedings
- E. Sample ToRs

A. Detailed Tables for OSRs and Wards

A.1. List of Priority OSRs for Sponge Park Upgrade

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil Type
1	955	1	7	Kcp road indiragandhi nagar	M	0.54	Sand
2	956		7	Kcp road indiragandhi nagar	M	0.28	Sand
3	957		7	Anna malai nagar main road	M	0.30	Sand
4	958		7	Balakrishna nagar vinayagapuram 2nd st	M	0.26	Sand
5	409		11	Thiruvottriyur high road	M	0.52	Sand
6	410		11	Ellaiamman koil street extention	M	0.35	Sand
7	411		11	State bank colony 2nd street	S	0.06	Sand
8	412		11	Tirupura sundari nagar	M	0.33	Sand
9	854		13	Udaiyasuriyan 1st street	S	0.15	Sand
10	417	3	29	Thanikachalam nagar e blk rajaji 5th st	S	0.07	Sand
11	420		29	Vgp santhosham nagar main road	M	0.23	Sand
12	414		29	Thanikachalam nagar a blk 4th main road	M	0.25	Sand
13	416		29	Sarangabani street	M	0.44	Sand
14	418		29	Selvam nagar extension,ponniammanmedu	S	0.08	Sand
15	419		29	Thanikachlam ngr e blk mahatma gandhi 2nd	S	0.06	Sand
16	413		29	Thanikachalam nagar b blk 5/2 street	M	0.35	Clay
17	538	4	34	Venkateswara nagar (part-ii) 2nd street	S	0.15	Sand
18	539		34	Vijayalakshmi nagar 1st street	S	0.04	Sand
19	540		34	Sr nagar 2nd street	S	0.11	Sand
20	525		34	Venkateswara colony 5th street	S	0.16	Sand
21	533		34	Thai nagar 2nd street	M	0.22	Sand
22	534		34	Thendral nagar 4th street	S	0.19	Sand
23	531		34	Cauvery nagar main road	M	0.29	Sand
24	535		34	Jai balaji nagar 1st street	S	0.04	Sand
25	536		34	Union carbide colony 9th street	M	0.85	Sand
26	651		35	G.N.T road	M	0.23	Sand
27	652		35	President krishnan street	M	0.28	Sand
28	764		36	16th west cross street	S	0.13	Sand
29	766		40	Illaya st	M	0.72	Sand
30	601		40	New vaidyanathan street	L	1.32	Sand
31	602		40	Cross road	S	0.14	Sand
32	765		40	Illaya St	M	0.86	Sand
33	121		41	J.J. Nagar, C10 Block 1st Street,	S	0.02	Sand
34	863		47	C.B. Road	M	0.99	Sand

Geology	Flood Susceptibility	Aquifer Firka Category	Park Access (within 10 mins of OSR)	Ward Park Need Category	OSR Ranking
Coastal Alluvium	5Y RP	Semi-critical	1	High	27
Coastal Alluvium	25Y RP	Semi-critical	1	High	26
Coastal Alluvium	25Y RP	Semi-critical	1	High	26
Coastal Alluvium	25Y RP	Semi-critical	1	High	26
Coastal Alluvium	Very Low	Semi-critical	1	High	23
Coastal Alluvium	Very Low	Semi-critical	1	High	23
Coastal Alluvium	Very Low	Semi-critical	1	High	23
Coastal Alluvium	Very Low	Semi-critical	1	High	23
Coastal Alluvium	100Y RP	Overexploited	None	Highest	26
Laterite	5Y RP	Overexploited	None	Highest	26
Laterite	5Y RP	Overexploited	None	Highest	26
Laterite	5Y RP	Overexploited	1	Highest	25
Laterite	5Y RP	Overexploited	1	Highest	25
Laterite	5Y RP	Overexploited	1	Highest	25
Laterite	5Y RP	Overexploited	1	Highest	25
Alluvium	5Y RP	Overexploited	2-4	Highest	22
Alluvium	5Y RP	Semi-critical	2-4	High	25
Alluvium	5Y RP	Semi-critical	2-4	High	25
Alluvium	5Y RP	Semi-critical	2-4	High	25
Alluvium	25Y RP	Semi-critical	2-4	High	24
Alluvium	25Y RP	Overexploited	1	High	24
Alluvium	25Y RP	Overexploited	1	High	24
Alluvium	100Y RP	Semi-critical	2-4	High	23
Alluvium	Very Low	Semi-critical	1	High	22
Alluvium	100Y RP	Semi-critical	5-10	High	22
Alluvium	5Y RP	Overexploited	2-4	Highest	25
Alluvium	5Y RP	Overexploited	2-4	Highest	25
Coastal Alluvium	100Y RP	Overexploited	5-10	Highest	23
Coastal Alluvium	25Y RP	Overexploited	5-10	High	23
Coastal Alluvium	Low	Overexploited	2-4	High	22
Coastal Alluvium	100Y RP	Overexploited	5-10	High	22
Coastal Alluvium	100Y RP	Overexploited	5-10	High	22
Coastal Alluvium	Low	Overexploited	None	High	24
Coastal Alluvium	5Y RP	Overexploited	None	Highest	28

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil Type
35	124	4	47	J.J. Nagar, B Street,	S	0.01	Sand
36	122		47	Periyar Salai (Anna Nagar Main Road)	M	0.29	Sand
37	123		47	J.J. Nagar, A1 Street,	S	0.06	Sand
38	125		47	J.J. Nagar, D Street,	S	0.03	Sand
39	126		47	J.J. Nagar, H Street,	S	0.01	Sand
40	995	5	61	Pantheon Road	S	0.07	Sand
41	994		61	Ethiraj Lane	S	0.16	Sand
42	865		63	Biyram Jung Bahadur Street	M	0.22	Sand
43	201	6	67	Pallavan Salai	M	0.32	Clay
44	182		68	Jawahar Nagar 2nd Circular Road	M	0.33	Clay
45	183		68	Jawahar Nagar 1st Circular Road	M	0.65	Clay
46	184		68	Jawahar Nagar 2nd Circular Road	S	0.12	Clay
47	185		68	Jawahar Nagar 5th Main Road	M	0.73	Clay
48	186		68	Jawahar Nagar 2nd Cross Street	M	0.82	Clay
49	1002		75	Barrakka Road	S	0.04	Clay
50	1004		75	Pumping Station Road	M	0.28	Clay
51	85		76	Perambur Barracks Road	L	1.20	Sand
52	82		76	Chellappa Street	M	0.46	Clay
53	84		76	Perambur Barracks Road	S	0.02	Clay
54	86		76	Strahans Road	M	0.67	Clay
55	156		77	Basin Elephant Gate Road	M	0.28	Sand
56	45	8	99	Evr Lane	S	0.05	Clay
57	48		99	Brickklin Road	M	0.21	Clay
58	49		99	Brickklin Road	L	1.40	Clay
59	44		100	Kilpauk Garden Rd	S	0.15	Clay
60	46		100	Periyar E.V.R. Salai	M	0.29	Clay
61	47		100	Harleys Lane	S	0.05	Clay
62	89		105	Kalki Nagar Main Road	S	0.03	Sand
63	90		105	Kalki Nagar 2nd Street	S	0.05	Sand
64	941	9	115	Whites Road (Osr Land)	M	0.22	Sand
65	999		117	Anna Salai From Teynampet Signal	S	0.11	Clay
66	72		123	Luz Church Road	S	0.04	Sand
67	1008		127	Duraisampath Street - Kumaran Nagar	S	0.11	Clay
68	1005		127	Ani Street - Chinmaya Nagar Stage II	M	0.22	Clay

Geology	Flood Susceptibility	Aquifer Firka Category	Park Access (within 10 mins of OSR)	Ward Park Need Category	OSR Ranking
Coastal Alluvium	Low	Overexploited	None	Highest	25
Coastal Alluvium	Low	Overexploited	1	Highest	24
Coastal Alluvium	Low	Overexploited	1	Highest	24
Coastal Alluvium	Low	Overexploited	1	Highest	24
Coastal Alluvium	Low	Overexploited	1	Highest	24
Coastal Alluvium	5Y RP	Overexploited	1	High	26
Coastal Alluvium	5Y RP	Overexploited	2-4	High	25
Coastal Alluvium	5Y RP	Overexploited	2-4	High	25
Alluvium	5Y RP	Overexploited	2-4	Highest	22
Coastal Alluvium	5Y RP	Overexploited	5-10	Highest	22
Coastal Alluvium	5Y RP	Overexploited	5-10	Highest	22
Coastal Alluvium	5Y RP	Overexploited	5-10	Highest	22
Coastal Alluvium	5Y RP	Overexploited	5-10	Highest	22
Coastal Alluvium	5Y RP	Overexploited	5-10	Highest	22
Coastal Alluvium	5Y RP	Overexploited	5-10	Highest	22
Coastal Alluvium	5Y RP	Overexploited	2-4	High	22
Coastal Alluvium	25Y RP	Overexploited	1	High	22
Coastal Alluvium	5Y RP	Overexploited	5-10	High	24
Coastal Alluvium	5Y RP	Overexploited	2-4	High	22
Coastal Alluvium	5Y RP	Overexploited	2-4	High	22
Coastal Alluvium	5Y RP	Overexploited	2-4	High	22
Coastal Alluvium	5Y RP	Overexploited	2-4	High	22
Coastal Alluvium	100Y RP	Overexploited	5-10	High	22
Coastal Alluvium	25Y RP	Overexploited	1	High	22
Coastal Alluvium	5Y RP	Overexploited	2-4	High	22
Coastal Alluvium	5Y RP	Overexploited	2-4	High	22
Coastal Alluvium	5Y RP	Overexploited	2-4	High	22
Coastal Alluvium	25Y RP	Overexploited	1	High	22
Coastal Alluvium	25Y RP	Overexploited	1	High	22
Alluvium	Low	Overexploited	2-4	Highest	22
Alluvium	Low	Overexploited	2-4	Highest	22
Coastal Alluvium	Low	Overexploited	2-4	Highest	23
Coastal Alluvium	5Y RP	Overexploited	1	High	23
Coastal Alluvium	5Y RP	Overexploited	1	Highest	27
Alluvium	5Y RP	Semi-critical	None	High	24
Alluvium	5Y RP	Semi-critical	1	High	23

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil Type
69	1007	10	127	Vaikasi Street - Chinmaya Nagar Stage II	M	0.28	Clay
70	1009		127	Samanthi Street - Brindavan Nagar	S	0.05	Clay
71	1010		127	Mullai Street - Brindavan Nagar	S	0.02	Clay
72	67		128	Vembuliamman Koil Street	M	0.21	Clay
73	70		128	Vembuliamman Koil Street	S	0.04	Clay
74	1027		129	State bank colony 1st street	M	0.42	Clay
75	452	11	148	Nesammal nagar annexe	S	0.11	Clay
76	451		148	Kamarajar salai	M	0.68	Clay
77	450		148	Kamarajar salai	L	1.46	Clay
78	654		152	Veerappa nagar main road	M	0.24	Clay
79	655		152	Kadamban st.	M	0.23	Clay
80	782		155	Amman nagar 1st main road	S	0.07	Sand
81	783		155	Thiruvalluvar salai	M	0.23	Sand
82	795		155	Jai balaji nagar	S	0.08	Sand
83	799		155	Kalasathamman koil street	S	0.10	Sand
84	781		155	Kalasanthamman koil street	S	0.12	Sand
85	796		155	Rayala nagar 2nd main road	M	0.27	Sand
86	798		155	Kalasanthamman koil street	M	0.27	Sand
87	793		155	Alagapuri nagar	S	0.14	Sand
88	576	13	179	Sivasundaram avenue 2nd street	M	0.62	Sand
89	573		179	29th cross street	S	0.19	Sand
90	578		179	Sivakamipuram 2nd street	S	0.03	Sand
91	581		179	Cge quarters 2nd street	M	0.21	Sand
92	572		179	Tiger varathachari road	S	0.07	Sand
93	574		179	Cge colony 1st street	M	0.34	Sand
94	575		179	Cge colony 1st street	S	0.17	Sand
95	577		179	Yamuna street	S	0.09	Sand
96	579		179	Rukumani road	M	0.34	Sand
97	580		179	Vaigai street	M	0.66	Sand
98	582		179	Cge quarters 4th street	M	0.25	Sand
99	583		179	M.G.R street	M	0.51	Sand
100	584		179	Gangai street	M	0.97	Sand
101	222	14	181	Kannappa nagar extn	S	0.05	Sand
102	349		183	East coast road	M	0.27	Sand

Geology	Flood Susceptibility	Aquifer Firka Category	Park Access (within 10 mins of OSR)	Ward Park Need Category	OSR Ranking
Alluvium	5Y RP	Semi-critical	1	High	23
Alluvium	100Y RP	Semi-critical	None	High	22
Alluvium	100Y RP	Semi-critical	None	High	22
Alluvium	5Y RP	Semi-critical	5-10	Highest	22
Alluvium	5Y RP	Semi-critical	5-10	Highest	22
Alluvium	5Y RP	Semi-critical	5-10	Highest	22
Alluvium	25Y RP	Semi-critical	None	Highest	24
Alluvium	5Y RP	Semi-critical	2-4	Highest	23
Alluvium	5Y RP	Semi-critical	2-4	High	22
Alluvium	25Y RP	Semi-critical	2-4	Highest	22
Alluvium	25Y RP	Semi-critical	2-4	Highest	22
Alluvium	5Y RP	Semi-critical	2-4	High	25
Alluvium	5Y RP	Semi-critical	2-4	High	25
Alluvium	5Y RP	Semi-critical	2-4	High	25
Alluvium	5Y RP	Semi-critical	2-4	High	25
Alluvium	25Y RP	Semi-critical	2-4	High	24
Alluvium	5Y RP	Semi-critical	5-10	High	24
Alluvium	25Y RP	Semi-critical	2-4	High	24
Alluvium	100Y RP	Semi-critical	5-10	High	22
Coastal Alluvium	5Y RP	Overexploited	1	High	26
Coastal Alluvium	25Y RP	Overexploited	2-4	High	24
Coastal Alluvium	Low	Overexploited	1	High	23
Coastal Alluvium	5Y RP	Safe	2-4	High	23
Coastal Alluvium	Low	Overexploited	2-4	High	22
Coastal Alluvium	25Y RP	Safe	2-4	High	22
Coastal Alluvium	25Y RP	Safe	2-4	High	22
Coastal Alluvium	25Y RP	Safe	2-4	High	22
Coastal Alluvium	Low	Overexploited	2-4	High	22
Coastal Alluvium	25Y RP	Safe	2-4	High	22
Coastal Alluvium	25Y RP	Safe	2-4	High	22
Coastal Alluvium	Low	Overexploited	2-4	High	22
Coastal Alluvium	Low	Overexploited	2-4	High	22
Coastal Alluvium	25Y RP	Safe	5-10	Highest	22
Coastal Alluvium	25Y RP	Safe	2-4	Highest	23

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil Type
103	350	14	183	V.G.P 4th main road	L	1.00	Sand
104	834	15	200	Rajiv gandhi road (old mahabalipuram road)	M	0.76	Sand
105	835		200	Rajiv gandhi road (old mahabalipuram road)	M	0.29	Sand
106	842		200	Rajiv gandhi road (old mahabalipuram road)	S	0.04	Sand
107	843		200	Ellaiamman koil street	M	0.30	Sand
108	844		200	Ellaiamman koil street	M	0.23	Sand
109	845		200	Ellaiamman koil street	S	0.11	Sand
110	846		200	Ellaiamman koil street	M	0.28	Sand
111	847		200	Pazhathotta salai	S	0.07	Sand
112	848		200	Rajiv gandhi road (old mahabalipuram road)	L	3.67	Sand

Geology	Flood Susceptibility	Aquifer Firka Category	Park Access (within 10 mins of OSR)	Ward Park Need Category	OSR Ranking
Coastal Alluvium	Low	Safe	1	Highest	22
Coastal Alluvium	Low	Safe	None	High	22
Coastal Alluvium	Low	Safe	None	High	22
Coastal Alluvium	Low	Safe	None	High	22
Coastal Alluvium	Low	Safe	None	High	22
Coastal Alluvium	Low	Safe	None	High	22
Coastal Alluvium	Low	Safe	None	High	22
Coastal Alluvium	Low	Safe	None	High	22
Coastal Alluvium	Low	Safe	None	High	22
Coastal Alluvium	Low	Safe	None	High	22

A.2. Zonal Summary of OSRs by Typology and Priority, and Wards by Parks Need

Zone	Total OSRs	Small OSRs	Medium OSRs	Large OSRs	Special OSRs	Lowest Priority OSR	Low Priority OSR
1	24	5	18	1	0	0	4
2	84	47	22	12	3	5	18
3	100	39	52	9	0	2	28
4	35	17	17	1	0	0	3
5	10	7	2	0	1	0	0
6	68	30	28	10	0	9	27
7	80	33	39	8	0	42	27
8	68	31	25	9	3	11	21
9	36	18	15	3	0	3	4
10	86	39	42	5	0	13	37
11	130	57	66	7	0	44	45
12	50	16	31	3	0	18	11
13	182	97	73	12	0	52	76
14	59	16	37	6	0	34	19
15	113	28	71	14	0	57	25
TOTAL	1125	480	538	100	7	290	345

Medium Priority OSR	High Priority OSR	Highest Priority OSR	Wards Lower Need	Wards Low Need	Wards Medium Need	Wards High Need	Wards Highest Need	High Priority OSRs in High Need Wards
9	6	5	6	1	1	3	2	9
37	17	7	5	3	0	0	0	0
38	21	11	7	2	0	1	1	7
8	9	15	2	2	4	4	3	23
1	3	6	1	2	4	2	6	3
17	14	1	0	6	0	5	3	13
11	0	0	2	3	6	4	0	0
18	18	0	2	2	6	3	1	8
7	19	3	1	4	7	4	1	3
28	7	1	1	1	2	3	9	8
19	13	9	0	6	2	3	2	13
15	5	1	5	1	3	2	1	0
30	18	6	5	2	1	1	4	13
3	3	0	1	3	0	2	5	3
15	16	0	2	2	3	2	0	9
256	169	65	40	40	39	39	38	112

A.3. Complete List of Wards with Attributes and Park Need

Ward	Area (km2)	% Built-up Area	Greenery Index	Population (Worldpop)	Pop. Density (pp/km2)	No of Parks	Total Area of Parks (m2)	Park Area per Capita (m2/pp)	Park Access Score	Park Need
1	1.73	15.32	0.45	5,785	3,336.97	2	6,139.00	1.06	1.66	Lower Park Need
2	2.92	17.08	0.61	11,045	3,787.76	3	6,160.73	0.56	1.62	Lower Park Need
3	3.16	14.51	0.50	9,843	3,116.25	1	1,061.31	0.11	1.35	Lower Park Need
4	2.08	27.55	0.32	12,568	6,039.69	1	1,738.70	0.14	0.90	Medium Park Need
5	2.32	23.53	0.46	17,099	7,373.56	5	8,550.89	0.50	1.36	Lower Park Need
6	1.38	26.92	0.58	15,115	10,972.00	3	3,481.87	0.23	1.26	Low Park Need
7	7.68	22.28	0.20	96,775	12,604.70	2	1,389.22	0.01	0.88	Medium Park Need
8	0.72	30.86	0.09	11,699	16,156.50	4	4,659.06	0.40	0.77	High Park Need
9	0.68	25.60	0.37	9,461	13,884.10	2	12,279.30	1.30	1.44	Lower Park Need
10	0.52	37.75	0.18	12,362	23,699.00	1	2,079.50	0.17	0.55	Highest Park Need
11	0.63	32.67	0.32	11,857	18,719.90	1	645.38	0.05	0.76	High Park Need
12	0.42	42.32	0.35	10,637	25,274.90	3	2,260.95	0.21	0.69	Highest Park Need
13	0.47	42.05	0.09	11,232	23,851.90	1	129.33	0.01	0.32	Highest Park Need
14	0.67	30.61	0.64	9,837	14,726.20	7	11,851.60	1.20	1.69	Lower Park Need
15	8.70	4.65	0.64	7,711	885.85	1	492.69	0.06	1.68	Lower Park Need
16	10.03	8.79	0.78	18,453	1,840.68	3	7,292.11	0.40	1.91	Lower Park Need
17	6.67	6.82	0.67	19,034	2,852.24	2	2,016.12	0.11	1.72	Lower Park Need
18	8.07	15.11	0.64	60,398	7,481.14	2	3,505.37	0.06	1.48	Lower Park Need
19	4.12	18.56	0.53	46,106	11,199.60	1	1,630.81	0.04	1.27	Low Park Need
20	0.64	27.15	0.45	10,216	16,023.50	3	2,127.94	0.21	1.12	Low Park Need
21	1.87	30.65	0.73	34,724	18,571.30	2	1,967.42	0.06	1.24	Low Park Need
22	2.15	13.01	0.66	15,926	7,396.40	8	10,516.60	0.66	1.92	Lower Park Need
23	4.15	20.29	0.63	49,519	11,920.90	15	10,537.00	0.21	1.74	Lower Park Need
24	2.71	22.91	0.60	37,751	13,925.40	9	6,458.38	0.17	1.49	Lower Park Need
25	3.98	25.36	0.60	61,067	15,336.10	13	21,202.20	0.35	1.61	Lower Park Need

Ward	Area (km2)	% Built-up Area	Greenery Index	Population (Worldpop)	Pop. Density (pp/km2)	No of Parks	Total Area of Parks (m2)	Park Area per Capita (m2/pp)	Park Access Score	Park Need
26	2.15	20.88	0.73	24,573	11,417.40	1	4,648.26	0.19	1.47	Lower Park Need
27	3.64	13.00	0.57	28,996	7,957.41	1	3,222.77	0.11	1.45	Lower Park Need
28	1.31	35.41	0.58	31,322	23,909.40	9	15,609.20	0.50	1.33	Lower Park Need
29	2.28	34.11	0.22	52,239	22,918.20	2	4,092.59	0.08	0.66	Highest Park Need
30	3.10	25.63	0.48	39,772	12,843.70	3	2,693.66	0.07	1.13	Low Park Need
31	2.49	19.56	0.55	26,734	10,747.30	2	10,434.50	0.39	1.42	Lower Park Need
32	4.97	22.75	0.40	50,889	10,245.90	1	760.98	0.01	1.04	Low Park Need
33	0.68	47.76	0.48	8,817	12,905.20	4	3,036.02	0.34	0.77	High Park Need
34	2.44	37.56	0.43	57,202	23,427.20	1	1,639.55	0.03	0.75	High Park Need
35	1.69	43.11	0.43	48,980	28,991.90	2	6,831.42	0.14	0.70	Highest Park Need
36	1.38	44.75	0.52	42,062	30,576.80	2	896.96	0.02	0.71	Highest Park Need
37	4.10	14.93	0.56	43,277	10,552.50	3	2,257.32	0.05	1.44	Lower Park Need
38	1.80	29.64	0.47	33,123	18,398.60	2	407.29	0.01	0.98	Medium Park Need
39	1.04	33.32	0.42	18,378	17,650.60	3	17,775.60	0.97	1.22	Low Park Need
40	1.07	34.59	0.41	27,098	25,394.10	2	3,511.58	0.13	0.86	High Park Need
41	0.89	39.02	0.42	23,308	26,121.80	1	2,551.91	0.11	0.74	High Park need
42	1.08	42.44	0.40	31,568	29,134.70	7	21,007.80	0.67	1.00	Medium Park Need
43	0.99	36.95	0.38	23,189	23,385.70	2	2,262.08	0.10	0.76	High Park Need
44	0.69	48.25	0.50	23,038	33,340.40	2	63,182.40	2.74	1.61	Lower Park Need
45	1.14	41.17	0.62	30,357	26,634.80	4	7,188.75	0.24	1.02	Medium Park Need
46	1.44	26.83	0.43	24,084	16,771.00	1	10,400.70	0.43	1.13	Medium Park Need
47	0.62	41.04	0.30	16,803	26,959.50	2	1,506.77	0.09	0.60	Highest Park Need
48	0.48	43.06	0.34	14,317	29,906.00	11	6,921.50	0.48	0.96	Medium Park Need
49	0.78	47.27	0.37	26,122	33,489.70	7	4,829.80	0.18	0.69	Highest Park Need
50	1.54	34.63	0.32	35,294	22,977.00	1	972.86	0.03	0.71	Highest Park Need

Ward	Area (km2)	% Built-up Area	Greenery Index	Population (Worldpop)	Pop. Density (pp/km2)	No of Parks	Total Area of Parks (m2)	Park Area per Capita (m2/pp)	Park Access Score	Park Need
51	0.40	46.79	0.49	11,247	27,905.90	7	5,726.14	0.51	0.94	Medium Park Need
52	1.04	33.05	0.54	22,967	22,153.10	5	7,532.70	0.33	1.17	Low Park Need
53	0.85	22.55	0.27	13,625	15,963.50	3	2,617.30	0.19	1.02	Medium Park Need
54	0.59	45.64	0.30	17,815	30,015.50	4	3,689.11	0.21	0.59	Highest Park Need
55	0.57	44.77	0.28	17,602	30,691.20	8	15,975.80	0.91	0.95	Medium Park Need
56	0.57	43.11	0.28	16,710	29,492.30	3	7,259.01	0.43	0.68	Highest Park Need
57	0.91	46.84	0.54	29,023	31,970.10	2	1,929.57	0.07	0.70	Highest Park Need
58	2.59	34.24	0.56	61,139	23,569.60	4	8,303.78	0.14	1.07	Low Park Need
59	2.82	28.47	0.29	52,629	18,687.40	3	8,515.15	0.16	0.91	Medium Park Need
60	5.14	23.73	0.57	80,594	15,683.80	4	9,681.01	0.12	1.30	Lower Park Need
61	2.22	35.52	0.34	52,479	23,665.90	3	1,279.55	0.02	0.75	High Park Need
62	0.83	39.44	0.35	23,551	28,256.00	2	3,688.37	0.16	0.70	Highest Park Need
63	0.96	39.78	0.41	26,883	27,891.00	3	2,087.91	0.08	0.76	High Park Need
64	1.58	46.69	0.46	40,774	25,733.50	2	16,702.10	0.41	0.75	High Park Need
65	1.88	44.70	0.38	32,993	17,540.80	3	10,003.00	0.30	0.70	Highest Park Need
66	1.04	49.93	0.40	25,995	25,113.30	7	9,581.54	0.37	0.73	High Park Need
67	0.90	47.65	0.46	28,545	31,737.80	2	7,523.79	0.26	0.68	Highest Park Need
68	1.39	45.57	0.44	41,777	30,093.30	3	3,201.18	0.08	0.66	Highest Park Need
69	1.05	46.93	0.59	32,470	30,957.10	11	24,578.10	0.76	1.23	Low Park Need
70	1.73	36.22	0.45	44,063	25,425.70	6	21,674.60	0.49	1.10	Low Park Need
71	1.53	37.15	0.59	37,027	24,156.90	6	12,365.80	0.33	1.16	Low Park Need
72	1.32	26.99	0.33	25,215	19,121.10	10	12,334.30	0.49	1.28	Lower Park Need
73	0.93	43.35	0.62	26,985	29,066.20	7	10,653.70	0.39	1.11	Lower Park Need
74	0.95	34.75	0.48	22,805	24,021.10	4	18,912.90	0.83	1.23	Lower Park Need
75	0.95	41.10	0.34	25,467	26,735.00	6	4,997.66	0.20	0.78	High Park Need

Ward	Area (km2)	% Built-up Area	Greenery Index	Population (Worldpop)	Pop. Density (pp/km2)	No of Parks	Total Area of Parks (m2)	Park Area per Capita (m2/pp)	Park Access Score	Park Need
76	0.62	43.97	0.45	18,879	30,669.50	7	5,186.13	0.27	0.88	Medium Park Need
77	0.57	38.75	0.33	14,154	24,658.30	2	7,908.20	0.56	0.85	High Park Need
78	0.67	47.76	0.57	21,461	31,911.70	3	6,348.06	0.30	0.83	High Park Need
79	2.09	36.46	0.48	22,101	10,565.90	5	6,952.05	0.31	1.03	Low Park Need
80	1.49	46.15	0.50	18,346	12,351.80	3	3,428.89	0.19	0.75	High Park Need
81	1.66	38.17	0.55	17,522	10,541.10	1	10,736.80	0.61	1.08	Low Park Need
82	3.88	34.04	0.40	33,081	8,531.73	4	12,055.50	0.36	0.99	Medium Park Need
83	6.64	18.48	0.49	51,523	7,761.44	8	96,863.90	1.88	2.07	Lower Park Need
84	3.13	39.23	0.11	35,679	11,387.30	14	21,185.00	0.59	0.93	Medium Park Need
85	4.38	25.71	0.57	30,659	7,001.31	1	503.06	0.02	1.15	Low Park Need
86	6.25	31.18	0.41	51,474	8,236.25	1	1,104.65	0.02	0.87	High Park Need
87	0.96	45.93	0.57	27,804	29,075.70	6	4,045.98	0.15	0.88	High Park Need
88	2.27	35.41	0.49	53,497	23,532.90	5	7,620.96	0.14	1.00	Medium Park Need
89	0.99	42.62	0.52	23,388	23,506.80	2	3,886.56	0.17	0.81	High Park Need
90	1.08	36.66	0.48	27,077	24,985.70	5	13,299.10	0.49	1.09	Low Park Need
91	1.22	40.45	0.46	15,872	13,052.30	12	16,546.50	1.04	1.36	Lower Park Need
92	1.04	41.86	0.43	17,039	16,378.30	4	3,008.25	0.18	0.79	High Park Need
93	1.41	40.23	0.47	38,553	27,321.20	7	13,540.50	0.35	1.00	Medium Park Need
94	1.50	38.33	0.49	41,577	27,689.40	3	83,510.90	2.01	1.57	Lower Park Need
95	2.34	39.41	0.80	60,920	26,049.40	2	1,602.69	0.03	1.10	Low Park need
96	2.75	22.16	0.39	40,688	14,790.50	1	697.42	0.02	1.04	Low Park Need
97	0.74	48.72	0.69	24,023	32,378.80	1	612.10	0.03	0.77	High Park Need
98	1.44	29.61	0.43	29,139	20,290.90	4	3,308.83	0.11	1.03	Low Park Need
99	1.30	40.28	0.55	34,309	26,418.00	2	3,039.67	0.09	0.86	High Park Need
100	2.20	40.58	0.57	59,538	27,003.80	2	1,794.20	0.03	0.86	High Park Need

Ward	Area (km2)	% Built-up Area	Greenery Index	Population (Worldpop)	Pop. Density (pp/km2)	No of Parks	Total Area of Parks (m2)	Park Area per Capita (m2/pp)	Park Access Score	Park Need
101	1.52	39.76	0.57	40,623	26,700.50	3	5,267.67	0.13	0.94	Medium Park Need
102	1.79	38.71	0.58	48,720	27,235.50	1	6,659.71	0.14	0.92	Medium Park Need
103	2.45	39.48	0.59	64,986	26,562.40	3	17,703.00	0.27	1.01	Medium Park Need
104	2.28	39.81	0.39	63,934	27,991.00	7	35,839.80	0.56	1.01	Medium Park Need
105	1.31	45.98	0.36	42,061	32,050.40	4	6,408.80	0.15	0.62	Highest Park Need
106	0.88	50.37	0.41	28,223	31,902.40	18	37,800.40	1.34	1.36	Lower Park Need
107	1.25	45.24	0.60	38,884	31,166.00	7	6,415.20	0.16	0.96	Medium Park Need
108	1.53	34.53	0.39	35,545	23,218.10	15	14,330.00	0.40	1.27	Lower Park Need
109	0.94	49.89	0.67	32,380	34,360.50	2	6,912.88	0.21	0.82	High Park Need
110	2.05	32.97	0.57	45,041	21,937.40	5	5,127.97	0.11	1.12	Low Park Need
111	2.72	37.06	0.47	71,498	26,314.90	3	53,723.60	0.75	1.12	Low Park Need
112	1.06	45.07	0.50	30,081	28,367.90	6	10,395.50	0.35	0.90	Medium Park Need
113	1.69	42.72	0.37	50,603	29,954.30	5	18,446.80	0.36	0.81	High Park Need
114	1.76	26.13	0.41	28,811	16,376.40	4	5,765.11	0.20	1.12	Low Park Need
115	0.85	40.89	0.36	22,350	26,233.40	3	4,847.12	0.22	0.73	High Park Need
116	0.68	39.50	0.51	17,663	25,978.40	2	1,904.68	0.11	0.85	High Park Need
117	1.33	44.44	0.58	38,487	28,978.80	2	3,166.49	0.08	0.80	High Park Need
118	1.91	37.81	0.53	51,360	26,928.00	4	5,651.68	0.11	0.95	Medium Park Need
119	1.39	43.25	0.56	39,997	28,844.30	40	54,966.00	1.37	2.23	Lower Park Need
120	0.53	34.65	0.48	11,392	21,347.30	2	534.39	0.05	0.90	Medium Park Need
121	0.92	36.43	0.66	23,505	25,423.80	1	362.49	0.02	1.00	Medium Park Need
122	1.82	35.53	0.56	42,731	23,535.60	3	2,526.65	0.06	0.99	Medium Park Need
123	2.24	42.00	0.38	64,684	28,876.10	1	19.14	0.00	0.60	Highest Park Need
124	1.02	42.24	0.47	29,827	29,100.40	6	9,657.38	0.32	0.93	Medium Park Need
125	1.24	36.55	0.49	28,325	22,865.40	8	8,562.26	0.30	1.11	Low Park Need

Ward	Area (km2)	% Built-up Area	Greenery Index	Population (Worldpop)	Pop. Density (pp/km2)	No of Parks	Total Area of Parks (m2)	Park Area per Capita (m2/pp)	Park Access Score	Park Need
126	1.04	39.58	0.49	25,259	24,286.80	6	6,431.67	0.25	0.98	Medium Park Need
127	3.86	34.38	0.42	90,376	23,427.90	2	1,166.02	0.01	0.83	High Park Need
128	1.60	46.43	0.46	49,178	30,815.60	4	2,226.78	0.05	0.67	Highest Park Need
129	1.90	45.69	0.36	58,410	30,766.40	3	1,420.41	0.02	0.56	Highest Park Need
130	1.20	50.94	0.45	43,435	36,131.40	6	2,987.98	0.07	0.63	Highest Park Need
131	1.05	48.40	0.50	34,839	33,335.90	19	32,219.70	0.92	1.37	Lower Park Need
132	1.10	45.65	0.49	34,162	31,156.30	9	14,822.80	0.43	0.99	Medium Park Need
133	1.84	43.38	0.40	53,421	29,063.00	1	374.89	0.01	0.59	Highest Park Need
134	0.95	50.49	0.56	31,280	33,070.00	1	1,323.89	0.04	0.61	Highest Park Need
135	1.48	41.18	0.57	42,198	28,542.20	4	2,710.24	0.06	0.91	Medium Park Need
136	1.19	41.83	0.45	32,000	26,817.50	4	2,096.32	0.07	0.77	High Park Need
137	1.62	42.94	0.43	46,888	28,910.40	2	717.33	0.02	0.66	Highest Park Need
138	1.26	45.47	0.38	36,207	28,640.00	1	1,252.54	0.03	0.54	Highest Park Need
139	0.72	50.01	0.39	26,645	36,801.30	5	3,739.90	0.14	0.59	Highest Park Need
140	0.76	50.46	0.46	23,111	30,375.10	1	947.42	0.04	0.51	Highest Park Need
141	0.78	44.88	0.36	24,639	31,656.20	16	13,774.70	0.56	1.10	
142	1.07	47.28	0.57	33,078	31,040.20	5	5,382.24	0.16	0.83	High Park Need
143	2.60	29.16	0.55	21,045	8,103.67	4	8,859.13	0.42	1.27	
144	1.39	36.04	0.49	26,557	19,134.30	6	14,894.40	0.56	1.17	
145	1.51	35.22	0.41	38,602	25,521.10	13	16,304.40	0.42	1.23	
146	1.08	46.64	0.51	13,454	12,450.80	3	5,488.23	0.41	0.83	High Park Need
147	2.05	40.31	0.35	23,957	11,701.90	7	11,858.30	0.49	0.93	Medium Park Need
148	0.88	50.85	0.51	29,376	33,283.80	1	2,432.54	0.08	0.57	Highest Park Need
149	1.42	44.74	0.53	43,575	30,764.60	4	2,093.74	0.05	0.78	High Park Need
150	3.54	27.97	0.48	26,269	7,429.92	3	2,700.81	0.10	1.09	
151	1.66	36.50	0.54	20,343	12,224.90	7	5,817.76	0.29	1.13	
152	1.60	42.14	0.04	44,017	27,436.40	6	10,882.70	0.25	0.47	Highest Park Need

Ward	Area (km2)	% Built-up Area	Greenery Index	Population (Worldpop)	Pop. Density (pp/km2)	No of Parks	Total Area of Parks (m2)	Park Area per Capita (m2/pp)	Park Access Score	Park Need
153	2.27	31.23	0.44	19,194	8,471.59	5	6,124.43	0.32	1.11	
154	1.17	41.36	0.46	30,279	25,841.70	9	11,025.80	0.36	1.02	Medium Park Need
155	1.54	42.52	0.54	45,198	29,254.60	4	3,659.65	0.08	0.85	High Park Need
156	2.78	39.20	0.78	28,143	10,130.20	7	12,926.60	0.46	1.38	
157	4.57	17.98	0.78	27,430	5,996.13	3	5,400.57	0.20	1.64	
158	2.01	13.84	0.59	18,076	8,985.93	7	6,363.07	0.35	1.70	
159	3.37	8.19	0.39	6,574	1,951.69	1	240.46	0.04	1.35	
160	0.67	41.45	0.45	17,863	26,661.40	7	9,227.28	0.52	1.02	Medium Park Need
161	0.79	41.12	0.48	22,741	28,916.50	3	1,951.90	0.09	0.80	High Park Need
162	1.24	36.64	0.37	20,001	16,128.10	4	2,022.10	0.10	0.81	High Park Need
163	0.76	46.80	0.39	25,552	33,651.60	12	19,884.20	0.78	1.06	
164	0.60	47.44	0.43	11,514	19,069.80	2	1,584.70	0.14	0.60	Highest Park Need
165	1.16	42.90	0.56	34,253	29,505.00	3	13,089.60	0.38	0.95	Medium Park Need
166	1.30	30.99	0.45	16,530	12,714.90	2	1,786.22	0.11	0.97	Medium Park Need
167	1.14	47.22	0.56	17,767	15,647.00	9	21,684.10	1.22	1.31	
168	3.56	33.27	0.74	80,892	22,704.20	1	2,360.13	0.03	1.16	Low Park Need
169	3.77	22.61	0.76	52,386	13,903.40	6	19,976.30	0.38	1.66	
170	2.70	26.05	0.55	47,962	17,757.00	8	17,166.10	0.36	1.42	
171	3.35	23.90	1.00	49,391	14,744.00	4	13,633.00	0.28	1.78	
172	8.38	11.78	0.51	69,832	8,337.06	15	21,471.20	0.31	1.85	
173	2.74	35.11	0.75	66,721	24,386.70	18	31,317.60	0.47	1.71	
174	3.46	21.32	0.42	48,179	13,914.40	3	10,944.20	0.23	1.22	Low Park Need
175	1.44	42.93	0.40	44,653	31,083.30	0	0.00	0.00	0.57	Highest Park Need
176	1.79	46.66	0.45	55,193	30,899.30	0	0.00	0.00	0.54	Highest Park Need
177	2.78	42.97	0.55	79,282	28,515.50	0	0.00	0.00	0.72	Highest Park Need
178	2.70	30.59	0.58	56,526	20,918.50	0	0.00	0.00	1.02	Medium Park Need
179	1.87	35.58	0.50	41,668	22,250.70	0	0.00	0.00	0.83	High Park Need
180	1.82	40.26	0.45	47,656	26,174.30	0	0.00	0.00	0.69	Highest Park Need
181	1.63	41.32	0.44	37,315	22,958.00	0	0.00	0.00	0.65	Highest Park Need

Ward	Area (km2)	% Built-up Area	Greenery Index	Population (Worldpop)	Pop. Density (pp/km2)	No of Parks	Total Area of Parks (m2)	Park Area per Capita (m2/pp)	Park Access Score	Park Need
182	3.28	36.26	0.43	31,632	9,644.87	0	0.00	0.00	0.75	High Park Need
183	1.54	39.82	0.49	17,977	11,671.10	0	0.00	0.00	0.73	High Park Need
184	3.12	33.89	0.42	46,503	14,918.00	0	0.00	0.00	0.79	High Park Need
185	0.95	48.11	0.41	26,985	28,541.00	0	0.00	0.00	0.47	Highest Park Need
186	2.39	41.86	0.23	59,567	24,974.70	0	0.00	0.00	0.42	Highest Park Need
187	0.99	39.63	0.44	29,731	29,982.40	0	0.00	0.00	0.68	Highest Park Need
188	3.42	37.38	0.77	71,997	21,033.70	0	0.00	0.00	1.06	Low Park Need
189	10.20	11.93	0.59	34,771	3,409.52	0	0.00	0.00	1.43	
190	3.06	25.91	0.74	23,761	7,753.71	0	0.00	0.00	1.28	
191	4.16	18.08	0.53	20,614	4,953.17	0	0.00	0.00	1.24	Low Park Need
192	2.55	36.60	0.45	28,400	11,123.90	0	0.00	0.00	0.76	High Park Need
193	2.08	33.94	0.57	19,809	9,515.00	0	0.00	0.00	0.94	Medium Park Need
194	4.51	26.77	0.51	35,506	7,866.94	0	0.00	0.00	1.03	Medium Park Need
195	2.49	32.68	0.50	25,572	10,276.60	0	0.00	0.00	0.90	
196	1.55	28.94	0.69	12,420	8,001.19	0	0.00	0.00	1.17	
197	8.47	17.36	0.53	43,885	5,179.42	0	0.00	0.00	1.26	
198	6.30	21.48	0.67	33,455	5,309.98	0	0.00	0.00	1.31	
199	8.07	13.45	0.70	31,367	3,884.61	0	0.00	0.00	1.51	
200	7.52	11.52	0.00	22,690	3,018.48	0	0.00	0.00		High Park Need

A.4. Complete List of OSRs with Attributes

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
1	603	1	1	Tnscb-housing	M	0.45	Sand	Coastal Alluvium
2	604	1	2	Nehru nagar foundries 2nd street	M	0.24	Sand	Coastal Alluvium
3	954	1	3	Tamilnadu slum clearance board block 2	L	1.13	Sand	Coastal Alluvium
4	953	1	3	Tamilnadu slum clearance board block 2	M	0.52	Sand	Coastal Alluvium
5	727	1	5	Srirangam new town 9th cross street	M	0.92	Sand	Coastal Alluvium
6	731	1	5	Ennore express road	M	0.35	Sand	Coastal Alluvium
7	726	1	5	Tiruvottriyur high road	M	0.29	Sand	Coastal Alluvium
8	728	1	5	Neithal nagar 2nd street	M	0.24	Sand	Coastal Alluvium
9	729	1	5	Neithal nagar 3rd street	M	0.24	Sand	Coastal Alluvium
10	730	1	5	Sakthipuram 2nd street	M	0.24	Sand	Coastal Alluvium
11	955	1	7	Kcp road indiragandhi nagar	M	0.54	Sand	Coastal Alluvium
12	956	1	7	Kcp road indiragandhi nagar	M	0.28	Sand	Coastal Alluvium
13	957	1	7	Anna malai nagar main road	M	0.30	Sand	Coastal Alluvium
14	958	1	7	Balakrishna nagar vinayagapuram 2nd st	M	0.26	Sand	Coastal Alluvium
15	605	1	9	Village street	S	0.01	Sand	Coastal Alluvium
16	409	1	11	Thiruvottriyur high road	M	0.52	Sand	Coastal Alluvium
17	410	1	11	Ellaiamman koil street extention	M	0.35	Sand	Coastal Alluvium
18	411	1	11	State bank colony 2nd street	S	0.06	Sand	Coastal Alluvium
19	412	1	11	Tirupura sundari nagar	M	0.33	Sand	Coastal Alluvium
20	854	1	13	Udaiyasuriyan 1st street	S	0.15	Sand	Coastal Alluvium
21	0	1	14	A'sathananddhapuram	M	0.45	Sand	Coastal Alluvium
22	1	1	14	Ondikuppam	S	0.16	Sand	Coastal Alluvium
23	2	1	14	Thiruchinankuppam road	S	0.04	Sand	Coastal Alluvium
24	3	1	14	Thiruchinankuppam road	M	0.22	Sand	Coastal Alluvium
25	305	2	15	Thulasi nagar	M	0.56	Sand	Alluvium
26	306	2	15	New colony 2nd street	M	0.23	Sand	Alluvium
27	308	2	15	Old colony	S	0.12	Sand	Alluvium
28	298	2	15	Manali new town 54th block 24 ft road 45th street	M	0.51	Sand	Alluvium
29	307	2	15	Manali new town 42th block 24 feet road 17th street	M	0.37	Sand	Alluvium
30	303	2	15	Manali new town 22nd block 30 feet road 10thstreet	L	1.28	Sand	Alluvium
31	304	2	15	Ponnamman nagar 3rd street(cross street to end)	S	0.19	Sand	Alluvium
32	299	2	15	Manali new town 63th block 30 ft road 46th street	S	0.19	Sand	Alluvium
33	300	2	15	Manali new town 65th block 30 ft road 50th street	S	0.20	Sand	Alluvium
34	301	2	15	Manali new town 31th block 20 feet road 31st street	M	0.40	Sand	Alluvium
35	302	2	15	Manali new town 18th block 30 feet road 11th street	L	1.22	Sand	Alluvium
36	282	2	16	Tnhb phase 2 block 3 20 feet road 2nd street	M	0.89	Sand	Alluvium
37	283	2	16	Tnhb phase 1 block 5 20 feet road 2nd street	L	1.48	Sand	Alluvium

Flood Susceptibility	Aquifer Firka Category	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	“High Priority OSR in High Need Ward”
Very Low	Saline	1	Lowest	18	
Very Low	Saline	None	Lowest	19	
25Y RP	Semi-critical	2-4	Lowest	22	
Very Low	Semi-critical	2-4	Lowest	19	
25Y RP	Semi-critical	2-4	Lowest	22	
Very Low	Semi-critical	None	Lowest	21	
Very Low	Semi-critical	1	Lowest	20	
Very Low	Semi-critical	1	Lowest	20	
Very Low	Semi-critical	1	Lowest	20	
Very Low	Semi-critical	2-4	Lowest	19	
5Y RP	Semi-critical	1	High	27	Yes
25Y RP	Semi-critical	1	High	26	Yes
25Y RP	Semi-critical	1	High	26	Yes
25Y RP	Semi-critical	1	High	26	Yes
Very Low	Semi-critical	None	Lowest	21	
Very Low	Semi-critical	1	High	23	Yes
Very Low	Semi-critical	1	High	23	Yes
Very Low	Semi-critical	1	High	23	Yes
Very Low	Semi-critical	1	High	23	Yes
100Y RP	Overexploited	None	Highest	26	Yes
Very Low	Overexploited	None	Lowest	20	
Very Low	Semi-critical	1	Lowest	20	
Very Low	Overexploited	None	Lowest	20	
Very Low	Overexploited	None	Lowest	20	
5Y RP	Safe	None	Lowest	21	
5Y RP	Safe	None	Lowest	21	
5Y RP	Safe	None	Lowest	21	
25Y RP	Semi-critical	5-10	Lowest	20	
5Y RP	Safe	2-4	Lowest	19	
25Y RP	Safe	2-4	Lowest	18	
25Y RP	Safe	2-4	Lowest	18	
25Y RP	Safe	5-10	Lowest	17	
25Y RP	Safe	5-10	Lowest	17	
25Y RP	Safe	5-10	Lowest	17	
25Y RP	Safe	5-10	Lowest	17	
5Y RP	Semi-critical	None	Lowest	24	
25Y RP	Semi-critical	1	Lowest	22	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
38	285	2	16	R I nagar	M	0.51	Sand	Alluvium
39	314	2	16	Ponneri panjetty salai	M	0.48	Sand	Alluvium
40	279	2	16	Manali new town 52nd block 24 feet road 63rdst	M	0.27	Sand	Alluvium
41	281	2	16	Tnhb phase 2 block 120 feet road 2nd street	S	0.12	Sand	Alluvium
42	284	2	16	Mrb nagar	L	1.46	Sand	Alluvium
43	286	2	16	Thanigai nagar	L	1.37	Sand	Alluvium
44	276	2	16	Manali new town 135th block 30 feet road 88th st	M	0.23	Sand	Alluvium
45	277	2	16	Manali new town 102th block 24 feet road 81street	M	0.40	Sand	Alluvium
46	278	2	16	Manali new town 99th block 24 feet road 79thstreet	S	0.19	Sand	Alluvium
47	280	2	16	Manali new town 78th block 16 feet road 78th street	S	0.07	Sand	Alluvium
48	296	2	17	Thiyagi viswanandha dass nagar	M	0.28	Sand	Alluvium
49	297	2	17	Thiyagi viswanandha dass nagar	M	0.26	Sand	Alluvium
50	290	2	17	C.K.Madhavan nagar	M	0.37	Laterite & Sandstone	Alluvium
51	293	2	17	Thiyagi viswanandha dass nagar	M	0.69	Laterite & Sandstone	Alluvium
52	288	2	17	Thirupathi devasthanam nagar	M	0.31	Laterite & Sandstone	Alluvium
53	291	2	17	V.C.N. Salai	L	1.02	Laterite & Sandstone	Alluvium
54	292	2	17	Vadaperumbakkam road	S	0.14	Laterite & Sandstone	Alluvium
55	294	2	17	Thiyagi viswanandha dass nagar	M	0.30	Laterite & Sandstone	Alluvium
56	295	2	17	Thiyagi viswanandha dass nagar	M	0.31	Laterite & Sandstone	Alluvium
57	289	2	17	V.C.N. Salai	S	0.07	Laterite & Sandstone	Alluvium
58	315	2	18	Ponneri panjetty salai	L	2.53	Sand	Alluvium
59	313	2	18	Cpcl layout 7th cross street	M	0.59	Sand	Alluvium
60	311	2	18	Vaikkadu cpcl layout	L	1.09	Sand	Alluvium
61	312	2	18	Cpcl layout 4th street	S	0.05	Sand	Alluvium
62	309	2	18	Vimalapuram 2nd street	S	0.12	Sand	Alluvium
63	310	2	18	Vimalapuram 1st street	S	0.01	Sand	Alluvium
64	379	2	19	Chinnasamy nagar 1st street	S	0.18	Sand	Alluvium
65	382	2	19	Cpcl 3rd main road	S	0.14	Sand	Alluvium
66	408	2	19	Cpcl 12th street	S	0.09	Sand	Alluvium
67	383	2	19	Cpcl 1st street	S	0.03	Sand	Alluvium
68	384	2	19	Cpcl 2nd street	S	0.03	Sand	Alluvium
69	385	2	19	Cpcl 3rd street	S	0.03	Sand	Alluvium
70	386	2	19	Cpcl 13th street	S	0.18	Sand	Alluvium
71	393	2	19	Ponnusamy nagar	M	0.22	Sand	Alluvium
72	380	2	19	Teacher's colony	S	0.02	Sand	Alluvium
73	399	2	19	Mmda 105th street	S	0.06	Sand	Alluvium
74	374	2	19	Mmda 26th street	S	0.06	Sand	Alluvium

Flood Susceptibility	Aquifer Firka Category"	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	"High Priority OSR in High Need Ward"
5Y RP	Semi-critical	2-4	Lowest	22	
25Y RP	Semi-critical	1	Lowest	22	
5Y RP	Semi-critical	5-10	Lowest	21	
25Y RP	Semi-critical	2-4	Lowest	21	
5Y RP	Semi-critical	5-10	Lowest	21	
25Y RP	Semi-critical	2-4	Lowest	21	
25Y RP	Semi-critical	5-10	Lowest	20	
25Y RP	Semi-critical	5-10	Lowest	20	
25Y RP	Semi-critical	5-10	Lowest	20	
25Y RP	Semi-critical	5-10	Lowest	20	
5Y RP	Semi-critical	None	Lowest	24	
5Y RP	Semi-critical	None	Lowest	24	
5Y RP	Semi-critical	None	Lowest	23	
5Y RP	Semi-critical	None	Lowest	23	
5Y RP	Semi-critical	2-4	Lowest	21	
100Y RP	Semi-critical	1	Lowest	20	
Low	Semi-critical	None	Lowest	20	
Low	Semi-critical	None	Lowest	20	
Low	Semi-critical	None	Lowest	20	
Very Low	Semi-critical	2-4	Lowest	17	
5Y RP	Semi-critical	1	Lowest	23	
25Y RP	Semi-critical	2-4	Lowest	21	
100Y RP	Semi-critical	2-4	Lowest	20	
100Y RP	Semi-critical	2-4	Lowest	20	
Low	Semi-critical	2-4	Lowest	19	
Very Low	Semi-critical	2-4	Lowest	18	
25Y RP	Semi-critical	None	Low	24	
25Y RP	Semi-critical	None	Low	24	
25Y RP	Semi-critical	None	Low	24	
100Y RP	Semi-critical	None	Low	23	
100Y RP	Semi-critical	None	Low	23	
100Y RP	Semi-critical	None	Low	23	
100Y RP	Semi-critical	None	Low	23	
100Y RP	Semi-critical	None	Low	23	
Low	Semi-critical	None	Low	22	
25Y RP	Semi-critical	2-4	Low	22	
Low	Semi-critical	1	Low	21	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
75	376	2	19	200 Feet erikarai	M	0.25	Sand	Alluvium
76	387	2	19	Gokulam street	S	0.19	Sand	Alluvium
77	404	2	19	Mmda 91th street	S	0.06	Sand	Alluvium
78	369	2	19	Mmda 52th street	S	0.06	Sand	Alluvium
79	372	2	19	Mmda 19th street	S	0.06	Sand	Alluvium
80	373	2	19	Mmda 21st street	S	0.06	Sand	Alluvium
81	375	2	19	Mmda 50th street	S	0.06	Sand	Alluvium
82	381	2	19	Kamarajar salai	S	0.02	Sand	Alluvium
83	388	2	19	Mmda 4th street	S	0.05	Sand	Alluvium
84	389	2	19	Mmda 10th street	S	0.05	Sand	Alluvium
85	390	2	19	Mmda 34th street	S	0.06	Sand	Alluvium
86	391	2	19	Mmda 30th street	S	0.06	Sand	Alluvium
87	392	2	19	Mmda 113th street	S	0.06	Sand	Alluvium
88	395	2	19	Mmda 6th street	S	0.05	Sand	Alluvium
89	407	2	19	Mmda 111th street	S	0.13	Sand	Alluvium
90	370	2	19	Mmda 118th street	S	0.07	Sand	Alluvium
91	371	2	19	Mmda 77th street	L	2.03	Sand	Alluvium
92	378	2	19	Kamarajar salai	S	0.20	Sand	Alluvium
93	394	2	19	Mmda 2nd main road	L	2.96	Sand	Alluvium
94	396	2	19	Mmda 39th street	S	0.06	Sand	Alluvium
95	397	2	19	Mmda 41th street	S	0.06	Sand	Alluvium
96	398	2	19	Mmda 40th street	S	0.06	Sand	Alluvium
97	400	2	19	Mmda 74th street	S	0.06	Sand	Alluvium
98	401	2	19	Mmda 64th street	S	0.06	Sand	Alluvium
99	402	2	19	Mmda 63th street	S	0.06	Sand	Alluvium
100	403	2	19	Mmda 83th street	S	0.06	Sand	Alluvium
101	405	2	19	Mmda 71th street	S	0.06	Sand	Alluvium
102	406	2	19	Mmda 72th street	S	0.07	Sand	Alluvium
103	316	2	20	Chinnamathur road	M	0.47	Sand	Alluvium
104	520	2	22	Kamarajar street	X	7.75	Sand	Alluvium
105	521	2	22	Kamarajar street	X	5.96	Sand	Alluvium
106	524	2	22	Parthasarathy street	X	5.19	Sand	Alluvium
107	522	2	22	Kamarajar street	L	2.50	Sand	Alluvium
108	523	2	22	Chinnasamy street	L	1.05	Sand	Alluvium
109	592	3	23	Macro marvel 3rd cross street	M	0.20	Laterite & Sandstone	Alluvium
110	590	3	23	Macro marvel 1st cross street	M	0.24	Laterite & Sandstone	Alluvium
111	591	3	23	Macro marvel 2nd cross street	S	0.06	Laterite & Sandstone	Alluvium

Flood Susceptibility	Aquifer Firka Category"	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	"High Priority OSR in High Need Ward"
Very Low	Semi-critical	None	Low	21	
Very Low	Semi-critical	None	Low	21	
100Y RP	Semi-critical	2-4	Low	21	
Very Low	Semi-critical	1	Low	20	
Very Low	Semi-critical	1	Low	20	
Very Low	Semi-critical	1	Low	20	
Very Low	Semi-critical	1	Low	20	
Very Low	Semi-critical	1	Low	20	
Very Low	Semi-critical	1	Low	20	
Very Low	Semi-critical	1	Low	20	
Very Low	Semi-critical	1	Low	20	
Very Low	Semi-critical	1	Low	20	
Very Low	Semi-critical	1	Low	20	
Low	Semi-critical	2-4	Low	20	
Very Low	Semi-critical	1	Low	20	
Low	Semi-critical	2-4	Low	20	
Very Low	Semi-critical	2-4	Low	19	
Very Low	Semi-critical	2-4	Low	19	
Very Low	Semi-critical	2-4	Low	19	
Very Low	Semi-critical	2-4	Low	19	
Very Low	Semi-critical	2-4	Low	19	
Very Low	Semi-critical	2-4	Low	19	
Very Low	Semi-critical	2-4	Low	19	
Very Low	Semi-critical	2-4	Low	19	
Very Low	Semi-critical	2-4	Low	19	
Very Low	Semi-critical	2-4	Low	19	
Very Low	Semi-critical	2-4	Low	19	
Very Low	Semi-critical	2-4	Low	19	
5Y RP	Semi-critical	5-10	Low	22	
5Y RP	Semi-critical	None	Lowest	24	
5Y RP	Overexploited	None	Lowest	23	
25Y RP	Semi-critical	None	Lowest	23	
25Y RP	Semi-critical	1	Lowest	22	
Low	Semi-critical	None	Lowest	21	
5Y RP	Semi-critical	2-4	Lowest	21	
25Y RP	Semi-critical	2-4	Lowest	20	
25Y RP	Semi-critical	2-4	Lowest	20	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
112	589	3	23	Grushanthi nagar 2nd cross street	M	0.20	Laterite & Sandstone	Coastal Alluvium
113	612	3	24	Sri balaji nagar 1st road	S	0.19	Sand	Alluvium
114	618	3	24	Ambattur road	M	0.72	Laterite & Sandstone	Coastal Alluvium
115	610	3	24	G.N.T. Road	M	0.75	Laterite & Sandstone	Coastal Alluvium
116	613	3	24	Rettaimalai srinivasan street	L	1.88	Laterite & Sandstone	Coastal Alluvium
117	616	3	24	Sri balaji nagar 1st road	M	0.69	Sand	Alluvium
118	607	3	24	Sri balaji nagar 3rd main road	M	0.70	Laterite & Sandstone	Alluvium
119	608	3	24	Sri balaji nagar 3rd main road	L	2.05	Laterite & Sandstone	Alluvium
120	609	3	24	Sri balaji nagar 3rd main road	L	1.25	Laterite & Sandstone	Alluvium
121	614	3	24	Sri balaji nagar 1st street	M	0.30	Sand	Alluvium
122	617	3	24	G.N.T. Road	S	0.19	Laterite & Sandstone	Coastal Alluvium
123	644	3	24	Secretariat officers colony	M	0.28	Sand	Alluvium
124	615	3	24	Sri balaji nagar 1st road	S	0.15	Sand	Alluvium
125	643	3	24	Secretariat officers colony	M	0.29	Sand	Alluvium
126	611	3	24	Ambattur road	M	0.25	Laterite & Sandstone	Coastal Alluvium
127	606	3	24	Sri balaji nagar 3rd main road	L	1.50	Laterite & Sandstone	Alluvium
128	619	3	24	Gangadaran main street	S	0.20	Laterite & Sandstone	Alluvium
129	620	3	24	Thiruvalluvar st	S	0.03	Laterite & Sandstone	Alluvium
130	755	3	25	Thattankulam road	M	0.44	Sand	Alluvium
131	756	3	25	Cmda	L	2.72	Sand	Alluvium
132	287	3	25	Vilakkupattu v.S.Mani nagar	L	2.49	Sand	Alluvium
133	753	3	25	Thattankulam road	M	0.41	Sand	Alluvium
134	640	3	25	V.S. Mani street	M	0.36	Sand	Alluvium
135	635	3	25	V.S. Mani street	S	0.06	Sand	Alluvium
136	638	3	25	Pukraj nagar 1st st	S	0.08	Sand	Alluvium
137	639	3	25	V.S. Mani street	S	0.08	Sand	Alluvium
138	641	3	25	V.S. Mani street	M	0.21	Sand	Alluvium
139	751	3	25	200 Ft road ring road	M	0.49	Sand	Alluvium
140	754	3	25	Natarajan nagar	M	0.24	Sand	Alluvium
141	631	3	25	Ring road housing sector	M	0.64	Sand	Alluvium
142	637	3	25	Alexnrbcol.Thiruvalluvar 2ndcross st	M	0.36	Sand	Alluvium
143	645	3	25	Ring road housing sector	M	0.47	Sand	Alluvium
144	633	3	25	Milk colony main road	M	0.43	Sand	Alluvium
145	634	3	25	Vrd nagar 1st cross road	M	0.82	Sand	Alluvium
146	636	3	25	Roja nagar extn	M	0.25	Sand	Alluvium
147	642	3	25	Victory field(interior)	S	0.04	Sand	Alluvium
148	760	3	26	Manjambakkam - main road	M	0.30	Sand	Alluvium

Flood Susceptibility	Aquifer Firka Category	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	“High Priority OSR in High Need Ward”
Very Low	Semi-critical	1	Lowest	19	
5Y RP	Semi-critical	None	Lowest	24	
5Y RP	Semi-critical	None	Lowest	24	
25Y RP	Semi-critical	None	Lowest	23	
5Y RP	Semi-critical	1	Lowest	23	
25Y RP	Semi-critical	None	Lowest	23	
25Y RP	Semi-critical	None	Lowest	22	
25Y RP	Semi-critical	None	Lowest	22	
25Y RP	Semi-critical	None	Lowest	22	
25Y RP	Semi-critical	1	Lowest	22	
25Y RP	Semi-critical	1	Lowest	22	
100Y RP	Semi-critical	None	Lowest	22	
25Y RP	Semi-critical	2-4	Lowest	21	
100Y RP	Semi-critical	1	Lowest	21	
Very Low	Semi-critical	None	Lowest	20	
100Y RP	Semi-critical	2-4	Lowest	19	
Very Low	Semi-critical	1	Lowest	18	
Very Low	Semi-critical	1	Lowest	18	
5Y RP	Semi-critical	None	Lowest	24	
5Y RP	Semi-critical	None	Lowest	24	
25Y RP	Semi-critical	None	Lowest	23	
100Y RP	Semi-critical	None	Lowest	22	
25Y RP	Semi-critical	2-4	Lowest	21	
100Y RP	Semi-critical	2-4	Lowest	20	
100Y RP	Semi-critical	2-4	Lowest	20	
100Y RP	Semi-critical	2-4	Lowest	20	
100Y RP	Semi-critical	2-4	Lowest	20	
Low	Semi-critical	1	Lowest	20	
Very Low	Semi-critical	None	Lowest	20	
Very Low	Semi-critical	1	Lowest	19	
Very Low	Semi-critical	1	Lowest	19	
Very Low	Semi-critical	1	Lowest	19	
Very Low	Semi-critical	2-4	Lowest	18	
Very Low	Semi-critical	2-4	Lowest	18	
Very Low	Semi-critical	2-4	Lowest	18	
Very Low	Semi-critical	2-4	Lowest	18	
25Y RP	Semi-critical	None	Lowest	23	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
149	758	3	26	A colony extn	S	0.06	Sand	Alluvium
150	759	3	26	Bharathidasan street	S	0.08	Sand	Alluvium
151	761	3	26	Venkateswara 2nd st	S	0.15	Sand	Alluvium
152	757	3	26	Assisi nagar 10th st	M	0.64	Sand	Alluvium
153	762	3	26	Assisi nagar 9th st	M	0.23	Sand	Alluvium
154	763	3	26	M.G.R. Street	S	0.06	Sand	Alluvium
155	630	3	27	Sastri nagar	S	0.17	Sand	Alluvium
156	621	3	27	Sri padmagiri nagar 7th street	M	0.76	Sand	Alluvium
157	629	3	27	Sri padmagiri nagar	L	1.71	Sand	Alluvium
158	377	3	27	Kamarajar salai	S	0.10	Sand	Alluvium
159	622	3	27	Sri krishna nagar main street	M	0.37	Sand	Alluvium
160	624	3	27	Rajasekara nagar	S	0.08	Sand	Alluvium
161	625	3	27	Meenatchi bharathy co-op nagar	S	0.05	Sand	Alluvium
162	626	3	27	Meenatchi bharathy co-op nagar	S	0.08	Sand	Alluvium
163	627	3	27	Nagoor meeran street 1st street	S	0.03	Sand	Alluvium
164	628	3	27	Bp nagar	M	0.49	Sand	Alluvium
165	623	3	27	Bank colony 5th street	M	0.34	Sand	Alluvium
166	415	3	28	G.N.T. Road	M	0.40	Sand	Laterite
167	600	3	28	Mrh road	S	0.07	Sand	Alluvium
168	526	3	28	K.K.R. Town 11th cross street	S	0.19	Sand	Alluvium
169	598	3	28	Kkr nagar 1st main road	M	0.80	Sand	Alluvium
170	599	3	28	Kkr garden 2nd st main road	L	1.05	Sand	Alluvium
171	632	3	28	Sivasakthi nagar 1st st	M	0.44	Sand	Alluvium
172	417	3	29	Thanikachalam nagar e blk rajaji 5th st	S	0.07	Sand	Laterite
173	420	3	29	Vgp santhosham nagar main road	M	0.23	Sand	Laterite
174	414	3	29	Thanikachalam nagar a blk 4th main road	M	0.25	Sand	Laterite
175	416	3	29	Sarangabani street	M	0.44	Sand	Laterite
176	418	3	29	Selvam nagar extension,ponniammanmedu	S	0.08	Sand	Laterite
177	419	3	29	Thanikachlam ngr e blk mahatma gandhi 2nd st.	S	0.06	Sand	Laterite
178	413	3	29	Thanikachalam nagar b blk 5/2 street	M	0.35	Clay	Alluvium
179	744	3	30	G.N.T. Road	S	0.11	Sand	Laterite
180	750	3	30	Secretariat colony main rd.	M	0.32	Laterite & Sandstone	Laterite
181	752	3	30	Secretariat colony main rd.	M	0.20	Laterite & Sandstone	Laterite
182	736	3	31	Brila avenue	M	0.54	Laterite & Sandstone	Laterite
183	739	3	31	Padmavathy nagar	M	0.59	Laterite & Sandstone	Laterite
184	741	3	31	Thirumal srinivasa nagar	S	0.17	Laterite & Sandstone	Laterite
185	742	3	31	Brila avenue	S	0.17	Laterite & Sandstone	Laterite

Flood Susceptibility	Aquifer Firka Category	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	“High Priority OSR in High Need Ward”
25Y RP	Semi-critical	2-4	Lowest	21	
100Y RP	Semi-critical	1	Lowest	21	
25Y RP	Semi-critical	2-4	Lowest	21	
Very Low	Semi-critical	None	Lowest	20	
Very Low	Semi-critical	None	Lowest	20	
Very Low	Semi-critical	1	Lowest	19	
5Y RP	Semi-critical	None	Lowest	24	
100Y RP	Semi-critical	None	Lowest	22	
100Y RP	Semi-critical	None	Lowest	22	
Very Low	Semi-critical	1	Low	20	
Very Low	Semi-critical	None	Lowest	20	
Very Low	Semi-critical	None	Lowest	20	
Very Low	Semi-critical	None	Lowest	20	
Very Low	Semi-critical	None	Lowest	20	
Very Low	Semi-critical	None	Lowest	20	
Very Low	Semi-critical	None	Lowest	20	
Very Low	Semi-critical	None	Lowest	20	
Very Low	Semi-critical	1	Lowest	19	
5Y RP	Overexploited	None	Lowest	22	
25Y RP	Overexploited	2-4	Lowest	20	
Very Low	Semi-critical	2-4	Lowest	18	
Low	Overexploited	2-4	Lowest	18	
Very Low	Semi-critical	2-4	Lowest	18	
Very Low	Semi-critical	2-4	Lowest	18	
5Y RP	Overexploited	None	Highest	26	Yes
5Y RP	Overexploited	None	Highest	26	Yes
5Y RP	Overexploited	1	Highest	25	Yes
5Y RP	Overexploited	1	Highest	25	Yes
5Y RP	Overexploited	1	Highest	25	Yes
5Y RP	Overexploited	1	Highest	25	Yes
5Y RP	Overexploited	2-4	Highest	22	Yes
25Y RP	Semi-critical	1	Low	22	
100Y RP	Overexploited	1	Low	19	
100Y RP	Overexploited	1	Low	19	
5Y RP	Semi-critical	None	Lowest	22	
5Y RP	Semi-critical	None	Lowest	22	
5Y RP	Semi-critical	None	Lowest	22	
5Y RP	Semi-critical	None	Lowest	22	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
186	732	3	31	Collector nagar main	M	0.37	Laterite & Sandstone	Laterite
187	734	3	31	Padmavathy nagar	M	0.23	Laterite & Sandstone	Laterite
188	735	3	31	Padmavathy nagar	S	0.17	Laterite & Sandstone	Laterite
189	738	3	31	Ranga avenue	M	0.54	Laterite & Sandstone	Laterite
190	740	3	31	Padmavathy nagar	S	0.16	Laterite & Sandstone	Laterite
191	743	3	31	Jai maruthy nagar	S	0.17	Laterite & Sandstone	Laterite
192	733	3	31	Srinivasa nagar	S	0.18	Laterite & Sandstone	Laterite
193	749	3	31	Sathyamoorthy nagar 3rd street	M	0.52	Laterite & Sandstone	Laterite
194	737	3	31	Mgr nagar	M	0.27	Laterite & Sandstone	Alluvium
195	746	3	31	Srinivasa nagar	S	0.13	Laterite & Sandstone	Laterite
196	747	3	31	Srinivasa nagar	S	0.06	Laterite & Sandstone	Laterite
197	748	3	31	Srinivasan main 2nd street	S	0.08	Laterite & Sandstone	Laterite
198	745	3	31	Gangaiamman koil st	M	0.32	Laterite & Sandstone	Laterite
199	594	3	32	Mettur link union road	L	1.31	Laterite & Sandstone	Laterite
200	596	3	32	Sri lakshmi amman nagar 5th street	S	0.20	Laterite & Sandstone	Laterite
201	595	3	32	Puthagaram road	M	0.27	Laterite & Sandstone	Laterite
202	593	3	32	Jasmin nagar	M	0.29	Laterite & Sandstone	Laterite
203	597	3	32	Dg nagar jp nagar link road	S	0.17	Laterite & Sandstone	Laterite
204	646	3	33	Teachers colony 6th main road	S	0.13	Laterite & Sandstone	Laterite
205	648	3	33	Teachers colony 4th main road	M	0.29	Laterite & Sandstone	Laterite
206	649	3	33	Teachers colony 4th main road	M	0.59	Laterite & Sandstone	Laterite
207	647	3	33	Teachers colony 4th cross st	M	0.38	Laterite & Sandstone	Laterite
208	650	3	33	Teachers colony 6th main road	S	0.11	Clay	Laterite
209	538	4	34	Venkateswara nagar (part-ii) 2nd street	S	0.15	Sand	Alluvium
210	539	4	34	Vijayalakshmi nagar 1st street	S	0.04	Sand	Alluvium
211	540	4	34	Sr nagar 2nd street	S	0.11	Sand	Alluvium
212	525	4	34	Venkateswara colony 5th street	S	0.16	Sand	Alluvium
213	533	4	34	Thai nagar 2nd street	M	0.22	Sand	Alluvium
214	534	4	34	Thendral nagar 4th street	S	0.19	Sand	Alluvium
215	531	4	34	Cauvery nagar main road	M	0.29	Sand	Alluvium
216	535	4	34	Jai balaji nagar 1st street	S	0.04	Sand	Alluvium
217	536	4	34	Union carbide colony 9th street	M	0.85	Sand	Alluvium
218	528	4	34	Binny nagar main road	M	0.23	Sand	Alluvium
219	532	4	34	Union carbide colony 14th street	M	0.21	Sand	Alluvium
220	527	4	34	Binny nagar main road	S	0.16	Sand	Alluvium
221	529	4	34	Poongavanam nagar main road	S	0.08	Sand	Alluvium
222	530	4	34	Venkateswara nagar (part-i) 3rd street	M	0.21	Sand	Alluvium

Flood Susceptibility	Aquifer Firka Category	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	“High Priority OSR in High Need Ward”
5Y RP	Semi-critical	1	Lowest	21	
5Y RP	Semi-critical	1	Lowest	21	
5Y RP	Semi-critical	1	Lowest	21	
5Y RP	Semi-critical	1	Lowest	21	
5Y RP	Semi-critical	1	Lowest	21	
5Y RP	Semi-critical	1	Lowest	21	
5Y RP	Overexploited	2-4	Lowest	19	
25Y RP	Semi-critical	2-4	Lowest	19	
Very Low	Semi-critical	1	Lowest	18	
25Y RP	Overexploited	2-4	Lowest	18	
25Y RP	Overexploited	2-4	Lowest	18	
25Y RP	Overexploited	2-4	Lowest	18	
Very Low	Semi-critical	1	Lowest	17	
Very Low	Overexploited	None	Highest	21	
5Y RP	Overexploited	1	Low	21	
25Y RP	Overexploited	1	Low	20	
Very Low	Overexploited	None	Low	18	
Very Low	Overexploited	2-4	Low	16	
5Y RP	Overexploited	5-10	High	21	
100Y RP	Overexploited	2-4	High	20	
100Y RP	Overexploited	2-4	High	20	
100Y RP	Overexploited	5-10	High	19	
5Y RP	Overexploited	5-10	High	19	
5Y RP	Semi-critical	2-4	High	25	Yes
5Y RP	Semi-critical	2-4	High	25	Yes
5Y RP	Semi-critical	2-4	High	25	Yes
25Y RP	Semi-critical	2-4	High	24	Yes
25Y RP	Overexploited	1	High	24	Yes
25Y RP	Overexploited	1	High	24	Yes
100Y RP	Semi-critical	2-4	High	23	Yes
Very Low	Semi-critical	1	High	22	Yes
100Y RP	Semi-critical	5-10	High	22	Yes
Low	Semi-critical	5-10	High	21	
Low	Semi-critical	5-10	High	21	
Very Low	Semi-critical	5-10	High	20	
Very Low	Semi-critical	5-10	High	20	
Very Low	Semi-critical	5-10	High	20	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
223	537	4	34	Venkateswara nagar (part-i) 2nd street	M	0.25	Sand	Alluvium
224	541	4	34	Binny nagar 1st street	S	0.09	Sand	Alluvium
225	651	4	35	G.N.T road	M	0.23	Sand	Alluvium
226	652	4	35	President krishnan street	M	0.28	Sand	Alluvium
227	764	4	36	16th west cross street	S	0.13	Sand	Coastal Alluvium
228	118	4	37	3rd link road	S	0.09	Sand	Coastal Alluvium
229	119	4	37	Central avenue road	M	0.25	Sand	Coastal Alluvium
230	120	4	37	Abirami avenue 14th street	M	0.29	Sand	Alluvium
231	766	4	40	Illaya st	M	0.72	Sand	Coastal Alluvium
232	601	4	40	New vaidyanathan street (or) vaidyanathan lane	L	1.32	Sand	Coastal Alluvium
233	602	4	40	Cross road	S	0.14	Sand	Coastal Alluvium
234	765	4	40	Illaya st	M	0.86	Sand	Coastal Alluvium
235	121	4	41	J.J. Nagar, c10 block 1st street,	S	0.02	Sand	Coastal Alluvium
236	864	4	45	Moorthingar street	M	0.67	Sand	Coastal Alluvium
237	266	4	45	Stephenson lane	M	0.30	Clay	Coastal Alluvium
238	863	4	47	C.B. Road	M	0.99	Sand	Coastal Alluvium
239	124	4	47	J.J. Nagar, b street,	S	0.01	Sand	Coastal Alluvium
240	122	4	47	Periyar salai (anna nagar main road)	M	0.29	Sand	Coastal Alluvium
241	123	4	47	J.J. Nagar, a1 street,	S	0.06	Sand	Coastal Alluvium
242	125	4	47	J.J. Nagar, d street,	S	0.03	Sand	Coastal Alluvium
243	126	4	47	J.J. Nagar, h street,	S	0.01	Sand	Coastal Alluvium
244	267	5	53	Mint modern city 5th main road	M	0.45	Sand	Coastal Alluvium
245	268	5	53	Basin bridge road	S	0.08	Sand	Coastal Alluvium
246	127	5	58	E.V.R salai	S	0.10	Sand	Coastal Alluvium
247	128	5	58	E.V.R salai	S	0.08	Sand	Coastal Alluvium
248	129	5	58	Jothi venkatachalam salai (atkinson road)	S	0.05	Sand	Coastal Alluvium
249	130	5	59	Wallajah road	S	0.14	Sand	Coastal Alluvium
250	653	5	60	Rajaji salai	X	10.77	Sand	Coastal Alluvium
251	995	5	61	Pantheon road	S	0.07	Sand	Coastal Alluvium
252	994	5	61	Ethiraj lane	S	0.16	Sand	Coastal Alluvium
253	865	5	63	Biyram jung bahadur street	M	0.22	Sand	Coastal Alluvium
254	136	6	64	Rohini street rajaji nagar	S	0.04	Clay	Coastal Alluvium
255	133	6	64	Thirumalai nagar ii main road	S	0.09	Clay	Laterite
256	141	6	64	Hussain colony ii street	S	0.17	Clay	Laterite
257	137	6	64	Senthil nagar 10th cross street	S	0.15	Clay	Alluvium
258	138	6	64	Senthil nagar 13th cross street	S	0.14	Clay	Alluvium
259	139	6	64	R.K. Syndicate nagar i street	S	0.12	Clay	Alluvium

Flood Susceptibility	Aquifer Firka Category	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	“High Priority OSR in High Need Ward”
Very Low	Semi-critical	5-10	High	20	
Very Low	Semi-critical	5-10	High	20	
5Y RP	Overexploited	2-4	Highest	25	Yes
5Y RP	Overexploited	2-4	Highest	25	Yes
100Y RP	Overexploited	5-10	Highest	23	Yes
100Y RP	Overexploited	5-10	Lowest	19	
100Y RP	Overexploited	5-10	Lowest	19	
100Y RP	Overexploited	5-10	Lowest	18	
25Y RP	Overexploited	5-10	High	23	Yes
Low	Overexploited	2-4	High	22	Yes
100Y RP	Overexploited	5-10	High	22	Yes
100Y RP	Overexploited	5-10	High	22	Yes
Low	Overexploited	None	High	24	Yes
25Y RP	Overexploited	2-4	Medium	23	
5Y RP	Overexploited	2-4	Medium	21	
5Y RP	Overexploited	None	Highest	28	Yes
Low	Overexploited	None	Highest	25	Yes
Low	Overexploited	1	Highest	24	Yes
Low	Overexploited	1	Highest	24	Yes
Low	Overexploited	1	Highest	24	Yes
Low	Overexploited	1	Highest	24	Yes
25Y RP	Overexploited	1	Medium	24	
5Y RP	Overexploited	2-4	Medium	24	
5Y RP	Overexploited	2-4	Low	23	
5Y RP	Overexploited	2-4	Low	23	
5Y RP	Overexploited	2-4	Low	23	
5Y RP	Overexploited	1	Medium	25	
Very Low	Overexploited	None	Lowest	20	
5Y RP	Overexploited	1	High	26	Yes
5Y RP	Overexploited	2-4	High	25	Yes
5Y RP	Overexploited	2-4	High	25	Yes
25Y RP	Overexploited	2-4	High	21	
5Y RP	Overexploited	5-10	High	19	
5Y RP	Overexploited	5-10	High	19	
100Y RP	Overexploited	5-10	High	18	
100Y RP	Overexploited	5-10	High	18	
100Y RP	Overexploited	5-10	High	18	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
260	132	6	64	Mahaveer nagar ii street	S	0.03	Clay	Laterite
261	134	6	64	P.V.Shanmugam nagar i street	S	0.05	Clay	Alluvium
262	135	6	64	Janagiram reddy colony ii street	S	0.17	Clay	Alluvium
263	140	6	64	Selvi nagar i street	S	0.09	Clay	Laterite
264	174	6	65	Anjugam nagar 4th c/s. Street	S	0.15	Clay	Alluvium
265	181	6	65	Girija nagar west i street	S	0.06	Clay	Laterite
266	175	6	65	Anjugam nagar 4th c/s. Street	S	0.19	Clay	Alluvium
267	176	6	65	Thiru.Vi.Ka. Street thenpalani nagar	S	0.05	Clay	Laterite
268	180	6	65	Vivek nagar iistreet	S	0.10	Clay	Laterite
269	178	6	65	Jayaram nagar i main road	S	0.08	Clay	Alluvium
270	177	6	65	Lakshmi nagar 3rd street	S	0.05	Clay	Laterite
271	192	6	66	Sakthivel nagar 2nd cross street	M	0.27	Clay	Alluvium
272	179	6	66	Thirupathi nagar i main road	M	0.22	Clay	Laterite
273	201	6	67	Pallavan salai	M	0.32	Clay	Alluvium
274	202	6	67	Pallavan salai	L	1.83	Clay	Coastal Alluvium
275	199	6	67	Pallavan salai	S	0.12	Clay	Coastal Alluvium
276	203	6	67	Thiru-vi-ka nagar (37 roads)	S	0.15	Clay	Alluvium
277	204	6	67	Thiru-vi-ka nagar (37 roads)	S	0.13	Clay	Coastal Alluvium
278	196	6	67	Maduraisamy madam street	L	1.21	Clay	Coastal Alluvium
279	197	6	67	Kennedy square 1st street (north)	M	0.34	Clay	Coastal Alluvium
280	198	6	67	Gurusamy street	M	0.47	Clay	Coastal Alluvium
281	200	6	67	Thiru-vi-ka nagar (37 roads)	M	0.37	Clay	Coastal Alluvium
282	182	6	68	Jawahar nagar 2nd circular road	M	0.33	Clay	Coastal Alluvium
283	183	6	68	Jawahar nagar 1st circular road	M	0.65	Clay	Coastal Alluvium
284	184	6	68	Jawahar nagar 2nd circular road	S	0.12	Clay	Coastal Alluvium
285	185	6	68	Jawahar nagar 5th main road	M	0.73	Clay	Coastal Alluvium
286	186	6	68	Jawahar nagar 2nd cross street	M	0.82	Clay	Coastal Alluvium
287	187	6	68	Periyar nagar 20th street	M	0.55	Clay	Coastal Alluvium
288	190	6	68	S.R.P. Colony 6th street	M	0.60	Clay	Coastal Alluvium
289	191	6	68	Ramnagar 2nd main road	S	0.12	Clay	Coastal Alluvium
290	188	6	68	Periyar nagar 15th street	M	0.56	Clay	Coastal Alluvium
291	189	6	68	Periyar nagar 4th street	L	1.12	Clay	Coastal Alluvium
292	193	6	69	Sundar raja perumal koil street south	S	0.17	Clay	Coastal Alluvium
293	194	6	69	Rangasayee street	M	0.76	Clay	Coastal Alluvium
294	195	6	69	Paper mills road	M	0.37	Clay	Coastal Alluvium
295	142	6	70	Anderson road	S	0.03	Clay	Coastal Alluvium
296	87	6	70	Konnur high road (from 10 to 156 and 230 to 367)	M	0.38	Clay	Coastal Alluvium

Flood Susceptibility	Aquifer Firka Category	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	“High Priority OSR in High Need Ward”
25Y RP	Overexploited	More than 10	High	17	
100Y RP	Overexploited	More than 10	High	17	
Low	Overexploited	5-10	High	17	
25Y RP	Overexploited	More than 10	High	17	
25Y RP	Overexploited	2-4	Highest	21	
Very Low	Overexploited	None	Highest	19	
Low	Overexploited	5-10	Highest	18	
100Y RP	Overexploited	5-10	Highest	18	
Very Low	Overexploited	1	Highest	18	
Very Low	Overexploited	5-10	Highest	17	
Very Low	Overexploited	5-10	Highest	16	
25Y RP	Overexploited	5-10	High	19	
100Y RP	Overexploited	2-4	High	18	
5Y RP	Overexploited	2-4	Highest	22	Yes
25Y RP	Overexploited	5-10	Highest	21	
100Y RP	Overexploited	5-10	Highest	20	
25Y RP	Overexploited	5-10	Highest	20	
100Y RP	Overexploited	5-10	Highest	20	
Low	Overexploited	5-10	Highest	19	
Low	Overexploited	5-10	Highest	19	
Very Low	Overexploited	5-10	Highest	18	
Very Low	Overexploited	5-10	Highest	18	
5Y RP	Overexploited	5-10	Highest	22	Yes
5Y RP	Overexploited	5-10	Highest	22	Yes
5Y RP	Overexploited	5-10	Highest	22	Yes
5Y RP	Overexploited	5-10	Highest	22	Yes
5Y RP	Overexploited	5-10	Highest	22	Yes
100Y RP	Overexploited	2-4	Highest	21	
25Y RP	Overexploited	5-10	Highest	21	
100Y RP	Overexploited	5-10	Highest	20	
Low	Overexploited	5-10	Highest	19	
Low	Overexploited	5-10	Highest	19	
100Y RP	Overexploited	5-10	Low	17	
Low	Overexploited	5-10	Low	16	
Low	Overexploited	5-10	Low	16	
25Y RP	Overexploited	2-4	Low	19	
Low	Overexploited	1	Low	18	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
297	88	6	70	Konnur high road	S	0.09	Clay	Coastal Alluvium
298	143	6	71	Dr. Ambedkar college road	M	0.92	Sand	Coastal Alluvium
299	144	6	71	Dr. Ambedkar college road	L	4.27	Clay	Coastal Alluvium
300	146	6	72	Brightons road	L	3.71	Sand	Coastal Alluvium
301	147	6	73	New ferrance road	L	2.40	Clay	Coastal Alluvium
302	148	6	73	New ferrance road	L	2.33	Clay	Coastal Alluvium
303	153	6	73	Strahans road	M	0.82	Clay	Coastal Alluvium
304	149	6	73	New ferrance road	L	1.27	Clay	Coastal Alluvium
305	151	6	73	New ferrance road	M	0.34	Clay	Coastal Alluvium
306	154	6	73	Cooks road	M	0.62	Clay	Coastal Alluvium
307	152	6	74	Cooks road	M	0.51	Clay	Coastal Alluvium
308	145	6	74	Cooks road	M	0.49	Clay	Coastal Alluvium
309	150	6	74	Cooks road	M	0.33	Clay	Coastal Alluvium
310	155	6	74	Cooks road	S	0.06	Clay	Coastal Alluvium
311	1002	6	75	Barrakka road	S	0.04	Clay	Coastal Alluvium
312	1004	6	75	Pumping station road	M	0.28	Clay	Coastal Alluvium
313	1000	6	75	Pumping station road	S	0.10	Clay	Coastal Alluvium
314	1001	6	75	Pumping station road	S	0.09	Clay	Coastal Alluvium
315	1003	6	75	Barrakka road	M	0.38	Clay	Coastal Alluvium
316	85	6	76	Perambur barracks road (veda vinayagar salai)	L	1.20	Sand	Coastal Alluvium
317	82	6	76	Chellappa street	M	0.46	Clay	Coastal Alluvium
318	84	6	76	Perambur barracks road (veda vinayagar salai)	S	0.02	Clay	Coastal Alluvium
319	86	6	76	Strahans road	M	0.67	Clay	Coastal Alluvium
320	83	6	76	C.S.Nagar park street	L	1.97	Clay	Coastal Alluvium
321	156	6	77	Basin elephant gate road	M	0.28	Sand	Coastal Alluvium
322	4	7	82	Narayanan nagar	S	0.01	Clay and Shale	Laterite
323	5	7	82	Karukku main road	M	0.21	Clay and Shale	Laterite
324	10	7	82	East balaji nagar 6th cross st	M	0.45	Laterite and Sand-stone	Laterite
325	6	7	82	Red hills road	L	2.35	Clay and Shale	Laterite
326	7	7	82	Red hills road	S	0.10	Clay and Shale	Laterite
327	9	7	82	Senthil murugan nagar	S	0.07	Clay and Shale	Laterite
328	365	7	83	Kandigai street	L	1.01	Laterite & Sandstone	Alluvium
329	361	7	83	61 St street	L	1.64	Clay	Alluvium
330	362	7	83	Subalakshmi 3rd street	M	0.33	Clay	Alluvium
331	8	7	83	Redhills road	M	0.54	Laterite & Sandstone	Laterite
332	364	7	83	Ranga gardan	S	0.20	Clay	Alluvium
333	363	7	83	Sastha nagar	S	0.14	Clay	Alluvium

Flood Susceptibility	Aquifer Firka Category"	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	"High Priority OSR in High Need Ward"
Low	Overexploited	1	Low	18	
5Y RP	Overexploited	2-4	Low	23	
5Y RP	Overexploited	2-4	Low	20	
5Y RP	Overexploited	2-4	Low	23	
5Y RP	Overexploited	2-4	Low	20	
5Y RP	Overexploited	2-4	Low	20	
5Y RP	Overexploited	2-4	Low	20	
5Y RP	Overexploited	5-10	Low	19	
25Y RP	Overexploited	2-4	Low	19	
5Y RP	Overexploited	5-10	Low	19	
5Y RP	Overexploited	5-10	Low	19	
25Y RP	Overexploited	5-10	Low	18	
25Y RP	Overexploited	5-10	Low	18	
25Y RP	Overexploited	5-10	Low	18	
5Y RP	Overexploited	2-4	High	22	Yes
25Y RP	Overexploited	1	High	22	Yes
25Y RP	Overexploited	2-4	High	21	
25Y RP	Overexploited	2-4	High	21	
25Y RP	Overexploited	2-4	High	21	
5Y RP	Overexploited	5-10	High	24	Yes
5Y RP	Overexploited	2-4	High	22	Yes
5Y RP	Overexploited	2-4	High	22	Yes
5Y RP	Overexploited	2-4	High	22	Yes
5Y RP	Overexploited	5-10	High	21	
100Y RP	Overexploited	5-10	High	22	Yes
5Y RP	Overexploited	None	Medium	20	
25Y RP	Overexploited	None	Medium	19	
Very Low	Overexploited	None	Medium	19	
Very Low	Overexploited	None	Medium	16	
Very Low	Overexploited	None	Medium	16	
Very Low	Overexploited	None	Medium	16	
5Y RP	Overexploited	2-4	Lowest	20	
100Y RP	Overexploited	1	Medium	19	
25Y RP	Overexploited	1	Lowest	18	
Very Low	Overexploited	1	Lowest	16	
25Y RP	Overexploited	5-10	Lowest	16	
Low	Overexploited	2-4	Lowest	15	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
334	18	7	84	K.R.Nagar(govinda reddy st.)	M	0.45	Clay	Alluvium
335	16	7	84	Tnhb iind street	M	0.90	Clay	Alluvium
336	15	7	84	Vinayagar koil street	S	0.05	Clay	Alluvium
337	12	7	85	Railway quarters	S	0.17	Clay and Shale	Laterite
338	11	7	85	Railway quarters	M	0.70	Clay and Shale	Laterite
339	13	7	85	Thiruvalluar street	M	0.42	Clay and Shale	Alluvium
340	29	7	86	V.G.N.Shanthi nagar.	M	0.39	Clay and Shale	Laterite
341	27	7	86	V.G.N. Nagar	M	0.61	Clay and Shale	Laterite
342	21	7	86	Vanagaram road	S	0.11	Clay and Shale	Alluvium
343	25	7	86	V.G.N.Shanthi nagar.	M	0.75	Clay and Shale	Laterite
344	26	7	86	V.G.N. Nagar	M	0.74	Clay and Shale	Laterite
345	28	7	86	V.G.N. Nagar	L	1.02	Clay and Shale	Laterite
346	31	7	86	Manickam pillai street	M	0.75	Clay and Shale	Alluvium
347	22	7	86	A.I.E.South phase	S	0.14	Clay	Alluvium
348	23	7	86	A.I.E.South phase	M	0.65	Clay	Alluvium
349	24	7	86	T t mathew road	S	0.04	Clay	Alluvium
350	20	7	86	Thamarabarani street	M	0.30	Clay and Shale	Alluvium
351	30	7	86	K.S.R. Nagar	M	0.36	Clay and Shale	Laterite
352	19	7	86	Thamarabarani street	M	0.22	Clay and Shale	Alluvium
353	14	7	87	East avenue	M	0.39	Clay	Alluvium
354	17	7	87	4 Th street	M	0.54	Clay	Alluvium
355	993	7	88	M.T.H.Road	M	0.22	Clay	Alluvium
356	516	7	88	Jeevan bhima nagar a.N.W.E.	S	0.04	Clay	Alluvium
357	519	7	88	34th street, tvs colony	S	0.06	Clay	Alluvium
358	1047	7	88	Welcome colony	S	0.18	Clay	Alluvium
359	1063	7	88	Welcome colony	S	0.13	Clay	Alluvium
360	992	7	88	M g r road	L	1.25	Clay	Alluvium
361	517	7	89	Jeevan bhima nagar a.N.W.E.	S	0.18	Clay	Alluvium
362	518	7	89	T.S.Krishna nagar	M	0.28	Clay	Alluvium
363	920	7	90	Akr road	L	1.28	Clay	Alluvium
364	1057	7	90	Golden jublee flats	M	0.80	Clay	Alluvium
365	1062	7	90	Padi kuppam main road	M	0.24	Clay	Alluvium
366	1065	7	90	Golden jubilee flats	M	0.24	Clay	Alluvium
367	1066	7	90	Golden jubilee flats	M	0.20	Clay	Alluvium
368	1067	7	90	Golden jubilee flats	S	0.05	Clay	Alluvium
369	1046	7	90	Tnhb,anna nagar west ext.	S	0.18	Clay	Alluvium
370	1048	7	90	Padi kuppam main road	S	0.18	Clay	Alluvium

Flood Susceptibility	Aquifer Firka Category"	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	"High Priority OSR in High Need Ward"
25Y RP	Overexploited	1	Medium	20	
25Y RP	Overexploited	2-4	Medium	19	
Very Low	Overexploited	None	Medium	18	
Low	Overexploited	None	Low	16	
Very Low	Overexploited	None	Low	15	
Low	Overexploited	2-4	Low	15	
5Y RP	Overexploited	None	High	21	
5Y RP	Overexploited	1	High	20	
Low	Overexploited	None	High	19	
5Y RP	Overexploited	2-4	High	19	
5Y RP	Overexploited	2-4	High	19	
5Y RP	Overexploited	2-4	High	19	
Low	Overexploited	1	High	18	
Very Low	Overexploited	2-4	High	17	
Very Low	Overexploited	2-4	High	17	
Low	Overexploited	5-10	High	17	
Low	Overexploited	5-10	High	16	
Low	Overexploited	2-4	High	16	
Very Low	Overexploited	5-10	High	15	
25Y RP	Overexploited	1	Medium	20	
Very Low	Overexploited	2-4	Medium	16	
25Y RP	Overexploited	1	Medium	20	
25Y RP	Overexploited	5-10	Medium	18	
Low	Overexploited	2-4	High	18	
25Y RP	Overexploited	5-10	Low	17	
25Y RP	Overexploited	5-10	Low	17	
Very Low	Overexploited	5-10	Medium	15	
25Y RP	Overexploited	5-10	High	19	
25Y RP	Overexploited	5-10	High	19	
5Y RP	Semi-critical	2-4	Low	20	
5Y RP	Overexploited	5-10	Low	18	
5Y RP	Overexploited	5-10	Low	18	
5Y RP	Overexploited	5-10	Low	18	
5Y RP	Overexploited	5-10	Low	18	
5Y RP	Overexploited	5-10	Low	18	
25Y RP	Overexploited	5-10	Low	17	
25Y RP	Overexploited	5-10	Low	17	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
371	1049	7	90	Welcome colony	S	0.16	Clay	Alluvium
372	1050	7	90	Welcome colony	M	0.31	Clay	Alluvium
373	1051	7	90	Welcome colony	S	0.17	Clay	Alluvium
374	1052	7	90	Santham colony	S	0.16	Clay	Alluvium
375	1053	7	90	Santham colony	M	0.29	Clay	Alluvium
376	1055	7	90	Padi kuppam main road	S	0.16	Clay	Alluvium
377	1058	7	90	Padi kuppam main road	M	0.22	Clay	Alluvium
378	1059	7	90	Padi kuppam main road	S	0.11	Clay	Alluvium
379	1064	7	90	Welcome colony	M	0.27	Clay	Alluvium
380	1068	7	90	Golden jubilee flats	S	0.04	Clay	Alluvium
381	1054	7	90	Santham colony	S	0.19	Clay	Alluvium
382	1056	7	90	Asiad colony	L	1.11	Clay	Alluvium
383	353	7	91	Jaswanth nagar	M	0.27	Clay	Alluvium
384	354	7	91	L.I.G eri scheme 15th cross street	S	0.03	Clay	Alluvium
385	355	7	91	Mugapair eri scheme, ch-37	S	0.14	Clay	Alluvium
386	356	7	91	Mugapair eri scheme, ch-37	M	0.34	Clay	Alluvium
387	357	7	91	Mugapair eri scheme, ch-37	S	0.01	Clay	Alluvium
388	359	7	91	Mugapair eri scheme, ch-37	M	0.30	Clay	Alluvium
389	351	7	91	Eri scheme 1st main road	M	0.23	Clay	Alluvium
390	352	7	91	Jaswanth nagar	S	0.07	Clay	Alluvium
391	324	7	92	Everest colony	L	2.82	Clay	Alluvium
392	358	7	92	Eri scheme 1st main road	M	0.30	Clay	Alluvium
393	327	7	92	Veeramamunivar salai	M	0.28	Clay	Alluvium
394	328	7	92	Church street	M	0.24	Clay	Alluvium
395	329	7	92	Church street	S	0.19	Clay	Alluvium
396	326	7	92	Vgp nagar	M	0.28	Clay	Alluvium
397	325	7	92	Venugopalswamy street	S	0.03	Clay	Alluvium
398	514	7	93	Rail nagar	S	0.05	Sand	Alluvium
399	515	7	93	O v joseph street g g nagar	M	0.45	Clay	Alluvium
400	513	7	93	4th block nakiransalai 14th cross st	S	0.03	Clay	Alluvium
401	1060	7	93	Collector nagar 1st street	M	0.60	Clay	Alluvium
402	80	8	94	Sidco nagar 32nd street	M	0.56	Clay	Coastal Alluvium
403	78	8	94	North jagannahan nagar 2nd main road	S	0.15	Clay	Coastal Alluvium
404	79	8	94	Rajamangalam main road	S	0.09	Clay	Alluvium
405	505	8	95	Thirunagar 11th street	L	1.99	Clay	Coastal Alluvium
406	75	8	95	Sidco nagar 1st main road	S	0.05	Clay	Coastal Alluvium
407	76	8	95	Sidco nagar 1st main road	S	0.08	Clay	Coastal Alluvium

Flood Susceptibility	Aquifer Firka Category"	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	"High Priority OSR in High Need Ward"
25Y RP	Overexploited	5-10	Low	17	
25Y RP	Overexploited	5-10	Low	17	
25Y RP	Overexploited	5-10	Low	17	
100Y RP	Overexploited	2-4	Low	17	
100Y RP	Overexploited	2-4	Low	17	
25Y RP	Overexploited	5-10	Low	17	
25Y RP	Overexploited	5-10	Low	17	
25Y RP	Overexploited	5-10	Low	17	
25Y RP	Overexploited	5-10	Low	17	
25Y RP	Overexploited	5-10	Low	17	
25Y RP	Overexploited	5-10	Low	17	
100Y RP	Overexploited	5-10	Low	16	
100Y RP	Overexploited	5-10	Low	16	
5Y RP	Overexploited	5-10	Lowest	17	
5Y RP	Overexploited	5-10	Lowest	17	
5Y RP	Overexploited	5-10	Lowest	17	
5Y RP	Overexploited	5-10	Lowest	17	
5Y RP	Overexploited	5-10	Lowest	17	
5Y RP	Overexploited	5-10	Lowest	17	
25Y RP	Overexploited	5-10	Lowest	16	
100Y RP	Overexploited	5-10	Lowest	15	
5Y RP	Overexploited	5-10	High	20	
5Y RP	Overexploited	5-10	High	20	
25Y RP	Overexploited	5-10	High	19	
25Y RP	Overexploited	5-10	High	19	
25Y RP	Overexploited	5-10	High	19	
100Y RP	Overexploited	5-10	High	18	
Low	Overexploited	5-10	High	17	
25Y RP	Overexploited	5-10	Medium	21	
5Y RP	Overexploited	5-10	Medium	19	
25Y RP	Overexploited	5-10	Medium	18	
100Y RP	Overexploited	5-10	High	18	
5Y RP	Overexploited	5-10	Lowest	18	
Low	Overexploited	2-4	Lowest	16	
Low	Overexploited	5-10	Lowest	14	
Low	Overexploited	2-4	Low	17	
Low	Overexploited	5-10	Low	16	
Low	Overexploited	5-10	Low	16	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
408	81	8	95	M.T.H.Road	S	0.15	Clay	Alluvium
409	504	8	95	Thirumangalam road	S	0.12	Clay	Coastal Alluvium
410	77	8	95	Sidco nagar 1st main road	S	0.08	Clay	Alluvium
411	74	8	98	Ayanavaram road	M	0.22	Clay	Coastal Alluvium
412	45	8	99	Evr lane	S	0.05	Clay	Coastal Alluvium
413	48	8	99	Brickklin road	M	0.21	Clay	Coastal Alluvium
414	49	8	99	Brickklin road	L	1.40	Clay	Coastal Alluvium
415	44	8	100	Kilpauk garden rd	S	0.15	Clay	Coastal Alluvium
416	46	8	100	Periyar e.V.R. Salai	M	0.29	Clay	Coastal Alluvium
417	47	8	100	Harleys lane	S	0.05	Clay	Coastal Alluvium
418	43	8	100	Prof. Subramaniam st	S	0.16	Clay	Coastal Alluvium
419	991	8	101	Big street	M	0.23	Clay	Coastal Alluvium
420	987	8	101	L- block 19th street	M	0.31	Clay	Coastal Alluvium
421	988	8	101	Pulla avenue	X	7.48	Clay	Coastal Alluvium
422	989	8	101	Pulla avenue	L	2.80	Clay	Coastal Alluvium
423	990	8	101	Second avenue exnt. Road	L	1.02	Clay	Coastal Alluvium
424	109	8	102	2nd main road	M	0.26	Clay	Coastal Alluvium
425	110	8	102	2nd main road	M	0.26	Clay	Coastal Alluvium
426	111	8	102	Crescent road	L	4.65	Clay	Coastal Alluvium
427	113	8	102	K-block 13th street	M	0.67	Clay	Coastal Alluvium
428	114	8	102	6th avenue road	L	2.75	Clay	Coastal Alluvium
429	115	8	102	N- block 24th street	M	0.24	Clay	Coastal Alluvium
430	116	8	102	O- block 37th street	S	0.08	Clay	Coastal Alluvium
431	117	8	102	Shenoy nagar 1st main road	X	5.74	Clay	Coastal Alluvium
432	112	8	102	C- block 6th street	M	0.63	Clay	Coastal Alluvium
433	34	8	103	7th main road tns cb tenement road	M	0.21	Sand	Alluvium
434	35	8	103	9th main road	S	0.05	Sand	Alluvium
435	36	8	103	3rd main road	S	0.16	Clay	Alluvium
436	33	8	103	Tower park road	X	17.24	Clay	Alluvium
437	42	8	103	7th main road tns cb tenement road	S	0.04	Clay	Alluvium
438	32	8	103	Ad block 3rd street	M	0.96	Clay	Alluvium
439	37	8	103	Ae block 1st street	M	0.82	Clay	Alluvium
440	39	8	103	7th main road tns cb tenement road	M	0.21	Clay	Alluvium
441	40	8	103	14th main road	L	1.09	Clay	Alluvium
442	41	8	103	7th main road	S	0.04	Clay	Alluvium
443	38	8	103	Al block 2nd street	M	0.81	Clay	Alluvium
444	918	8	104	Belly area main road	S	0.07	Clay	Alluvium

Flood Susceptibility	Aquifer Firka Category	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	“High Priority OSR in High Need Ward”
Low	Overexploited	2-4	Low	16	
Low	Overexploited	5-10	Low	16	
Very Low	Overexploited	5-10	Low	14	
100Y RP	Overexploited	1	Medium	20	
25Y RP	Overexploited	1	High	22	Yes
5Y RP	Overexploited	2-4	High	22	Yes
5Y RP	Overexploited	2-4	High	22	Yes
5Y RP	Overexploited	2-4	High	22	Yes
25Y RP	Overexploited	1	High	22	Yes
25Y RP	Overexploited	1	High	22	Yes
Low	Overexploited	2-4	High	19	
5Y RP	Overexploited	1	Medium	22	
5Y RP	Overexploited	2-4	Medium	21	
5Y RP	Overexploited	2-4	Medium	21	
5Y RP	Overexploited	2-4	Medium	21	
5Y RP	Overexploited	2-4	Medium	21	
5Y RP	Overexploited	2-4	Medium	21	
5Y RP	Overexploited	2-4	Medium	21	
5Y RP	Overexploited	2-4	Medium	21	
5Y RP	Overexploited	2-4	Medium	21	
5Y RP	Overexploited	2-4	Medium	21	
5Y RP	Overexploited	2-4	Medium	21	
5Y RP	Overexploited	2-4	Medium	21	
5Y RP	Overexploited	2-4	Medium	21	
5Y RP	Overexploited	2-4	Medium	21	
5Y RP	Overexploited	2-4	Medium	21	
25Y RP	Overexploited	2-4	Medium	20	
5Y RP	Overexploited	2-4	Medium	23	
5Y RP	Overexploited	2-4	Medium	23	
5Y RP	Overexploited	1	Medium	21	
5Y RP	Overexploited	2-4	Medium	20	
5Y RP	Overexploited	2-4	Medium	20	
5Y RP	Overexploited	5-10	Medium	19	
5Y RP	Overexploited	5-10	Medium	19	
5Y RP	Overexploited	5-10	Medium	19	
5Y RP	Overexploited	5-10	Medium	19	
5Y RP	Overexploited	5-10	Medium	19	
25Y RP	Overexploited	5-10	Medium	18	
5Y RP	Overexploited	2-4	Medium	20	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
445	917	8	104	Belly area main road	S	0.06	Clay	Alluvium
446	921	8	104	15th main road	L	1.33	Clay	Alluvium
447	922	8	104	15th main road	M	0.99	Clay	Alluvium
448	912	8	104	H-block 14th street	M	0.47	Clay	Alluvium
449	913	8	104	H-block 16th street	M	0.55	Clay	Alluvium
450	914	8	104	J-block 10th street	M	0.62	Clay	Alluvium
451	915	8	104	Kathiravan colony	M	0.23	Clay	Alluvium
452	916	8	104	Ponni colony main road	S	0.11	Clay	Alluvium
453	919	8	104	Nvn nagar 14th street	S	0.03	Clay	Alluvium
454	923	8	104	Nvn nagar 2nd street	S	0.12	Clay	Alluvium
455	925	8	104	15th main road	M	0.27	Clay	Alluvium
456	924	8	104	Nvn nagar 2nd street	S	0.10	Clay	Alluvium
457	1061	8	104	Emerald flats anna nagar west	M	0.63	Clay	Alluvium
458	89	8	105	Kalki nagar main road	S	0.03	Sand	Alluvium
459	90	8	105	Kalki nagar 2nd street	S	0.05	Sand	Alluvium
460	1011	8	105	Saf games village	L	1.48	Clay	Alluvium
461	506	8	107	Nelson manickam road	M	0.43	Sand	Coastal Alluvium
462	507	8	107	Metal factory road	M	0.46	Sand	Coastal Alluvium
463	509	8	107	Nelson manickam road	S	0.10	Sand	Coastal Alluvium
464	510	8	107	Nelson manickam road	S	0.06	Sand	Coastal Alluvium
465	511	8	107	Nelson manickam road	S	0.15	Sand	Coastal Alluvium
466	512	8	107	Nelson manickam road	S	0.16	Sand	Coastal Alluvium
467	508	8	107	Nelson manickam road	S	0.04	Sand	Coastal Alluvium
468	92	8	108	Venkatasamy street	S	0.03	Clay	Coastal Alluvium
469	93	8	108	Mc nichols road (zonal office side)	S	0.03	Clay	Coastal Alluvium
470	50	9	110	Harrington road	M	0.28	Sand	Coastal Alluvium
471	939	9	111	Binny road	M	0.50	Sand	Coastal Alluvium
472	943	9	111	College road	S	0.06	Sand	Coastal Alluvium
473	946	9	111	Safee mohamed road	M	0.34	Sand	Coastal Alluvium
474	948	9	111	Club house road	L	1.14	Sand	Coastal Alluvium
475	942	9	111	College lane	M	0.82	Sand	Coastal Alluvium
476	944	9	111	College road	M	0.39	Sand	Coastal Alluvium
477	945	9	111	Haddows road	L	1.77	Sand	Coastal Alluvium
478	947	9	111	Smith lane	S	0.05	Sand	Coastal Alluvium
479	949	9	111	Pycrofts garden road	S	0.03	Sand	Coastal Alluvium
480	951	9	111	Haddows road	S	0.04	Sand	Coastal Alluvium
481	952	9	111	Pathari road	S	0.16	Sand	Coastal Alluvium

Flood Susceptibility	Aquifer Firka Category	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	“High Priority OSR in High Need Ward”
5Y RP	Overexploited	5-10	Medium	19	
25Y RP	Overexploited	2-4	Medium	19	
25Y RP	Overexploited	2-4	Medium	19	
25Y RP	Overexploited	5-10	Medium	18	
25Y RP	Overexploited	5-10	Medium	18	
25Y RP	Overexploited	5-10	Medium	18	
25Y RP	Overexploited	5-10	Medium	18	
25Y RP	Overexploited	5-10	Medium	18	
100Y RP	Overexploited	2-4	Medium	18	
100Y RP	Overexploited	2-4	Medium	18	
25Y RP	Overexploited	5-10	Medium	18	
100Y RP	Overexploited	5-10	Medium	17	
100Y RP	Overexploited	2-4	Low	17	
Low	Overexploited	2-4	Highest	22	Yes
Low	Overexploited	2-4	Highest	22	Yes
100Y RP	Overexploited	More than 10	Highest	18	
5Y RP	Overexploited	5-10	Medium	23	
5Y RP	Overexploited	5-10	Medium	23	
5Y RP	Overexploited	5-10	Medium	23	
5Y RP	Overexploited	5-10	Medium	23	
5Y RP	Overexploited	5-10	Medium	23	
5Y RP	Overexploited	5-10	Medium	23	
25Y RP	Overexploited	5-10	Medium	22	
25Y RP	Overexploited	5-10	Low	18	
Low	Overexploited	2-4	Low	17	
5Y RP	Overexploited	2-4	Low	23	
5Y RP	Overexploited	2-4	Low	23	
5Y RP	Overexploited	2-4	Low	23	
5Y RP	Overexploited	2-4	Low	23	
5Y RP	Overexploited	2-4	Low	23	
5Y RP	Overexploited	5-10	Low	22	
25Y RP	Overexploited	2-4	Low	22	
5Y RP	Overexploited	5-10	Low	22	
5Y RP	Overexploited	5-10	Low	22	
5Y RP	Overexploited	5-10	Low	22	
25Y RP	Overexploited	5-10	Low	21	
100Y RP	Overexploited	2-4	Low	21	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
482	940	9	111	Nungambakkam iv lane	M	0.69	Sand	Coastal Alluvium
483	981	9	112	Railway boarder road	M	0.22	Sand	Coastal Alluvium
484	984	9	112	Trustpuram 10th street	M	0.41	Clay	Coastal Alluvium
485	980	9	112	Choolai medu high road	S	0.01	Clay	Coastal Alluvium
486	982	9	112	Trustpuram 6th cross street	M	0.28	Clay	Alluvium
487	985	9	112	Trustpuram 4th cross street	L	4.43	Clay	Coastal Alluvium
488	986	9	112	Puliyur 1st main road	S	0.10	Clay	Coastal Alluvium
489	983	9	112	Ganga nagar 3rd cross street	S	0.11	Clay	Alluvium
490	950	9	113	Anna salai	S	0.19	Clay	Coastal Alluvium
491	996	9	113	Chari street	M	0.25	Clay	Coastal Alluvium
492	131	9	114	Wallajah road	S	0.00	Sand	Coastal Alluvium
493	941	9	115	Whites road (osr land)	M	0.22	Sand	Coastal Alluvium
494	999	9	117	Anna salai from teynampet signal to kamarajar	S	0.11	Clay	Coastal Alluvium
495	91	9	118	Venus colony iind street	M	0.29	Sand	Coastal Alluvium
496	997	9	118	Vijayaraghava road	S	0.11	Clay	Coastal Alluvium
497	998	9	118	Anna salai from teynampet signal to kamarajar	M	0.46	Clay	Coastal Alluvium
498	51	9	119	C.I.T. Colony 5th cross street	S	0.03	Sand	Coastal Alluvium
499	52	9	121	Nainar salai	M	0.28	Sand	Coastal Alluvium
500	54	9	122	S.M.Nagar	S	0.19	Clay	Coastal Alluvium
501	55	9	122	Jogithottam slum road	S	0.03	Clay	Coastal Alluvium
502	72	9	123	Luz church road	S	0.04	Sand	Coastal Alluvium
503	73	9	124	Ranganathapuram	S	0.03	Sand	Coastal Alluvium
504	53	9	125	Santhome high road	S	0.02	Sand	Coastal Alluvium
505	56	9	126	2nd trust main road	M	0.40	Sand	Coastal Alluvium
506	1008	10	127	Duraisampath street - kumaran nagar	S	0.11	Clay	Alluvium
507	1005	10	127	Ani street - chinmaya nagar stage ii	M	0.22	Clay	Alluvium
508	1007	10	127	Vaikasi street - chinmaya nagar stage ii	M	0.28	Clay	Alluvium
509	1009	10	127	Samanthi street - brindavan nagar	S	0.05	Clay	Alluvium
510	1010	10	127	Mullai street - brindavan nagar	S	0.02	Clay	Alluvium
511	62	10	127	Main road - tarachand nagar	S	0.16	Clay	Alluvium
512	1015	10	127	Saf games village	M	0.55	Clay	Alluvium
513	1018	10	127	Saf games village	S	0.17	Clay	Alluvium
514	1019	10	127	Saf games village	M	0.32	Clay	Alluvium
515	1023	10	127	Saf games village	M	0.40	Clay	Alluvium
516	1017	10	127	Saf games village	M	0.20	Clay	Alluvium
517	1020	10	127	Saf games village	S	0.18	Clay	Alluvium
518	1021	10	127	Saf games village	S	0.13	Clay	Alluvium

Flood Susceptibility	Aquifer Firka Category"	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	"High Priority OSR in High Need Ward"
100Y RP	Overexploited	5-10	Low	20	
25Y RP	Overexploited	2-4	Medium	23	
25Y RP	Overexploited	2-4	Medium	20	
Low	Overexploited	1	Medium	19	
100Y RP	Overexploited	2-4	Medium	18	
Low	Overexploited	5-10	Medium	17	
Low	Overexploited	5-10	Medium	17	
Low	Overexploited	5-10	Medium	16	
100Y RP	Overexploited	2-4	High	20	
Low	Overexploited	2-4	High	19	
25Y RP	Overexploited	None	Low	24	
Low	Overexploited	2-4	Highest	23	Yes
5Y RP	Overexploited	1	High	23	Yes
Low	Overexploited	None	Medium	23	
5Y RP	Overexploited	1	Medium	22	
5Y RP	Overexploited	2-4	Medium	21	
25Y RP	Overexploited	2-4	Lowest	21	
5Y RP	Overexploited	2-4	Medium	24	
25Y RP	Overexploited	None	Medium	22	
25Y RP	Overexploited	None	Medium	22	
5Y RP	Overexploited	1	Highest	27	Yes
25Y RP	Overexploited	2-4	Medium	23	
Low	Overexploited	5-10	Low	19	
25Y RP	Overexploited	2-4	Medium	23	
5Y RP	Semi-critical	None	High	24	Yes
5Y RP	Semi-critical	1	High	23	Yes
5Y RP	Semi-critical	1	High	23	Yes
100Y RP	Semi-critical	None	High	22	Yes
100Y RP	Semi-critical	None	High	22	Yes
5Y RP	Semi-critical	5-10	High	21	
100Y RP	Overexploited	None	High	21	
100Y RP	Overexploited	None	High	21	
100Y RP	Overexploited	None	High	21	
100Y RP	Overexploited	None	High	21	
Low	Overexploited	None	High	20	
5Y RP	Overexploited	5-10	High	20	
5Y RP	Overexploited	5-10	High	20	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
519	1012	10	127	Saf games village	L	1.27	Clay	Alluvium
520	1016	10	127	Saf games village	M	0.39	Clay	Alluvium
521	1013	10	127	Saf games village	M	0.24	Clay	Alluvium
522	1014	10	127	Saf games village	S	0.09	Clay	Alluvium
523	1022	10	127	Saf games village	M	0.30	Clay	Alluvium
524	67	10	128	Vembuliamman koil street	M	0.21	Clay	Alluvium
525	70	10	128	Vembuliamman koil street	S	0.04	Clay	Alluvium
526	66	10	128	Vembuliamman koil street	M	0.40	Clay	Alluvium
527	58	10	128	Vembuliamman koil street	S	0.06	Clay	Alluvium
528	60	10	128	South street - elango nagar	M	0.35	Clay	Alluvium
529	61	10	128	1 Cross street - crr puram phase 1	S	0.07	Clay	Alluvium
530	64	10	128	2nd street - lakshmi nagar	S	0.14	Clay	Alluvium
531	65	10	128	Main road - elango nagar	S	0.13	Clay	Alluvium
532	57	10	128	Arcot road	M	0.28	Clay	Alluvium
533	59	10	128	Co-op society colony	S	0.06	Clay	Alluvium
534	63	10	128	5 Street - new colony	M	0.24	Clay	Alluvium
535	69	10	128	Annaji rao nagar 2nd main road	M	0.44	Clay	Alluvium
536	1027	10	129	State bank colony 1st street	M	0.42	Clay	Alluvium
537	1031	10	129	Mullai street	S	0.03	Clay	Alluvium
538	107	10	129	Thillaadi valliamma street	S	0.02	Clay	Alluvium
539	1029	10	129	Kaveri rangar nagar pillaiyar koil street	M	0.24	Clay	Alluvium
540	1030	10	129	Devaraj nagar navalur high road	S	0.13	Clay	Alluvium
541	97	10	129	Arcot salai	M	0.45	Clay	Alluvium
542	98	10	129	Bangaru street	S	0.03	Clay	Alluvium
543	102	10	129	Abusali street	M	0.58	Clay	Alluvium
544	103	10	129	Nsk lane	S	0.15	Clay	Alluvium
545	105	10	129	Kumaran colony 4th street	M	0.39	Clay	Alluvium
546	106	10	129	Arcot salai	S	0.02	Clay	Alluvium
547	435	10	129	Vijayaraghavapuram 1st street	S	0.12	Clay	Alluvium
548	858	10	129	N.S.K salai	M	0.24	Clay	Alluvium
549	1024	10	129	Muthukumarappa street (from arcot road)	S	0.03	Clay	Alluvium
550	1025	10	129	Muthukumarappa street (from arcot road)	S	0.14	Clay	Alluvium
551	1026	10	129	Vivekandanar street	M	0.63	Clay	Alluvium
552	1028	10	129	Velayutham colony 1st main road	M	0.29	Clay	Alluvium
553	1032	10	129	2nd street - annamalai colony	S	0.19	Clay	Alluvium
554	108	10	129	Arunachalam street	S	0.11	Clay	Alluvium
555	856	10	130	Ponnammal street	L	1.34	Clay	Alluvium

Flood Susceptibility	Aquifer Firka Category	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	“High Priority OSR in High Need Ward”
100Y RP	Overexploited	2-4	High	19	
100Y RP	Overexploited	2-4	High	19	
100Y RP	Overexploited	5-10	High	18	
100Y RP	Overexploited	5-10	High	18	
Low	Overexploited	2-4	High	18	
5Y RP	Semi-critical	5-10	Highest	22	Yes
5Y RP	Semi-critical	5-10	Highest	22	Yes
25Y RP	Semi-critical	5-10	Highest	21	
100Y RP	Semi-critical	5-10	Highest	20	
Low	Semi-critical	2-4	Highest	20	
100Y RP	Semi-critical	5-10	Highest	20	
Low	Semi-critical	2-4	Highest	20	
Low	Semi-critical	2-4	Highest	20	
Low	Semi-critical	5-10	Highest	19	
Low	Semi-critical	5-10	Highest	19	
Low	Semi-critical	5-10	Highest	19	
Very Low	Semi-critical	2-4	Highest	19	
5Y RP	Semi-critical	5-10	Highest	22	Yes
5Y RP	Overexploited	5-10	Highest	21	
100Y RP	Semi-critical	5-10	Highest	20	
100Y RP	Semi-critical	5-10	Highest	20	
100Y RP	Semi-critical	5-10	Highest	20	
Low	Overexploited	2-4	Highest	19	
Low	Semi-critical	5-10	Highest	19	
Low	Semi-critical	5-10	Highest	19	
Low	Semi-critical	5-10	Highest	19	
100Y RP	Overexploited	5-10	Highest	19	
Low	Semi-critical	5-10	Highest	19	
Low	Overexploited	2-4	Highest	19	
Low	Overexploited	2-4	Highest	19	
Low	Semi-critical	5-10	Highest	19	
Low	Semi-critical	5-10	Highest	19	
Low	Semi-critical	5-10	Highest	19	
Low	Semi-critical	5-10	Highest	19	
Low	Semi-critical	5-10	Highest	19	
Low	Overexploited	5-10	Highest	18	
100Y RP	Overexploited	5-10	Highest	19	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
556	857	10	130	N.S.K salai	M	0.52	Clay	Alluvium
557	855	10	130	Amman koil street (west)	M	0.49	Clay	Alluvium
558	767	10	131	62nd street	M	0.45	Clay	Coastal Alluvium
559	768	10	131	Postal colony 4th street / part	M	0.60	Clay	Coastal Alluvium
560	421	10	136	K.K.Nagar i sector 6th street	M	0.60	Clay	Alluvium
561	422	10	136	K.K.Nagar ii sector 11th street	M	0.43	Clay	Alluvium
562	440	10	136	15th street 4th sector	M	0.68	Clay	Alluvium
563	99	10	136	Arcot salai	S	0.11	Clay	Alluvium
564	423	10	136	6th sector 28th street	M	0.63	Clay	Alluvium
565	434	10	136	Model house 2nd street	S	0.10	Clay	Alluvium
566	100	10	136	Arcot salai	M	0.23	Clay	Alluvium
567	101	10	136	Arcot salai	S	0.12	Clay	Alluvium
568	104	10	136	Arcot salai	S	0.08	Clay	Alluvium
569	433	10	136	Banumathi krishna street bahrani colony	M	0.40	Clay	Alluvium
570	424	10	136	P.T. Rajan road	L	3.05	Clay	Alluvium
571	425	10	136	P.T. Rajan road	S	0.01	Clay	Alluvium
572	426	10	136	Bobbiliraja salai	M	0.42	Clay	Alluvium
573	427	10	136	Rani anna nagar street, block 35	M	0.28	Clay	Alluvium
574	428	10	136	Rani anna nagar street, block 10 to 15	S	0.17	Clay	Alluvium
575	429	10	136	Rani anna nagar street, block 16 to 21	S	0.18	Clay	Alluvium
576	430	10	136	13th sector 83rd street	S	0.16	Clay	Alluvium
577	431	10	136	13th sector 83rd street	S	0.14	Clay	Alluvium
578	432	10	136	Vijayaraghavapuram 1st street	M	0.24	Clay	Alluvium
579	436	10	137	61st street 10th sector	M	0.73	Clay	Alluvium
580	437	10	137	67th street 11th sector	M	0.99	Clay	Alluvium
581	438	10	137	41st street 8th sector	M	0.53	Clay	Alluvium
582	439	10	137	74th street 12th sector	M	0.41	Clay	Alluvium
583	442	10	138	S.M.Block - v.M.Balakrishnan street	S	0.18	Clay	Alluvium
584	441	10	138	Ashok pillar road	M	0.38	Clay	Alluvium
585	444	10	139	R.V.Nagar 69th street	S	0.07	Clay	Coastal Alluvium
586	443	10	139	R.R.Colony ii cross street	L	2.34	Clay	Coastal Alluvium
587	446	10	140	Reddy kuppam road	S	0.03	Clay	Coastal Alluvium
588	445	10	142	Kodambakkam road	L	1.67	Clay	Coastal Alluvium
589	1043	10	142	Jones road	S	0.14	Clay	Coastal Alluvium
590	1044	10	142	Jones road	M	0.27	Clay	Coastal Alluvium
591	1045	10	142	Jones road lane (south)	S	0.02	Clay	Coastal Alluvium
592	1110	11	143	Andal street	M	0.55	Clay	Alluvium

Flood Susceptibility	Aquifer Firka Category"	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	"High Priority OSR in High Need Ward"
Low	Overexploited	5-10	Highest	18	
Very Low	Overexploited	5-10	Highest	17	
5Y RP	Safe	2-4	Lowest	17	
5Y RP	Safe	2-4	Lowest	17	
25Y RP	Overexploited	2-4	High	20	
5Y RP	Overexploited	5-10	High	20	
25Y RP	Semi-critical	5-10	High	20	
100Y RP	Semi-critical	5-10	High	19	
Low	Semi-critical	2-4	High	19	
25Y RP	Overexploited	5-10	High	19	
Low	Semi-critical	5-10	High	18	
Low	Semi-critical	5-10	High	18	
Low	Semi-critical	5-10	High	18	
Low	Semi-critical	5-10	High	18	
Low	Overexploited	5-10	High	17	
Low	Overexploited	5-10	High	17	
Low	Overexploited	5-10	High	17	
Low	Overexploited	5-10	High	17	
Low	Overexploited	5-10	High	17	
Low	Overexploited	5-10	High	17	
Low	Overexploited	5-10	High	17	
Low	Overexploited	5-10	High	17	
Low	Overexploited	5-10	High	17	
100Y RP	Semi-critical	5-10	Highest	20	
Low	Semi-critical	2-4	Highest	20	
Low	Semi-critical	2-4	Highest	20	
Low	Semi-critical	2-4	Highest	20	
100Y RP	Semi-critical	2-4	Highest	21	
100Y RP	Overexploited	2-4	Highest	20	
25Y RP	Safe	5-10	Highest	19	
100Y RP	Safe	5-10	Highest	18	
100Y RP	Overexploited	2-4	Highest	21	
100Y RP	Overexploited	5-10	High	19	
5Y RP	Safe	5-10	High	19	
5Y RP	Safe	5-10	High	19	
Low	Safe	5-10	High	16	
25Y RP	Overexploited	None	Low	20	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
593	1115	11	143	Sivan koil street	S	0.06	Clay	Alluvium
594	1125	11	143	Annamalai avenue	M	0.53	Clay	Alluvium
595	1081	11	143	S&p garden	M	0.25	Clay	Alluvium
596	1121	11	143	S&p garden	M	0.37	Clay	Alluvium
597	1072	11	143	7th cross street	L	1.03	Clay	Alluvium
598	1075	11	143	13th cross street	M	0.69	Clay	Alluvium
599	1083	11	143	2nd main road	S	0.03	Clay	Alluvium
600	1086	11	143	S&p garden	M	0.27	Clay	Alluvium
601	1088	11	143	Mck nagar	M	0.23	Clay	Alluvium
602	1095	11	143	Dabc phase iii	M	0.24	Clay	Alluvium
603	1096	11	143	Dabc-mithilam	M	0.73	Clay	Alluvium
604	1097	11	143	Dabc phase iii	S	0.10	Clay	Alluvium
605	1111	11	143	Union road	S	0.11	Clay	Alluvium
606	1112	11	143	Gangai amman nagar	S	0.05	Clay	Alluvium
607	1113	11	143	Perumal koil street	L	1.04	Clay	Alluvium
608	1114	11	143	Phase-i	S	0.09	Clay	Alluvium
609	1119	11	143	Phase-ii	S	0.06	Clay	Alluvium
610	1123	11	143	Annamalai avenue	L	2.11	Clay	Alluvium
611	1124	11	143	Annamalai avenue	M	0.94	Clay	Alluvium
612	1069	11	143	7th main road	M	0.25	Clay	Alluvium
613	1070	11	143	3rd main road	M	0.94	Clay	Alluvium
614	1078	11	143	13th cross street	M	0.22	Clay	Alluvium
615	1080	11	143	6th cross street	S	0.05	Clay	Alluvium
616	1082	11	143	Mogappair west main road	M	0.59	Clay	Alluvium
617	1084	11	143	Sakthi nagar	M	0.36	Clay	Alluvium
618	1089	11	143	Vgn minerva	M	0.26	Clay	Alluvium
619	1090	11	143	Vgn minerva	M	0.66	Clay	Alluvium
620	1091	11	143	Phase-ii	S	0.15	Clay	Alluvium
621	1092	11	143	Tanu road	S	0.12	Clay	Alluvium
622	1094	11	143	Sriram nagar	S	0.18	Clay	Alluvium
623	1098	11	143	Dabc phase iii	S	0.13	Clay	Alluvium
624	1099	11	143	Dabc phase iii	S	0.08	Clay	Alluvium
625	1100	11	143	Sakthi nagar	S	0.18	Clay	Alluvium
626	1101	11	143	Sriram nagar	M	0.27	Clay	Alluvium
627	1107	11	143	Vgn minerva	M	0.27	Clay	Alluvium
628	1108	11	143	Vgn minerva	M	0.44	Clay	Alluvium
629	1109	11	143	Vgn minerva	M	0.35	Clay	Alluvium

Flood Susceptibility	Aquifer Firka Category	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	“High Priority OSR in High Need Ward”
5Y RP	Overexploited	1	Low	20	
25Y RP	Overexploited	None	Low	20	
5Y RP	Overexploited	2-4	Low	19	
5Y RP	Overexploited	2-4	Low	19	
5Y RP	Overexploited	5-10	Low	18	
5Y RP	Overexploited	5-10	Low	18	
5Y RP	Overexploited	5-10	Low	18	
5Y RP	Overexploited	5-10	Low	18	
25Y RP	Overexploited	2-4	Low	18	
5Y RP	Overexploited	5-10	Low	18	
5Y RP	Overexploited	5-10	Low	18	
5Y RP	Overexploited	5-10	Low	18	
5Y RP	Overexploited	5-10	Low	18	
25Y RP	Overexploited	2-4	Low	18	
25Y RP	Overexploited	2-4	Low	18	
5Y RP	Overexploited	5-10	Low	18	
5Y RP	Overexploited	5-10	Low	18	
25Y RP	Overexploited	2-4	Low	18	
25Y RP	Semi-critical	5-10	Low	18	
5Y RP	Overexploited	More than 10	Low	17	
5Y RP	Overexploited	More than 10	Low	17	
5Y RP	Overexploited	More than 10	Low	17	
5Y RP	Overexploited	More than 10	Low	17	
5Y RP	Overexploited	More than 10	Low	17	
5Y RP	Overexploited	More than 10	Low	17	
5Y RP	Overexploited	More than 10	Low	17	
5Y RP	Overexploited	More than 10	Low	17	
5Y RP	Overexploited	More than 10	Low	17	
25Y RP	Overexploited	5-10	Low	17	
5Y RP	Overexploited	More than 10	Low	17	
5Y RP	Overexploited	More than 10	Low	17	
5Y RP	Overexploited	More than 10	Low	17	
5Y RP	Overexploited	More than 10	Low	17	
5Y RP	Overexploited	More than 10	Low	17	
25Y RP	Overexploited	5-10	Low	17	
5Y RP	Overexploited	More than 10	Low	17	
5Y RP	Overexploited	More than 10	Low	17	
5Y RP	Overexploited	More than 10	Low	17	
5Y RP	Overexploited	More than 10	Low	17	
25Y RP	Overexploited	5-10	Low	17	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
630	1116	11	143	5th main road	S	0.11	Clay	Alluvium
631	1120	11	143	Sakthi nagar	S	0.14	Clay	Alluvium
632	1122	11	143	Vgn minerva	S	0.10	Clay	Alluvium
633	360	11	143	Jaswanth nagar	S	0.05	Clay	Alluvium
634	1073	11	143	3rd cross street	M	0.41	Clay	Alluvium
635	1074	11	143	6th main road	S	0.18	Clay	Alluvium
636	1079	11	143	1st main road	M	0.23	Clay	Alluvium
637	1085	11	143	Voc street	M	0.42	Clay	Alluvium
638	1093	11	143	4th main road	S	0.06	Clay	Alluvium
639	1105	11	143	Guruswamy street	M	0.53	Clay	Alluvium
640	1106	11	143	Guruswamy street	S	0.19	Clay	Alluvium
641	1117	11	143	4th main road	M	0.38	Clay	Alluvium
642	1118	11	143	27th cross street	M	0.27	Clay	Alluvium
643	1071	11	143	9th main road	M	0.24	Clay	Alluvium
644	1087	11	143	5th block	S	0.04	Clay	Alluvium
645	1104	11	143	4th main road	M	0.27	Clay	Alluvium
646	1076	11	143	9th main road	S	0.14	Clay	Alluvium
647	1077	11	143	Channel road	M	0.36	Clay	Alluvium
648	1102	11	143	Dabc ayshvariam road	M	0.29	Clay	Alluvium
649	1103	11	143	Dabc avenue	S	0.07	Clay	Alluvium
650	808	11	144	M.M.D.A colony	S	0.14	Sand	Alluvium
651	809	11	144	Vip amutha nagar 2nd pradana salai	S	0.14	Sand	Alluvium
652	810	11	144	Vgp amutha nagar 3rd street	S	0.17	Sand	Alluvium
653	811	11	144	Poovai high road 1st pradana salai	S	0.04	Sand	Alluvium
654	447	11	145	Arulmighu meenakshi amman nagar	S	0.07	Sand	Alluvium
655	449	11	145	New colony	S	0.03	Sand	Alluvium
656	448	11	145	P.H.Road	S	0.12	Sand	Alluvium
657	1006	11	145	1 Cross street - ayyappa nagar	S	0.06	Clay	Alluvium
658	860	11	147	Bharathi naga 1st cross street	M	0.31	Clay	Alluvium
659	861	11	147	Gandhi nagar 8th street	S	0.10	Clay	Alluvium
660	862	11	147	Ganga nagar 6th street	S	0.18	Clay	Alluvium
661	452	11	148	Nesammal nagar annexe	S	0.11	Clay	Alluvium
662	451	11	148	Kamarajar salai	M	0.68	Clay	Alluvium
663	450	11	148	Kamarajar salai	L	1.46	Clay	Alluvium
664	453	11	149	Radhakrishanan salai	M	0.75	Clay	Alluvium
665	455	11	149	Gandhi salai	M	0.51	Clay	Alluvium
666	458	11	149	Tagore street	L	1.17	Clay	Alluvium

Flood Susceptibility	Aquifer Firka Category"	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	"High Priority OSR in High Need Ward"
5Y RP	Overexploited	More than 10	Low	17	
5Y RP	Overexploited	More than 10	Low	17	
5Y RP	Overexploited	More than 10	Low	17	
100Y RP	Overexploited	5-10	Low	16	
25Y RP	Overexploited	More than 10	Low	16	
25Y RP	Overexploited	More than 10	Low	16	
25Y RP	Overexploited	More than 10	Low	16	
25Y RP	Overexploited	More than 10	Low	16	
25Y RP	Overexploited	More than 10	Low	16	
25Y RP	Overexploited	More than 10	Low	16	
25Y RP	Overexploited	More than 10	Low	16	
25Y RP	Overexploited	More than 10	Low	16	
25Y RP	Overexploited	More than 10	Low	16	
25Y RP	Overexploited	More than 10	Low	16	
100Y RP	Overexploited	More than 10	Low	15	
100Y RP	Overexploited	More than 10	Low	15	
100Y RP	Overexploited	More than 10	Low	15	
Low	Overexploited	More than 10	Low	14	
Low	Overexploited	More than 10	Low	14	
Low	Overexploited	More than 10	Low	14	
Low	Overexploited	More than 10	Low	14	
5Y RP	Semi-critical	None	Low	25	
5Y RP	Overexploited	1	Low	23	
5Y RP	Overexploited	1	Low	23	
Very Low	Semi-critical	1	Low	20	
100Y RP	Semi-critical	None	Low	23	
100Y RP	Semi-critical	None	Low	23	
25Y RP	Overexploited	1	Low	22	
25Y RP	Semi-critical	1	Low	20	
25Y RP	Semi-critical	1	Medium	21	
100Y RP	Semi-critical	None	Medium	21	
100Y RP	Semi-critical	1	Medium	20	
25Y RP	Semi-critical	None	Highest	24	Yes
5Y RP	Semi-critical	2-4	Highest	23	Yes
5Y RP	Semi-critical	2-4	High	22	Yes
Low	Semi-critical	2-4	High	19	
Low	Semi-critical	2-4	High	19	
Low	Semi-critical	2-4	High	19	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
667	460	11	149	Palaniappa nagar	M	0.35	Clay	Alluvium
668	454	11	149	Brindhavan nagar	M	0.62	Clay	Alluvium
669	457	11	149	Neithal street	M	0.48	Clay	Alluvium
670	459	11	149	Arcot road	M	0.48	Clay	Alluvium
671	456	11	149	Brindhavan nagar	S	0.16	Clay	Alluvium
672	772	11	150	Maharishi avene extn	S	0.07	Sand	Alluvium
673	773	11	150	Ponni nagar ponniamman koil street	M	0.34	Sand	Alluvium
674	774	11	150	Chettiyar agaram main road	M	0.20	Sand	Alluvium
675	779	11	150	Agni fairy land	M	0.38	Sand	Alluvium
676	770	11	150	Karambakkam 1st street	S	0.12	Sand	Alluvium
677	771	11	150	Subagiri nagar 1st street	S	0.13	Sand	Alluvium
678	775	11	150	Thilagar street	M	0.64	Sand	Alluvium
679	776	11	150	Sri parasnath nagar	M	0.34	Sand	Alluvium
680	777	11	150	Park street	M	0.32	Sand	Alluvium
681	778	11	150	Moorthi nagar iind street	M	0.43	Sand	Alluvium
682	780	11	150	Chettyar agaram	L	2.05	Sand	Alluvium
683	71	11	150	Metro nagar 4th main salai	M	0.27	Clay	Alluvium
684	769	11	150	Rajeswari nagar main road	M	0.23	Clay	Alluvium
685	859	11	150	Arcot road	S	0.08	Clay	Alluvium
686	787	11	151	Mount poonamallee road	M	0.42	Sand	Alluvium
687	657	11	151	Sairam avenue 1st st	S	0.03	Clay	Alluvium
688	784	11	151	Sabari nagar 5th cross street	S	0.17	Sand	Alluvium
689	788	11	151	Lakshmi nagar 5th cross street	S	0.12	Sand	Alluvium
690	785	11	151	Mount poonamallee road	L	1.53	Sand	Alluvium
691	789	11	151	Lakshmi nagar 40 feet main road	M	0.31	Clay	Alluvium
692	786	11	151	Mount poonamallee road	M	0.46	Sand	Alluvium
693	853	11	151	Chinna porur anna salai	M	0.33	Clay	Alluvium
694	851	11	151	Lakshmi nagar 5th cross street	S	0.05	Clay	Alluvium
695	852	11	151	Lakshmi nagar extn. 4th main road (east)	M	0.43	Clay	Alluvium
696	654	11	152	Veerappa nagar main road	M	0.24	Clay	Alluvium
697	655	11	152	Kadamban st.	M	0.23	Clay	Alluvium
698	68	11	152	Lambert nagar ii main road	M	0.22	Clay	Alluvium
699	656	11	152	Chowdry nagar 11th st	M	0.53	Clay	Alluvium
700	658	11	152	Rajaji avenue 1st st	S	0.02	Clay	Alluvium
701	659	11	152	Bharathi colony	S	0.07	Clay	Alluvium
702	661	11	153	Udaya nagar main road	S	0.20	Sand	Alluvium
703	662	11	153	Ramasamy nagar main road	M	0.31	Sand	Alluvium

Flood Susceptibility	Aquifer Firka Category"	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	"High Priority OSR in High Need Ward"
Low	Semi-critical	2-4	High	19	
Low	Semi-critical	5-10	High	18	
Low	Semi-critical	5-10	High	18	
Low	Semi-critical	5-10	High	18	
Very Low	Semi-critical	5-10	High	17	
Low	Semi-critical	None	Low	22	
25Y RP	Semi-critical	2-4	Low	22	
Very Low	Semi-critical	1	Low	20	
Very Low	Semi-critical	1	Low	20	
Very Low	Semi-critical	2-4	Low	19	
Very Low	Semi-critical	2-4	Low	19	
Very Low	Semi-critical	2-4	Low	19	
Very Low	Semi-critical	2-4	Low	19	
Very Low	Semi-critical	2-4	Low	19	
Very Low	Semi-critical	2-4	Low	19	
Very Low	Semi-critical	2-4	Low	19	
Very Low	Semi-critical	1		18	
Low	Semi-critical	2-4	Low	17	
Very Low	Semi-critical	2-4	Low	16	
Very Low	Semi-critical	2-4	Low	16	
5Y RP	Semi-critical	2-4	Low	23	
5Y RP	Semi-critical	2-4	Low	20	
Low	Semi-critical	2-4	Low	20	
Low	Semi-critical	2-4	Low	20	
Very Low	Semi-critical	2-4	Low	19	
25Y RP	Semi-critical	2-4	Low	19	
Very Low	Semi-critical	5-10	Low	18	
100Y RP	Semi-critical	2-4	Low	18	
Low	Semi-critical	2-4	Low	17	
Low	Semi-critical	2-4	Low	17	
25Y RP	Semi-critical	2-4	Highest	22	Yes
25Y RP	Semi-critical	2-4	Highest	22	Yes
25Y RP	Semi-critical	5-10	Highest	21	
Low	Semi-critical	1	Highest	21	
Low	Semi-critical	2-4	Highest	20	
Very Low	Semi-critical	2-4	Highest	19	
25Y RP	Semi-critical	5-10	Low	21	
25Y RP	Semi-critical	5-10	Low	21	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
704	660	11	153	Harivarasan st, ramakrishna nagar extn	M	0.50	Sand	Alluvium
705	665	11	153	Sterling avenue main road	M	0.46	Sand	Alluvium
706	663	11	153	Ramakrishna nagar main road	M	0.26	Sand	Alluvium
707	664	11	153	Kanniappan salai	M	0.21	Sand	Alluvium
708	791	11	154	Giri nagar 1st street	S	0.07	Clay	Alluvium
709	800	11	154	Kurunji nagar 3rd street	S	0.12	Clay	Alluvium
710	782	11	155	Amman nagar 1st main road	S	0.07	Sand	Alluvium
711	783	11	155	Thiruvalluvar salai	M	0.23	Sand	Alluvium
712	795	11	155	Jai balaji nagar	S	0.08	Sand	Alluvium
713	799	11	155	Kalasathamman koil street	S	0.10	Sand	Alluvium
714	781	11	155	Kalasanthamman koil street	S	0.12	Sand	Alluvium
715	796	11	155	Rayala nagar 2nd main road	M	0.27	Sand	Alluvium
716	798	11	155	Kalasanthamman koil street	M	0.27	Sand	Alluvium
717	793	11	155	Alagapuri nagar	S	0.14	Sand	Alluvium
718	794	11	155	K.P. Nagar 1st main road	S	0.11	Clay	Alluvium
719	790	11	155	Rayala nagar 1st main road	M	0.28	Clay	Alluvium
720	792	11	155	Eswaran nagar 4th street	S	0.17	Clay	Alluvium
721	797	11	155	Rayala nagar 1st cross street	S	0.16	Clay	Alluvium
722	871	12	156	Thiruvalluvar nagar	L	1.19	Sand	Alluvium
723	866	12	156	Ramamoorthi avenue	M	0.31	Sand	Alluvium
724	867	12	156	Lavendar street	S	0.10	Sand	Alluvium
725	868	12	156	V.G.N. Blooming garden	M	0.42	Sand	Alluvium
726	870	12	156	Kalaimagal street	L	1.32	Sand	Alluvium
727	872	12	156	Vgn lakshmi nagar	S	0.16	Sand	Alluvium
728	874	12	156	V.N.D.Avenue	M	0.52	Sand	Alluvium
729	878	12	156	Madha nagar main road	M	0.42	Sand	Alluvium
730	887	12	156	Sabari nagar main road	S	0.20	Sand	Alluvium
731	894	12	156	Madananthapuram	M	0.38	Sand	Alluvium
732	875	12	156	Annai velankanni nagar 2nd street	M	0.33	Sand	Alluvium
733	882	12	156	Annai velankanni nagar 5th street	M	0.34	Sand	Alluvium
734	885	12	156	Subhashree nagar extn-5	S	0.06	Sand	Alluvium
735	886	12	156	Sabari nagar main road	S	0.19	Sand	Alluvium
736	888	12	156	Sabari nagar	S	0.17	Sand	Alluvium
737	892	12	156	Kundrathur main road	M	0.34	Sand	Alluvium
738	869	12	156	Blueming garden	M	0.40	Sand	Alluvium
739	873	12	156	Kumutham nagar 2nd street	M	0.66	Sand	Alluvium
740	877	12	156	E.V.P.Rajeshwari avenue	M	0.48	Sand	Alluvium

Flood Susceptibility	Aquifer Firka Category"	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	"High Priority OSR in High Need Ward"
Low	Semi-critical	5-10	Low	19	
Very Low	Semi-critical	2-4	Low	19	
Very Low	Semi-critical	5-10	Low	18	
Very Low	Semi-critical	5-10	Low	18	
Low	Semi-critical	2-4	Medium	18	
Low	Semi-critical	2-4	Medium	18	
5Y RP	Semi-critical	2-4	High	25	Yes
5Y RP	Semi-critical	2-4	High	25	Yes
5Y RP	Semi-critical	2-4	High	25	Yes
5Y RP	Semi-critical	2-4	High	25	Yes
25Y RP	Semi-critical	2-4	High	24	Yes
5Y RP	Semi-critical	5-10	High	24	Yes
25Y RP	Semi-critical	2-4	High	24	Yes
100Y RP	Semi-critical	5-10	High	22	Yes
25Y RP	Semi-critical	2-4	High	21	
Low	Semi-critical	5-10	High	18	
Low	Semi-critical	5-10	High	18	
Low	Semi-critical	5-10	High	18	
5Y RP	Semi-critical	2-4	Lowest	22	
25Y RP	Semi-critical	5-10	Lowest	20	
100Y RP	Semi-critical	2-4	Lowest	20	
100Y RP	Semi-critical	2-4	Lowest	20	
25Y RP	Semi-critical	5-10	Lowest	20	
25Y RP	Semi-critical	5-10	Lowest	20	
25Y RP	Semi-critical	5-10	Lowest	20	
25Y RP	Semi-critical	5-10	Lowest	20	
25Y RP	Semi-critical	5-10	Lowest	20	
25Y RP	Semi-critical	5-10	Lowest	20	
25Y RP	Semi-critical	5-10	Lowest	20	
100Y RP	Semi-critical	5-10	Lowest	19	
100Y RP	Semi-critical	5-10	Lowest	19	
Low	Semi-critical	2-4	Lowest	19	
100Y RP	Semi-critical	5-10	Lowest	19	
Low	Semi-critical	2-4	Lowest	19	
Low	Semi-critical	2-4	Lowest	19	
Low	Semi-critical	5-10	Lowest	18	
Low	Semi-critical	5-10	Lowest	18	
Low	Semi-critical	5-10	Lowest	18	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
741	893	12	156	Kundrathur main road	S	0.13	Sand	Alluvium
742	879	12	156	Ags colony phase iii main road	M	0.73	Sand	Alluvium
743	880	12	156	Annai velankanni nagar phase ii main road	M	0.53	Sand	Alluvium
744	881	12	156	Subbaiya nagar	S	0.07	Sand	Alluvium
745	883	12	156	Devadoss street	M	0.37	Sand	Alluvium
746	890	12	156	Rajrajeshwari nagar	M	0.97	Sand	Alluvium
747	891	12	156	Rajrajeshwari nagar	S	0.11	Sand	Alluvium
748	889	12	156	Ramachandra street	L	1.64	Sand	Alluvium
749	910	12	157	Micro marvel river view county	M	0.52	Sand	Alluvium
750	884	12	157	Krishnaveni nagar	M	0.70	Sand	Alluvium
751	666	12	157	M.G.R. Nagar	S	0.02	Hard Rock	Alluvium
752	895	12	157	C.R.R.Puram	S	0.01	Sand	Alluvium
753	906	12	157	Kaviya garden	M	0.31	Sand	Alluvium
754	876	12	157	C.R.R.Puram	M	0.50	Sand	Alluvium
755	896	12	157	C.R.R.Puram	S	0.02	Sand	Alluvium
756	903	12	157	River view colony narmatha street	M	0.48	Hard Rock	Alluvium
757	908	12	157	River view avenue road	M	0.23	Hard Rock	Alluvium
758	909	12	157	Arcot road main road	M	0.29	Hard Rock	Alluvium
759	911	12	157	Sethu lakshmi avenue	S	0.15	Hard Rock	Alluvium
760	905	12	157	Bhel nagar 4th cross street	M	0.37	Sand	Alluvium
761	904	12	157	River view colony krishna street	M	0.53	Hard Rock	Charnokite
762	907	12	157	Macro marval main salai	M	0.42	Sand	Alluvium
763	322	12	161	City link road	M	0.27	Hard Rock	Charnokite
764	323	12	161	City link road santhinigathan	M	0.41	Hard Rock	Charnokite
765	320	12	162	Nobel 1st street	M	0.52	Hard Rock	Charnokite
766	319	12	162	Nehru street	S	0.19	Hard Rock	Pyroxanegranite
767	321	12	162	Mkn road	M	0.27	Hard Rock	Charnokite
768	318	12	164	Nanganallur 29th street	S	0.06	Hard Rock	Charnokite
769	698	12	165	A.G.S colony 5th cross street	M	0.37	Hard Rock	Charnokite
770	938	12	165	Velachery main road	S	0.10	Hard Rock	Charnokite
771	317	12	167	Sip colony	M	0.45	Hard Rock	Charnokite
772	158	13	168	Labour colony 1st street,	M	0.50	Sand	Charnokite
773	157	13	168	Mount road	S	0.07	Sand	Charnokite
774	815	13	168	Mount road	S	0.05	Sand	Charnokite
775	812	13	168	Costoms colony street	S	0.16	Clay	Charnokite
776	813	13	168	Central excise colony street	S	0.11	Clay	Charnokite
777	817	13	168	Jawaharlal nehru road	M	0.39	Hard Rock	Charnokite

Flood Susceptibility	Aquifer Firka Category"	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	"High Priority OSR in High Need Ward"
Very Low	Semi-critical	2-4	Lowest	18	
Very Low	Semi-critical	5-10	Lowest	17	
Very Low	Semi-critical	5-10	Lowest	17	
Very Low	Semi-critical	5-10	Lowest	17	
Very Low	Semi-critical	5-10	Lowest	17	
Very Low	Semi-critical	5-10	Lowest	17	
Very Low	Semi-critical	5-10	Lowest	17	
Very Low	Semi-critical	More than 10	Lowest	16	
5Y RP	Semi-critical	None	Lowest	24	
25Y RP	Semi-critical	None	Lowest	23	
5Y RP	Semi-critical	None	Lowest	22	
5Y RP	Semi-critical	2-4	Lowest	22	
5Y RP	Semi-critical	2-4	Lowest	22	
25Y RP	Semi-critical	2-4	Lowest	21	
100Y RP	Semi-critical	2-4	Lowest	20	
5Y RP	Semi-critical	2-4	Lowest	20	
5Y RP	Semi-critical	2-4	Lowest	20	
5Y RP	Semi-critical	2-4	Lowest	20	
25Y RP	Semi-critical	1	Lowest	20	
100Y RP	Semi-critical	5-10	Lowest	19	
25Y RP	Semi-critical	2-4	Lowest	17	
Very Low	Semi-critical	5-10	Lowest	17	
Low	Safe	2-4	High	15	
Very Low	Safe	2-4	High	14	
Very Low	Safe	None	High	16	
Very Low	Safe	1	High	14	
Very Low	Safe	2-4	High	14	
Low	Safe	1	Highest	17	
5Y RP	Safe	2-4	Medium	17	
5Y RP	Safe	2-4	Medium	17	
Very Low	Safe	More than 10	Lowest	9	
5Y RP	Safe	1	Low	19	
100Y RP	Overexploited	2-4	Low	18	
5Y RP	Safe	2-4	Low	18	
5Y RP	Safe	2-4	Low	15	
5Y RP	Safe	2-4	Low	15	
Low	Safe	2-4	Low	13	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
778	269	13	169	Venkatapuram tenements 14th street	S	0.05	Sand	Charnokite
779	336	13	170	Lake view road	L	1.25	Sand	Charnokite
780	342	13	170	Lock street	S	0.05	Sand	Charnokite
781	331	13	170	River view road	M	0.33	Sand	Charnokite
782	333	13	170	Kotturpuram 3rd main road	S	0.04	Sand	Charnokite
783	334	13	170	Kotturpuram 3rd main road	M	0.33	Sand	Charnokite
784	337	13	170	Kotturpuram 2nd main road	S	0.16	Sand	Charnokite
785	338	13	170	Kotturpuram 2nd main road	M	0.46	Sand	Charnokite
786	339	13	170	River view road	L	3.99	Sand	Charnokite
787	344	13	170	Dhandayuthapani nagar cross street	M	0.39	Sand	Charnokite
788	332	13	170	Lake view road	S	0.03	Sand	Charnokite
789	330	13	170	Ponni amman koil street	S	0.14	Sand	Charnokite
790	341	13	170	Kottur garden iv main road	S	0.09	Sand	Charnokite
791	345	13	170	Ambadi road	S	0.20	Sand	Charnokite
792	335	13	170	Kottur garden i cross street	M	0.81	Sand	Charnokite
793	343	13	170	Kottur garden iv main road	S	0.17	Sand	Charnokite
794	340	13	170	Tank bund road	S	0.16	Sand	Charnokite
795	667	13	171	R.K. Mutt road	L	2.96	Sand	Coastal Alluvium
796	673	13	171	Sathya dev avenue extrn.,	M	0.32	Sand	Coastal Alluvium
797	674	13	171	Sathyadev avenue	L	1.35	Sand	Coastal Alluvium
798	677	13	171	Rohini garden cross street	M	0.58	Sand	Coastal Alluvium
799	680	13	171	P.S.Kumarasamy raja salai	S	0.11	Sand	Coastal Alluvium
800	681	13	171	P.S.Kumarasamy raja salai	S	0.12	Sand	Coastal Alluvium
801	668	13	171	Kamaraj salai	L	1.14	Sand	Coastal Alluvium
802	670	13	171	Kesava perumal puram east avenue	M	0.24	Sand	Coastal Alluvium
803	671	13	171	Kesavaperumalpuram central avenue	M	0.20	Sand	Coastal Alluvium
804	672	13	171	Kamaraj salai	M	0.62	Sand	Coastal Alluvium
805	675	13	171	Vasanth avenue	M	0.42	Sand	Coastal Alluvium
806	676	13	171	May flower garden	M	0.37	Sand	Coastal Alluvium
807	678	13	171	M.R.C. Nagar main road	M	0.39	Sand	Coastal Alluvium
808	683	13	171	Greenways road (or) dr.D.G.S.Dhinakaran salai	S	0.10	Sand	Coastal Alluvium
809	684	13	171	Greenways road (or) dr.D.G.S.Dhinakaran salai	S	0.02	Sand	Coastal Alluvium
810	685	13	171	R.K. Mutt road	S	0.16	Sand	Coastal Alluvium
811	686	13	171	Kesavaperumal puram north avenue	S	0.01	Sand	Coastal Alluvium
812	669	13	171	Krishna puri main road	M	0.38	Sand	Coastal Alluvium
813	682	13	171	P.S.Kumarasamy raja salai	S	0.01	Sand	Coastal Alluvium
814	687	13	171	Park view street	M	0.31	Sand	Coastal Alluvium

Flood Susceptibility	Aquifer Firka Category	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	“High Priority OSR in High Need Ward”
Very Low	Overexploited	2-4	Lowest	15	
25Y RP	Overexploited	1	Lowest	19	
5Y RP	Overexploited	2-4	Lowest	19	
5Y RP	Overexploited	5-10	Lowest	18	
5Y RP	Overexploited	5-10	Lowest	18	
5Y RP	Overexploited	5-10	Lowest	18	
5Y RP	Overexploited	5-10	Lowest	18	
5Y RP	Overexploited	5-10	Lowest	18	
5Y RP	Overexploited	5-10	Lowest	18	
5Y RP	Overexploited	5-10	Lowest	18	
100Y RP	Overexploited	1	Lowest	18	
25Y RP	Overexploited	5-10	Lowest	17	
25Y RP	Overexploited	5-10	Lowest	17	
100Y RP	Overexploited	2-4	Lowest	17	
100Y RP	Overexploited	5-10	Lowest	16	
100Y RP	Overexploited	5-10	Lowest	16	
Very Low	Overexploited	2-4	Lowest	15	
25Y RP	Overexploited	2-4	Lowest	21	
5Y RP	Overexploited	5-10	Lowest	21	
5Y RP	Overexploited	5-10	Lowest	21	
5Y RP	Overexploited	5-10	Lowest	21	
25Y RP	Overexploited	2-4	Lowest	21	
25Y RP	Overexploited	2-4	Lowest	21	
25Y RP	Overexploited	5-10	Lowest	20	
25Y RP	Overexploited	5-10	Lowest	20	
25Y RP	Overexploited	5-10	Lowest	20	
100Y RP	Overexploited	2-4	Lowest	20	
25Y RP	Overexploited	5-10	Lowest	20	
25Y RP	Overexploited	5-10	Lowest	20	
25Y RP	Overexploited	5-10	Lowest	20	
25Y RP	Overexploited	5-10	Lowest	20	
25Y RP	Overexploited	5-10	Lowest	20	
25Y RP	Overexploited	5-10	Lowest	20	
25Y RP	Overexploited	5-10	Lowest	20	
100Y RP	Overexploited	5-10	Lowest	19	
100Y RP	Overexploited	5-10	Lowest	19	
100Y RP	Overexploited	5-10	Lowest	19	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
815	688	13	171	Park view street	S	0.16	Sand	Coastal Alluvium
816	679	13	171	M.R.C. Nagar extn.,	L	1.45	Sand	Coastal Alluvium
817	245	13	172	Seva nagar 1st street	M	0.53	Hard Rock	Charnokite
818	814	13	172	Mount road	M	0.84	Sand	Charnokite
819	819	13	172	Sankaran avenue 3rd street	L	1.17	Hard Rock	Charnokite
820	822	13	172	Velachery main road	S	0.05	Hard Rock	Charnokite
821	820	13	172	Race course road	S	0.16	Hard Rock	Charnokite
822	821	13	172	Velachery main road	S	0.01	Hard Rock	Charnokite
823	818	13	172	Secretariat colony	M	0.50	Hard Rock	Charnokite
824	272	13	173	Indira nagar 7th cross street	M	0.79	Sand	Coastal Alluvium
825	274	13	173	Indira nagar 11th lane	M	0.27	Sand	Coastal Alluvium
826	275	13	173	Indira nagar 26th cross st	S	0.16	Sand	Coastal Alluvium
827	270	13	173	Indira nagar 4th cross street	L	1.56	Sand	Coastal Alluvium
828	271	13	173	Venkatathinam nagar main road	M	0.47	Sand	Coastal Alluvium
829	273	13	173	Srinivasamoorthy avenue	S	0.06	Sand	Coastal Alluvium
830	162	13	173	L b road	S	0.20	Sand	Coromandal soil
831	163	13	173	L b road	M	0.27	Sand	Coromandal soil
832	169	13	173	Kamaraj nagar 13th west street	S	0.19	Sand	Coromandal soil
833	170	13	173	Kamaraj nagar 2nd (w) street	M	0.31	Sand	Coromandal soil
834	161	13	173	L b road	S	0.19	Sand	Coromandal soil
835	168	13	173	Kamaraj nagar 4th (w) street	M	0.48	Sand	Coromandal soil
836	160	13	173	L b road	M	0.40	Sand	Coromandal soil
837	802	13	174	Sastri nagar 14th cross street	L	1.08	Sand	Coastal Alluvium
838	805	13	174	Durgabai deshmukh road	S	0.13	Sand	Coastal Alluvium
839	801	13	174	Padmanabha nagar 5th street	S	0.13	Sand	Coastal Alluvium
840	803	13	174	State bank colony	S	0.07	Sand	Coastal Alluvium
841	806	13	174	Besant nagar 21st cross street	M	0.27	Sand	Coastal Alluvium
842	807	13	174	Besant nagar 32nd cross street	L	1.05	Sand	Coastal Alluvium
843	804	13	174	Durgabai deshmukh road	M	0.96	Sand	Coastal Alluvium
844	462	13	175	Dr. Ambedkar nagar 1st main road	S	0.09	Hard Rock	Charnokite
845	471	13	175	T.N.H.B 4th street	S	0.16	Hard Rock	Charnokite
846	463	13	175	N.N.G.O colony 2nd main road	M	0.49	Hard Rock	Charnokite
847	469	13	175	L.H. Nagar 4th cross street	S	0.10	Hard Rock	Charnokite
848	461	13	175	L.H. Nagar 3rd cross street	M	0.41	Hard Rock	Charnokite
849	464	13	175	Indira gandhi nagar 3rd street	S	0.03	Hard Rock	Charnokite
850	466	13	175	Telephone colony 2nd main road	S	0.05	Hard Rock	Charnokite
851	467	13	175	Mahalakshmi nagar 1st main road	S	0.12	Hard Rock	Charnokite

Flood Susceptibility	Aquifer Firka Category	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	“High Priority OSR in High Need Ward”
100Y RP	Overexploited	5-10	Lowest	19	
Low	Overexploited	5-10	Lowest	18	
Very Low	Overexploited	1	Highest	18	
100Y RP	Safe	2-4	Lowest	15	
5Y RP	Safe	2-4	Lowest	15	
Very Low	Overexploited	1	Lowest	14	
Very Low	Safe	None	Lowest	13	
Very Low	Safe	None	Lowest	13	
Low	Safe	2-4	Lowest	12	
5Y RP	Overexploited	2-4	Lowest	22	
5Y RP	Overexploited	2-4	Lowest	22	
Low	Overexploited	1	Lowest	20	
Low	Overexploited	2-4	Lowest	19	
Very Low	Overexploited	2-4	Lowest	18	
Very Low	Overexploited	2-4	Lowest	18	
5Y RP	Overexploited	2-4	Lowest	17	
5Y RP	Overexploited	2-4	Lowest	17	
5Y RP	Overexploited	2-4	Lowest	17	
25Y RP	Overexploited	1	Lowest	17	
25Y RP	Overexploited	2-4	Lowest	16	
25Y RP	Overexploited	2-4	Lowest	16	
100Y RP	Overexploited	2-4	Lowest	15	
5Y RP	Overexploited	None	Low	25	
5Y RP	Overexploited	1	Low	24	
Low	Overexploited	None	Low	22	
Low	Overexploited	1	Low	21	
Low	Overexploited	1	Low	21	
Very Low	Overexploited	None	Low	21	
Very Low	Overexploited	2-4	Low	19	
25Y RP	Safe	1	Highest	19	
5Y RP	Safe	2-4	Highest	19	
25Y RP	Safe	2-4	Highest	18	
25Y RP	Safe	2-4	Highest	18	
100Y RP	Safe	2-4	Highest	17	
100Y RP	Safe	2-4	Highest	17	
100Y RP	Safe	2-4	Highest	17	
25Y RP	Safe	5-10	Highest	17	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
852	465	13	175	Sastri nagar 4th street	M	0.87	Hard Rock	Charnokite
853	476	13	175	Kakkan nagar 3rd cross street	S	0.04	Hard Rock	Charnokite
854	473	13	175	Mahalakshmi nagar 1st cross st	S	0.16	Hard Rock	Charnokite
855	474	13	175	Shawalace colony 2nd street	S	0.09	Hard Rock	Charnokite
856	690	13	176	Ram nagar 7th main road	S	0.05	Hard Rock	Charnokite
857	689	13	176	Ram nagar 5th street	S	0.05	Hard Rock	Charnokite
858	691	13	176	Ram nagar north extn 1st street	M	0.22	Hard Rock	Charnokite
859	692	13	176	Ram nagar 1st street	S	0.08	Hard Rock	Charnokite
860	693	13	176	Vijaya nagar 4th cross st	S	0.10	Hard Rock	Charnokite
861	696	13	176	A.G.S colony 9th cross street	M	0.47	Hard Rock	Charnokite
862	697	13	176	A.G.S colony 9th cross street	M	0.69	Hard Rock	Charnokite
863	699	13	176	A.G.S colony 6th main road	S	0.16	Hard Rock	Charnokite
864	700	13	176	Padmavathi nagar extn main road	S	0.08	Hard Rock	Charnokite
865	468	13	176	Krishnaraja nagar extn. 1st st	M	0.33	Hard Rock	Charnokite
866	475	13	176	Ramakrishna nagar 3rd main road	S	0.19	Hard Rock	Charnokite
867	470	13	176	Gangai nagar 2nd main roa	S	0.06	Hard Rock	Charnokite
868	472	13	176	Andal nagar 2nd main road	S	0.10	Hard Rock	Charnokite
869	703	13	177	Jeganathapuram (rajalakshmi nagar) 1st main road	S	0.06	Hard Rock	Charnokite
870	228	13	177	Pillaiyar koil street (annai indira nagar)	S	0.07	Hard Rock	Charnokite
871	227	13	177	Seetharam nagar 2nd street	S	0.08	Hard Rock	Charnokite
872	231	13	177	Bethel avenue	M	0.29	Hard Rock	Charnokite
873	232	13	177	Bethel avenue 1st street	S	0.15	Hard Rock	Charnokite
874	235	13	177	Vgp selava nagar extention	S	0.16	Hard Rock	Charnokite
875	236	13	177	V.G.P. Selva nagar extn 4 th main road	M	0.64	Hard Rock	Charnokite
876	238	13	177	Bhuvaneswari nagar 1st main road	S	0.02	Hard Rock	Charnokite
877	239	13	177	Vgp selava nagar 2nd main road	M	0.65	Hard Rock	Charnokite
878	243	13	177	Balamurugan nagar 3rd main road	S	0.12	Hard Rock	Charnokite
879	244	13	177	Thiruvalluvar street (annai indira nagar)	M	0.23	Hard Rock	Charnokite
880	246	13	177	Subramanian colony	S	0.07	Hard Rock	Charnokite
881	250	13	177	Vgp selva nagar 1st main road	M	0.26	Hard Rock	Charnokite
882	252	13	177	Seshadripuram main road	M	0.21	Hard Rock	Charnokite
883	254	13	177	Vgp selava nagar extention	L	1.11	Hard Rock	Charnokite
884	255	13	177	Vanchinathan street	S	0.04	Hard Rock	Charnokite
885	262	13	177	Anna nagar extention	S	0.04	Hard Rock	Charnokite
886	263	13	177	Velachery main road	S	0.04	Hard Rock	Charnokite
887	264	13	177	Velachery main road	M	0.42	Hard Rock	Charnokite
888	223	13	177	Velachery main road	S	0.07	Hard Rock	Charnokite

Flood Susceptibility	Aquifer Firka Category	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	“High Priority OSR in High Need Ward”
Low	Safe	2-4	Highest	16	
Low	Safe	2-4	Highest	16	
Very Low	Safe	5-10	Highest	14	
Very Low	Safe	5-10	Highest	14	
5Y RP	Safe	None	Highest	21	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
25Y RP	Safe	2-4	Highest	18	
25Y RP	Safe	2-4	Highest	18	
Very Low	Safe	1	Highest	16	
25Y RP	Safe	2-4	Medium	16	
5Y RP	Overexploited	2-4	Highest	21	
5Y RP	Safe	1	Highest	20	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
25Y RP	Safe	1	Highest	19	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
Low	Overexploited	2-4	Highest	18	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
889	224	13	177	Seethapatty nagar 3rd cross street	S	0.17	Hard Rock	Charnokite
890	240	13	177	Subramanian colony	S	0.09	Hard Rock	Charnokite
891	241	13	177	Dhandeeswaram 7th main road	M	0.42	Hard Rock	Charnokite
892	242	13	177	Bharathi street (annai indira nagar)	S	0.09	Hard Rock	Charnokite
893	249	13	177	Spic nagar	M	0.20	Hard Rock	Charnokite
894	257	13	177	Andal avenue 1st street	S	0.02	Hard Rock	Charnokite
895	259	13	177	Velachery main road	M	0.27	Hard Rock	Charnokite
896	694	13	177	Bhelsakthi nagar 1st main road	M	0.26	Hard Rock	Charnokite
897	695	13	177	Devi karumariamman nagar 7th street	S	0.07	Hard Rock	Charnokite
898	225	13	177	Tansi nagar 6th street	S	0.07	Hard Rock	Charnokite
899	226	13	177	Baby nagar 2nd main road	M	0.32	Hard Rock	Charnokite
900	230	13	177	Shanthi 1st cross st	S	0.05	Hard Rock	Charnokite
901	233	13	177	Gandhi salai	S	0.15	Hard Rock	Charnokite
902	248	13	177	New colony main road	S	0.18	Hard Rock	Charnokite
903	701	13	177	100 Feet bypass road	M	0.21	Hard Rock	Charnokite
904	702	13	177	Rajalakshmi nagar 8th cross st	M	0.22	Hard Rock	Charnokite
905	234	13	177	Velachery main road	S	0.19	Hard Rock	Charnokite
906	258	13	177	Velachery main road	M	0.40	Hard Rock	Charnokite
907	261	13	177	Velachery main road	S	0.11	Hard Rock	Charnokite
908	265	13	177	Velachery main road	S	0.03	Hard Rock	Charnokite
909	173	13	178	Vilayattu vinayagar koil street	M	0.54	Sand	Coastal Alluvium
910	165	13	178	Vilayattu vinayagar koil street	M	0.40	Sand	Coastal Alluvium
911	164	13	178	Cpt road	M	0.39	Sand	Coastal Alluvium
912	166	13	178	Vilayattu vinayagar koil street	M	0.50	Sand	Coastal Alluvium
913	167	13	178	Vilayattu vinayagar koil street	M	0.76	Sand	Coastal Alluvium
914	171	13	178	Nehru street kanagam	S	0.12	Sand	Coastal Alluvium
915	172	13	178	Nehru street kanagam	M	0.32	Sand	Coastal Alluvium
916	237	13	178	Bharani street	S	0.01	Hard Rock	Charnokite
917	159	13	178	L b road	S	0.10	Sand	Coromandal soil
918	229	13	178	Seshadripuram main road	S	0.07	Hard Rock	Charnokite
919	253	13	178	Sanjay garden street	S	0.04	Hard Rock	Charnokite
920	247	13	178	Udhyam colony 2nd main road	S	0.04	Hard Rock	Charnokite
921	256	13	178	Park avenue 1st street	S	0.13	Hard Rock	Charnokite
922	251	13	178	Ramagiri 1st street	S	0.14	Hard Rock	Charnokite
923	260	13	178	Ramagiri 2nd street	S	0.08	Hard Rock	Charnokite
924	576	13	179	Sivasundaram avenue 2nd street	M	0.62	Sand	Coastal Alluvium
925	573	13	179	29th cross street	S	0.19	Sand	Coastal Alluvium

Flood Susceptibility	Aquifer Firka Category"	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	"High Priority OSR in High Need Ward"
Low	Overexploited	2-4	Highest	18	
25Y RP	Safe	2-4	Highest	18	
Low	Overexploited	2-4	Highest	18	
25Y RP	Safe	2-4	Highest	18	
25Y RP	Safe	2-4	Highest	18	
Very Low	Overexploited	1	Highest	18	
Low	Overexploited	2-4	Highest	18	
25Y RP	Safe	2-4	Highest	18	
25Y RP	Safe	2-4	Highest	18	
100Y RP	Safe	2-4	Highest	17	
100Y RP	Safe	2-4	Highest	17	
Very Low	Overexploited	2-4	Highest	17	
Very Low	Overexploited	2-4	Highest	17	
Very Low	Overexploited	2-4	Highest	17	
Low	Safe	2-4	Highest	16	
Low	Safe	2-4	Highest	16	
Very Low	Safe	2-4	Highest	15	
Very Low	Safe	2-4	Highest	15	
Very Low	Safe	2-4	Highest	15	
Very Low	Safe	2-4	Highest	15	
5Y RP	Overexploited	1	Medium	25	
25Y RP	Overexploited	1	Medium	24	
100Y RP	Overexploited	1	Medium	23	
Low	Overexploited	None	Medium	23	
Low	Overexploited	None	Medium	23	
Low	Overexploited	1	Medium	22	
Very Low	Overexploited	1	Medium	21	
25Y RP	Overexploited	2-4	Medium	18	
100Y RP	Overexploited	2-4	Medium	17	
5Y RP	Safe	2-4	Medium	17	
5Y RP	Safe	2-4	Medium	17	
Low	Overexploited	2-4	Medium	16	
25Y RP	Safe	2-4	Medium	16	
Very Low	Overexploited	2-4	Medium	15	
Very Low	Overexploited	2-4	Medium	15	
5Y RP	Overexploited	1	High	26	Yes
25Y RP	Overexploited	2-4	High	24	Yes

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
926	578	13	179	Sivakamipuram 2nd street	S	0.03	Sand	Coastal Alluvium
927	581	13	179	Cge quarters 2nd street	M	0.21	Sand	Coastal Alluvium
928	572	13	179	Tiger varathachari road	S	0.07	Sand	Coastal Alluvium
929	574	13	179	Cge colony 1st street	M	0.34	Sand	Coastal Alluvium
930	575	13	179	Cge colony 1st street	S	0.17	Sand	Coastal Alluvium
931	577	13	179	Yamuna street	S	0.09	Sand	Coastal Alluvium
932	579	13	179	Rukamani road	M	0.34	Sand	Coastal Alluvium
933	580	13	179	Vaigai street	M	0.66	Sand	Coastal Alluvium
934	582	13	179	Cge quarters 4th street	M	0.25	Sand	Coastal Alluvium
935	583	13	179	M.G.R street	M	0.51	Sand	Coastal Alluvium
936	584	13	179	Gangai street	M	0.97	Sand	Coastal Alluvium
937	207	13	180	Thiruvalluvar nagar 7th cross street	M	0.49	Sand	Coastal Alluvium
938	211	13	180	Thiruvalluvar nagar 11th cross street	S	0.07	Sand	Coastal Alluvium
939	215	13	180	3rd sea ward road	S	0.12	Sand	Coastal Alluvium
940	214	13	180	3rd seaward road	S	0.16	Sand	Coastal Alluvium
941	217	13	180	1st seaward road	M	0.34	Sand	Coastal Alluvium
942	205	13	180	Thiruvalluvar nagar 1st avenue	M	0.68	Sand	Coastal Alluvium
943	206	13	180	Thiruvalluvar nagar 44th cross street	M	0.38	Sand	Coastal Alluvium
944	208	13	180	Thiruvalluvar nagar 7th cross street	L	2.04	Sand	Coastal Alluvium
945	209	13	180	Thiruvalluvar nagar 6th main road	S	0.03	Sand	Coastal Alluvium
946	210	13	180	Thiruvalluvar nagar 6th main road	S	0.07	Sand	Coastal Alluvium
947	212	13	180	Thiruvalluvar nagar 43rd cross street	M	0.21	Sand	Coastal Alluvium
948	213	13	180	Thiruvalluvar nagar 7th main road	S	0.05	Sand	Coastal Alluvium
949	218	13	180	Journalist colony 2nd street	M	0.45	Sand	Coastal Alluvium
950	219	13	180	Thiruvalluvar nagar 2nd avenue	M	0.32	Sand	Coastal Alluvium
951	220	13	180	Kurinji,mullai,marutham 9th street	M	0.23	Sand	Coastal Alluvium
952	221	13	180	Kurinji,mullai,marutham 3rd street	S	0.13	Sand	Coastal Alluvium
953	216	13	180	Aibea nagar	S	0.12	Sand	Coromandal soil
954	222	14	181	Kannappa nagar extn	S	0.05	Sand	Coastal Alluvium
955	367	14	181	Rajiv gandhi road	M	0.42	Sand	Coromandal soil
956	368	14	181	Rajiv gandhi road	S	0.13	Sand	Coastal Alluvium
957	366	14	181	Omr road	M	0.38	Sand	Coromandal soil
958	95	14	182	Mgr nedunchalai	M	0.25	Sand	Coastal Alluvium
959	94	14	182	Mgr nedunchalai	M	0.52	Sand	Coastal Alluvium
960	346	14	182	Omr road	M	0.44	Sand	Coastal Alluvium
961	347	14	182	Omr road	S	0.06	Sand	Coastal Alluvium
962	96	14	182	Mgr nedunchalai	M	0.50	Hard Rock	Coastal Alluvium

Flood Susceptibility	Aquifer Firka Category"	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	"High Priority OSR in High Need Ward"
Low	Overexploited	1	High	23	Yes
5Y RP	Safe	2-4	High	23	Yes
Low	Overexploited	2-4	High	22	Yes
25Y RP	Safe	2-4	High	22	Yes
25Y RP	Safe	2-4	High	22	Yes
25Y RP	Safe	2-4	High	22	Yes
Low	Overexploited	2-4	High	22	Yes
25Y RP	Safe	2-4	High	22	Yes
25Y RP	Safe	2-4	High	22	Yes
Low	Overexploited	2-4	High	22	Yes
Low	Overexploited	2-4	High	22	Yes
100Y RP	Safe	5-10	Highest	21	
100Y RP	Safe	5-10	Highest	21	
Low	Safe	2-4	Highest	21	
Very Low	Safe	2-4	Highest	20	
Very Low	Safe	2-4	Highest	20	
Very Low	Safe	5-10	Highest	19	
Very Low	Safe	5-10	Highest	19	
Very Low	Safe	5-10	Highest	19	
Very Low	Safe	5-10	Highest	19	
Very Low	Safe	5-10	Highest	19	
Very Low	Safe	5-10	Highest	19	
Very Low	Safe	5-10	Highest	19	
Very Low	Safe	5-10	Highest	19	
Very Low	Safe	5-10	Highest	19	
Very Low	Safe	5-10	Highest	19	
Very Low	Safe	5-10	Highest	19	
100Y RP	Safe	2-4	Highest	17	
25Y RP	Safe	5-10	Highest	22	Yes
25Y RP	Safe	2-4	Highest	18	
Very Low	Safe	5-10	High	18	
Very Low	Safe	5-10	Highest	14	
Very Low	Safe	None	High	21	
Low	Safe	2-4	High	20	
Very Low	Safe	5-10	High	18	
Very Low	Safe	5-10	High	18	
Very Low	Safe	2-4	High	17	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
963	349	14	183	East coast road	M	0.27	Sand	Coastal Alluvium
964	350	14	183	V.G.P 4th main road	L	1.00	Sand	Coastal Alluvium
965	348	14	183	Govindan nagar	S	0.10	Sand	Coromandal soil
966	899	14	184	Panchayat main salai	S	0.08	Sand	Coastal Alluvium
967	900	14	184	Thirumalai nagar 1st main road	L	1.14	Sand	Coastal Alluvium
968	901	14	184	Oomathurai street	S	0.15	Sand	Coastal Alluvium
969	897	14	184	Rajiv nagar 1st main road	M	0.69	Hard Rock	Coastal Alluvium
970	898	14	184	Venkateswara nagar 1st cross street	M	0.30	Hard Rock	Coastal Alluvium
971	902	14	184	Rajiv nagar 1st main road	M	0.36	Hard Rock	Coastal Alluvium
972	929	14	186	Ags colony 1st cross street	M	0.44	Hard Rock	Charnokite
973	932	14	186	Balaji nagar east extn. 2nd 32nd street	S	0.17	Hard Rock	Charnokite
974	933	14	186	Balaji nagar east extn. 2nd 35th street	S	0.07	Hard Rock	Charnokite
975	937	14	186	Otteri salai	S	0.07	Hard Rock	Charnokite
976	927	14	186	Iyyen thiruvalluvar street	M	0.30	Hard Rock	Charnokite
977	928	14	186	Balaji nagar east extn. 1st 19th street	M	0.80	Hard Rock	Charnokite
978	930	14	186	Annai theasa nagar -14th street	M	0.34	Hard Rock	Charnokite
979	931	14	186	E.P.R. Colony	M	0.33	Hard Rock	Charnokite
980	935	14	186	Balaji nagar east extn. 1st 24th street	L	1.55	Hard Rock	Charnokite
981	934	14	186	Sheela nagar 1st street	S	0.06	Hard Rock	Charnokite
982	926	14	186	Hindu colony 2nd main road	S	0.16	Hard Rock	Charnokite
983	936	14	186	Sarathy nagar 2nd street	M	0.35	Hard Rock	Charnokite
984	1039	14	188	J.V.Nagar	S	0.20	Hard Rock	Charnokite
985	1042	14	188	Ram nagar south 8th main road	M	0.30	Hard Rock	Charnokite
986	1040	14	188	Meenakshi nagar	S	0.13	Hard Rock	Charnokite
987	1041	14	188	Senthil nagar main road	M	0.28	Hard Rock	Charnokite
988	723	14	189	Sowteswari nagar	M	0.58	Hard Rock	Quartz Gravel
989	972	14	189	Kamakoti nagar 6th street (north)	M	0.75	Hard Rock	Charnokite
990	1035	14	189	Chettinadu enclave	M	0.20	Hard Rock	Charnokite
991	968	14	189	Kamakotti nagar 1st main road	L	1.58	Hard Rock	Charnokite
992	970	14	189	Kamakoti nagar 9th street (south)	M	0.41	Hard Rock	Charnokite
993	971	14	189	Kamakoti nagar 9th street (north)	M	0.75	Hard Rock	Charnokite
994	973	14	189	Kamakoti nagar 6th street (south)	M	0.73	Hard Rock	Charnokite
995	977	14	189	A.G.S colony 3rd street	M	0.67	Hard Rock	Charnokite
996	1037	14	189	Chettinadu enclave	S	0.03	Hard Rock	Charnokite
997	969	14	189	Kamakotti nagar 5th street	M	0.55	Hard Rock	Charnokite
998	974	14	189	V.G.P. Shanthi nagar santhosh street	M	0.39	Hard Rock	Charnokite
999	1038	14	189	Chettinadu enclave	M	0.52	Hard Rock	Charnokite

Flood Susceptibility	Aquifer Firka Category	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	“High Priority OSR in High Need Ward”
25Y RP	Safe	2-4	Highest	23	Yes
Low	Safe	1	Highest	22	Yes
25Y RP	Safe	2-4	Highest	18	
Low	Safe	5-10	High	19	
Low	Safe	5-10	High	19	
Low	Safe	5-10	High	19	
100Y RP	Safe	5-10	High	18	
Low	Safe	5-10	High	17	
Low	Safe	5-10	High	17	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
5Y RP	Safe	2-4	Highest	19	
25Y RP	Safe	1	Highest	19	
25Y RP	Safe	2-4	Highest	18	
5Y RP	Safe	5-10	Highest	18	
25Y RP	Safe	2-4	Highest	18	
5Y RP	Safe	5-10	Highest	18	
5Y RP	Safe	5-10	Highest	18	
Low	Safe	1	Highest	17	
Low	Safe	2-4	Highest	16	
Very Low	Safe	2-4	Highest	15	
5Y RP	Safe	None	Low	18	
5Y RP	Safe	1	Low	17	
5Y RP	Safe	2-4	Low	16	
25Y RP	Safe	2-4	Low	15	
5Y RP	Safe	None	Medium	20	
5Y RP	Safe	2-4	Lowest	15	
5Y RP	Safe	2-4	Lowest	15	
25Y RP	Safe	2-4	Lowest	14	
25Y RP	Safe	2-4	Lowest	14	
25Y RP	Safe	2-4	Lowest	14	
25Y RP	Safe	2-4	Lowest	14	
25Y RP	Safe	2-4	Lowest	14	
25Y RP	Safe	2-4	Lowest	14	
25Y RP	Safe	2-4	Lowest	14	
100Y RP	Safe	2-4	Lowest	13	
Low	Safe	1	Lowest	13	
100Y RP	Safe	2-4	Lowest	13	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
1000	966	14	189	I. I. T colony 3rd main road	M	0.80	Hard Rock	Charnokite
1001	967	14	189	Arumugam nagar 2nd street	M	0.23	Hard Rock	Charnokite
1002	975	14	189	V.G.P. Shanthi nagar 3rd street (elango)	M	0.60	Hard Rock	Charnokite
1003	976	14	189	Parasuram nagar	M	0.41	Hard Rock	Charnokite
1004	965	14	189	Astalakshmi nagar avenue	M	0.41	Hard Rock	Charnokite
1005	1033	14	189	Chettinadu enclave	M	0.47	Hard Rock	Charnokite
1006	1034	14	189	Chettinadu enclave	M	0.25	Hard Rock	Charnokite
1007	962	14	191	Gandhi street	M	0.61	Hard Rock	Charnokite
1008	963	14	191	Krishna nagar main road	S	0.05	Hard Rock	Charnokite
1009	964	14	191	Anchaneya nagar kannadasan street	S	0.10	Hard Rock	Charnokite
1010	959	14	191	Jayachandran nagar 5th main road	M	0.55	Hard Rock	Charnokite
1011	960	14	191	Selen estate, jalladampet - perumbakkam link road	L	1.48	Hard Rock	Charnokite
1012	961	14	191	Jayachandiran nagar 1st main road (south)	L	1.55	Hard Rock	Charnokite
1013	477	15	192	Workers estate 1st main road	M	0.23	Sand	Coastal Alluvium
1014	478	15	192	Raja nagar 1st main road	M	0.43	Sand	Coastal Alluvium
1015	825	15	193	Customs colony main road	M	0.84	Sand	Coastal Alluvium
1016	828	15	193	Balamurugan garden iii street	L	1.06	Sand	Coastal Alluvium
1017	827	15	193	Sakthi nagar main road	M	0.28	Sand	Coastal Alluvium
1018	709	15	193	Kamarajar street	M	0.52	Hard Rock	Quartz Gravel
1019	706	15	193	Secretariat colony 1st main road	L	2.03	Sand	Coromandal soil
1020	823	15	193	Sai nagar main road	L	1.83	Hard Rock	Quartz Gravel
1021	830	15	193	Post office street	S	0.04	Sand	Coastal Alluvium
1022	831	15	193	200 Feet road (radial road)	M	0.38	Sand	Coastal Alluvium
1023	832	15	193	Sai nagar 10th cross street	L	1.21	Hard Rock	Quartz Gravel
1024	826	15	193	Ananda nagar	M	0.67	Hard Rock	Quartz Gravel
1025	979	15	193	Bethal nagar	M	0.37	Hard Rock	Quartz Gravel
1026	829	15	193	Ananda nagar main road	M	0.22	Hard Rock	Quartz Gravel
1027	824	15	193	R.E. Nagar	M	0.22	Hard Rock	Quartz Gravel
1028	978	15	193	Bethal nagar	M	0.33	Hard Rock	Quartz Gravel
1029	586	15	194	Anna enclave	M	0.21	Sand	Coastal Alluvium
1030	587	15	194	M. K. Radha avenue	M	0.76	Sand	Coastal Alluvium
1031	585	15	194	V.G.P 2nd avenue	M	0.57	Sand	Coastal Alluvium
1032	708	15	195	Bharathiyar nagar	M	0.31	Sand	Coastal Alluvium
1033	713	15	195	Rajiv garden salai	M	0.60	Sand	Coastal Alluvium
1034	707	15	195	Sakthi srinivasan salai	M	0.79	Sand	Coastal Alluvium
1035	712	15	195	Guindy engeeneering lat out	M	0.35	Sand	Coastal Alluvium
1036	704	15	195	Chandrasekaran avenue	L	1.14	Sand	Quartz Gravel

Flood Susceptibility	Aquifer Firka Category	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	“High Priority OSR in High Need Ward”
Low	Safe	2-4	Lowest	12	
Low	Safe	2-4	Lowest	12	
Low	Safe	2-4	Lowest	12	
Low	Safe	2-4	Lowest	12	
Low	Safe	5-10	Lowest	11	
Very Low	Safe	2-4	Lowest	11	
Very Low	Safe	2-4	Lowest	11	
Very Low	Safe	None	Low	14	
Very Low	Safe	None	Low	14	
Very Low	Safe	None	Low	14	
Low	Safe	2-4	Low	13	
Very Low	Safe	1	Low	13	
Low	Safe	2-4	Low	13	
Low	Safe	2-4	High	20	
Low	Safe	2-4	High	20	
5Y RP	Safe	2-4	Medium	22	
25Y RP	Safe	2-4	Medium	21	
100Y RP	Safe	2-4	Medium	20	
25Y RP	Safe	None	Medium	19	
5Y RP	Safe	1	Medium	18	
5Y RP	Safe	2-4	Medium	18	
Very Low	Safe	2-4	Medium	18	
Very Low	Safe	2-4	Medium	18	
5Y RP	Safe	2-4	Medium	18	
5Y RP	Safe	5-10	Medium	17	
Low	Safe	None	Medium	17	
25Y RP	Safe	5-10	Medium	16	
100Y RP	Safe	5-10	Medium	15	
100Y RP	Safe	5-10	Medium	15	
25Y RP	Safe	None	Medium	23	
25Y RP	Safe	1	Medium	22	
Very Low	Safe	1	Medium	19	
5Y RP	Safe	2-4	Medium	22	
5Y RP	Safe	2-4	Medium	22	
25Y RP	Safe	2-4	Medium	21	
5Y RP	Safe	5-10	Medium	21	
100Y RP	Safe	1	Medium	19	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
1037	711	15	195	Rajiv gandhi road	M	0.24	Sand	Quartz Gravel
1038	718	15	195	Rajiv gandhi salai(omr)	M	0.92	Sand	Quartz Gravel
1039	705	15	195	Pallavan kudiruppu	M	0.33	Sand	Quartz Gravel
1040	710	15	195	Rajiv gandhi road	M	0.56	Sand	Quartz Gravel
1041	724	15	195	Rajiv gandhi salai(omr)	M	0.94	Sand	Quartz Gravel
1042	719	15	196	Shakthi garden	M	0.57	Sand	Coastal Alluvium
1043	720	15	196	Shakthi garden	M	0.24	Sand	Coastal Alluvium
1044	721	15	196	Pillayar koil street	M	0.70	Sand	Coastal Alluvium
1045	716	15	196	Kannaki nagar	M	0.62	Sand	Coastal Alluvium
1046	715	15	196	Kannaki nagar	M	0.31	Sand	Coastal Alluvium
1047	717	15	196	Kannaki nagar	M	0.54	Sand	Coastal Alluvium
1048	722	15	196	Thiruvalluvar street	S	0.07	Sand	Coastal Alluvium
1049	714	15	196	Kannaki nagar	M	0.57	Sand	Coastal Alluvium
1050	725	15	196	Annai indira nagar	M	0.85	Sand	Quartz Gravel
1051	562	15	197	Adithya ram nagar	M	0.99	Sand	Coastal Alluvium
1052	503	15	197	V.G.P 2nd main road	M	0.34	Sand	Coastal Alluvium
1053	543	15	197	Sea cliff conclave	M	0.77	Sand	Coastal Alluvium
1054	558	15	197	East coast road	L	1.28	Sand	Coastal Alluvium
1055	588	15	197	Jagajevanram avenue	M	0.50	Sand	Coastal Alluvium
1056	560	15	197	East coast road	M	0.45	Sand	Coastal Alluvium
1057	561	15	197	East coast road	L	1.05	Sand	Coastal Alluvium
1058	559	15	198	Akkarai village main street	M	0.71	Sand	Coastal Alluvium
1059	487	15	198	Wipro salai	M	0.82	Sand	Coastal Alluvium
1060	488	15	198	Sadagopa naickar street	M	0.42	Sand	Coastal Alluvium
1061	1036	15	198	Pasupon nagar 1st street	L	1.83	Hard Rock	Quartz Gravel
1062	480	15	198	Rajiv gandhi road (old mahabalipuram road)	M	0.53	Sand	Coastal Alluvium
1063	483	15	198	Nehru street	S	0.18	Sand	Coastal Alluvium
1064	490	15	198	Eswaran street	S	0.03	Sand	Quartz Gravel
1065	491	15	198	Eswaran street	S	0.09	Sand	Quartz Gravel
1066	495	15	198	Riverview residency 4th street	L	1.23	Sand	Quartz Gravel
1067	499	15	198	Lalbahadur sastri street	S	0.10	Sand	Coastal Alluvium
1068	484	15	198	Rajiv gandhi road (old mahabalipuram road)	M	0.37	Sand	Coastal Alluvium
1069	493	15	198	Anna street	M	0.35	Sand	Coastal Alluvium
1070	497	15	198	Devaraj nagar	M	0.82	Sand	Coastal Alluvium
1071	485	15	198	Rajiv gandhi road (old mahabalipuram road)	M	0.34	Sand	Coastal Alluvium
1072	498	15	198	New kumaran nagar main street	M	0.95	Sand	Coromandal soil
1073	501	15	199	Prithyangara koil street	M	0.50	Sand	Coastal Alluvium

Flood Susceptibility	Aquifer Firka Category	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	“High Priority OSR in High Need Ward”
Low	Safe	None	Medium	19	
100Y RP	Safe	2-4	Medium	18	
Low	Safe	2-4	Medium	17	
Very Low	Safe	1	Medium	17	
Low	Safe	2-4	Medium	17	
5Y RP	Safe	None	Low	23	
5Y RP	Safe	2-4	Low	21	
5Y RP	Safe	2-4	Low	21	
5Y RP	Safe	5-10	Low	20	
100Y RP	Safe	2-4	Low	19	
100Y RP	Safe	2-4	Low	19	
25Y RP	Safe	5-10	Low	19	
100Y RP	Safe	5-10	Low	18	
Low	Safe	2-4	Low	16	
Low	Safe	None	Low	20	
Low	Safe	1	Low	19	
Low	Safe	1	Low	19	
Low	Safe	1	Low	19	
Very Low	Safe	None	Low	19	
Low	Safe	2-4	Low	18	
Low	Safe	2-4	Low	18	
5Y RP	Safe	None	Low	23	
25Y RP	Safe	1	Lowest	20	
100Y RP	Safe	2-4	Lowest	18	
5Y RP	Safe	None	Lowest	18	
Very Low	Safe	1	Lowest	17	
100Y RP	Safe	5-10	Lowest	17	
25Y RP	Safe	2-4	Lowest	17	
25Y RP	Safe	2-4	Lowest	17	
25Y RP	Safe	2-4	Lowest	17	
100Y RP	Safe	5-10	Lowest	17	
Low	Safe	5-10	Lowest	16	
Low	Safe	5-10	Lowest	16	
Low	Safe	5-10	Lowest	16	
Low	Safe	More than 10	Lowest	15	
5Y RP	Safe	2-4	Lowest	15	
Low	Safe	None	Lowest	19	

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
1074	549	15	199	Housing board road c14	L	1.66	Sand	Coastal Alluvium
1075	550	15	199	Housing board road c12	L	1.68	Sand	Coastal Alluvium
1076	563	15	199	Puduchery salai	M	0.27	Sand	Coastal Alluvium
1077	564	15	199	T. N. Housing board a road	S	0.09	Sand	Coastal Alluvium
1078	486	15	199	Rajiv gandhi road (old mahabalipuram road)	M	0.27	Sand	Coastal Alluvium
1079	489	15	199	Sozhanganallur link street	M	0.27	Sand	Coastal Alluvium
1080	492	15	199	Rajiv gandhi road (old mahabalipuram road)	S	0.13	Sand	Coastal Alluvium
1081	546	15	199	Housing board road e17	M	0.28	Sand	Coastal Alluvium
1082	547	15	199	Housing board road e22	S	0.13	Sand	Coastal Alluvium
1083	548	15	199	Housing board road d40	M	0.47	Sand	Coastal Alluvium
1084	551	15	199	Housing board road b6	L	1.77	Sand	Coastal Alluvium
1085	552	15	199	Housing board road c9	M	0.85	Sand	Coastal Alluvium
1086	566	15	199	Housing board road d3	S	0.10	Sand	Coastal Alluvium
1087	569	15	199	Housing board road d1	S	0.11	Sand	Coastal Alluvium
1088	571	15	199	Housing board road d2	S	0.09	Sand	Coastal Alluvium
1089	481	15	199	Elcot avenue ist street	M	0.30	Sand	Quartz Gravel
1090	482	15	199	Kumarasamy nagar main road	M	0.41	Sand	Quartz Gravel
1091	494	15	199	Kumarasamy nagar vth cross street	M	0.79	Sand	Quartz Gravel
1092	479	15	199	Kumarasamy nagar main road	M	0.47	Hard Rock	Quartz Gravel
1093	496	15	199	Nedunchezhiyan street	M	0.31	Sand	Coromandal soil
1094	500	15	199	Prithyangara koil street	M	0.95	Sand	Coromandal soil
1095	502	15	199	Model school road	M	0.32	Hard Rock	Quartz Gravel
1096	544	15	199	Housing board road c1	S	0.13	Sand	Coromandal soil
1097	570	15	199	Gangaiamman koil main st	S	0.04	Sand	Coromandal soil
1098	542	15	199	Housing board road e12	M	0.56	Sand	Coromandal soil
1099	545	15	199	Housing board road e1	S	0.18	Sand	Coromandal soil
1100	553	15	199	Housing board road c6	M	0.25	Sand	Coromandal soil
1101	554	15	199	Housing board road e43	S	0.07	Sand	Coromandal soil
1102	555	15	199	Housing board road d5	M	0.75	Sand	Coromandal soil
1103	556	15	199	Housing board road e36	M	0.79	Sand	Coromandal soil
1104	557	15	199	Housing board road c7	S	0.17	Sand	Coromandal soil
1105	565	15	199	Housing board road d3	M	0.22	Sand	Coromandal soil
1106	567	15	199	Housing board b1 road	S	0.05	Sand	Coromandal soil
1107	568	15	199	Housing board b1 road	S	0.08	Sand	Coromandal soil
1108	834	15	200	Rajiv gandhi road (old mahabalipuram road)	M	0.76	Sand	Coastal Alluvium
1109	835	15	200	Rajiv gandhi road (old mahabalipuram road)	M	0.29	Sand	Coastal Alluvium
1110	842	15	200	Rajiv gandhi road (old mahabalipuram road)	S	0.04	Sand	Coastal Alluvium

Flood Susceptibility	Aquifer Firka Category	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	“High Priority OSR in High Need Ward”
Low	Safe	None	Lowest	19	
Low	Safe	2-4	Lowest	17	
Low	Safe	2-4	Lowest	17	
Low	Safe	2-4	Lowest	17	
Low	Safe	5-10	Lowest	16	
Low	Safe	5-10	Lowest	16	
Low	Safe	5-10	Lowest	16	
Low	Safe	5-10	Lowest	16	
Low	Safe	5-10	Lowest	16	
Low	Safe	5-10	Lowest	16	
Low	Safe	5-10	Lowest	16	
Low	Safe	5-10	Lowest	16	
Low	Safe	5-10	Lowest	16	
Low	Safe	5-10	Lowest	16	
Low	Safe	5-10	Lowest	16	
Low	Safe	5-10	Lowest	16	
Low	Safe	5-10	Lowest	14	
Low	Safe	5-10	Lowest	14	
Low	Safe	5-10	Lowest	14	
Low	Safe	5-10	Lowest	12	
Low	Safe	2-4	Lowest	12	
Low	Safe	2-4	Lowest	12	
Low	Safe	5-10	Lowest	12	
Low	Safe	2-4	Lowest	12	
Low	Safe	2-4	Lowest	12	
Low	Safe	5-10	Lowest	11	
Low	Safe	5-10	Lowest	11	
Low	Safe	5-10	Lowest	11	
Low	Safe	5-10	Lowest	11	
Low	Safe	5-10	Lowest	11	
Low	Safe	5-10	Lowest	11	
Low	Safe	5-10	Lowest	11	
Low	Safe	5-10	Lowest	11	
Low	Safe	None	High	22	Yes
Low	Safe	None	High	22	Yes
Low	Safe	None	High	22	Yes

#	GIS ID (FID_OSR_11)	Zone	Ward	Street	Typology	Area (Ac)	Soil	Geology
1111	843	15	200	Ellaiamman koil street	M	0.30	Sand	Coastal Alluvium
1112	844	15	200	Ellaiamman koil street	M	0.23	Sand	Coastal Alluvium
1113	845	15	200	Ellaiamman koil street	S	0.11	Sand	Coastal Alluvium
1114	846	15	200	Ellaiamman koil street	M	0.28	Sand	Coastal Alluvium
1115	847	15	200	Pazhathotta salai	S	0.07	Sand	Coastal Alluvium
1116	848	15	200	Rajiv gandhi road (old mahabalipuram road)	L	3.67	Sand	Coastal Alluvium
1117	833	15	200	Nunkam palayam link road	S	0.08	Sand	Coastal Alluvium
1118	838	15	200	Nunkam palayam link road	M	0.68	Sand	Coastal Alluvium
1119	840	15	200	Rajiv gandhi road (old mahabalipuram road)	M	0.44	Sand	Coastal Alluvium
1120	841	15	200	Pondicherry pattai salai	S	0.08	Sand	Coastal Alluvium
1121	850	15	200	Co-operative maha nagar	S	0.12	Hard Rock	Quartz Gravel
1122	836	15	200	Majestic lay out	L	1.37	Sand	Coromandal soil
1123	849	15	200	Majestic lay out	S	0.04	Sand	Coromandal soil
1124	837	15	200	Nunkam palayam link road	S	0.18	Hard Rock	Charnokite
1125	839	15	200	Nunkam palayam link road	S	0.13	Hard Rock	Charnokite

Flood Susceptibility	Aquifer Firka Category	Park Access (within 10 mins of OSR)	Ward Park Need	OSR Priority Scoring	"High Priority OSR in High Need Ward"
Low	Safe	None	High	22	Yes
Low	Safe	None	High	22	Yes
Low	Safe	None	High	22	Yes
Low	Safe	None	High	22	Yes
Low	Safe	None	High	22	Yes
Low	Safe	None	High	22	Yes
Low	Safe	1	High	21	
Low	Safe	1	High	21	
Low	Safe	1	High	21	
Low	Safe	2-4	High	20	
Low	Safe	None	High	18	
Low	Safe	None	High	17	
Low	Safe	None	High	17	
Low	Safe	1	High	16	
Low	Safe	1	High	16	

B. Detailed Guides

B.1. Detailed Notes on Soil

One of the main potential constraints to use in the use of filtration is soil. For a soil to be suitable for infiltrating design runoff events, it should be permeable, and unsaturated. Ensure sufficient thickness and extent of the infiltration system to effectively disperse water.

1. Infiltration Rate and Soil Properties:

- Infiltration rate depends on soil properties and underlying geology.
- Soil's ability to infiltrate water is measured by the infiltration coefficient, which is the long-term infiltration rate divided by the area of infiltration.
- The infiltration rate is related to soil permeability.

2. Permeability and Hydraulic Conductivity:

- Permeability (k) of saturated soil refers to its ability to transmit fluid under a hydraulic pressure gradient.
- Darcy's law defines the flow per unit area under saturated conditions.
- Infiltration into soil above the water table typically occurs in partially saturated soils, described by complex relationships between soil properties and flow, often using empirical infiltration rates (q) derived from tests.

3. Soil Texture and Infiltration:

- Permeability (or infiltration rate) is high for coarse-grained soils (e.g., sands, gravels) and low for fine soils (e.g., silts, clays).

- Sand and gravel deposits may have reduced infiltration rates due to high silt or clay content.

4. Infiltration Coefficients:

- Provides typical infiltration coefficients based on soil textures.
- Soil textures are defined by the proportion of different-sized particles.

5. Field Testing and Design:

- Field tests are necessary to determine infiltration coefficients accurately.
- Construction activities can affect infiltration rates if soil compaction or blockage occurs. Local soil characteristics should inform infiltration design.

6. Design Considerations:

- Infiltration viability should be considered based on site-specific rates. Interception (runoff capture) can be achieved without infiltration via green roofs or bio retention systems.

The above information is sourced from "SUDS Manual"

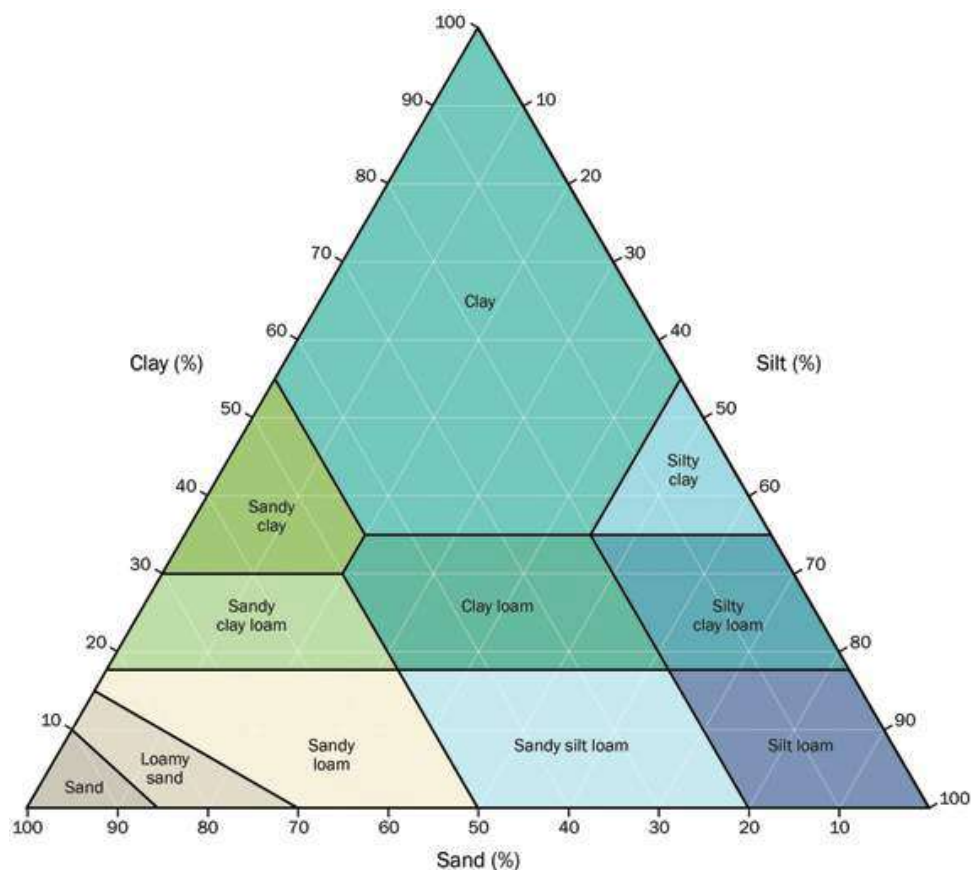


Fig 1. Soil texture classification (from Land IS, 2015)

Table. 1. Pollution removal for bio retention systems designed to FAWB guidelines (after FAWB, 2009)

Soil type / Texture	ISO 14688-1 description (After Blake, 2010)	Typical infiltration Coefficients (m/s)
Good Infiltration Media - Gravel - Sand - Loamy sand - Sandy loam	Sandy Gravel Slightly Silty ,Slightly Clayey Sand Silty Slightly Clayey Sand Silty Clayey Sand	$3 \times 10^{-4} - 3 \times 10^{-2}$ $1 \times 10^{-5} - 5 \times 10^{-5}$ $1 \times 10^{-4} - 3 \times 10^{-5}$ $1 \times 10^{-7} - 1 \times 10^{-}$
Poor Infiltration Media - Loam - Silt loam - Chalk (structureless) - Sandy clay loam	Very Silty Clayey Sand Very Sandy Clayey Silt N/A Very Clayey Silty Sand	$1 \times 10^{-7} - 5 \times 10^{-6}$ $1 \times 10^{-7} - 1 \times 10^{-5}$ $3 \times 10^{-8} - 3 \times 10^{-6}$ $3 \times 10^{-10} - 3 \times 10^{-7}$
Very Poor Infiltration Media - Silty Clay Loam - Clay - Till	– – Can be any texture of soil described above	$1 \times 10^{-8} - 1 \times 10^{-6}$ $< 3 \times 10^{-8}$ $3 \times 10^{-9} - 3 \times 10^{-6}$
Other Rock (note mass infiltration capacity will depend on the type of rock and the extent and nature of discontinuities and any infill)	N/A	$3 \times 10^{-9} - 3 \times 10^{-5}$

Facility for Advancing Water Biofiltration (FAWB) is based in Monash University and is an initiative of the Victoria Government in Australia for setting up standards for Water Sensitive Cities

B.2. Detailed Notes on Hydrology

1. General considerations

a. Preliminary Hydrology Calculations for BGI Scheme Design:

- Estimate runoff rates and volumes for the existing site.
- Estimate runoff rates and volumes for the proposed development in its developed state, considering future development and climate change.

b. BGI Design Considerations Based on Calculations:

- Control of Runoff Rates: Design must control runoff rates to meet water quantity standard using specific calculation methods
- Control of Runoff Volumes: Design must limit allowable discharge volumes based on calculated runoff volumes
- Attenuation Storage and Infiltration Components: Include attenuation storage to manage peak runoff rates during rainfall events.
- Use infiltration components to prevent runoff from occurring or to manage excess runoff volumes. Long-Term Storage: Implement long-term storage to manage and tightly control additional storage volumes beyond allowable discharge volumes.
- Interception Design: Ensure adequate interception to prevent runoff from small rainfall events.
- Flow Conveyance and Management: Design drainage components to convey flow between points on the site up to specified standards.

c. Infiltration Design Criteria:

- If measured infiltration rates are ≥ 6.35 mm per hour, design the system for infiltration.
- For rates < 6.35 mm per hour but with underlying permeable layers, consider infiltration columns or soil replacement to enhance infiltration.
- Soils with highly variable or very high infiltration rates may require special treatments like over-excavation, soil replacement, or impermeable liners.
- When multiple infiltration tests are conducted for a system, calculate the infiltration rate using the geometric mean.
- Minimize infiltration loading ratios (impervious drainage area to infiltration area) where feasible.
- Consider sediment loading, ground cover, and land use when designing loading ratios.
- Evaluate higher loading ratios case by case based on geotechnical conditions and with approval from the SWD department.
- Pretreatment measures should be considered for systems with higher loading ratios.
- Consideration of Total Contributing Drainage Area: Design loading ratios considering both pervious and impervious contributing areas and overall site conditions.
- Ponding areas in surface features should drain completely in less than 24 hours
- Use the provided equation to calculate drain down time for infiltration systems, or use model calculations where available.

$$t = \frac{\left(\frac{V}{A_i}\right)}{i} * 12$$

Where,

t = Time (hrs)

V = Storage Volume (cf)

A_i = Infiltration Footprint (sf)

i = Infiltration Rate (in/hr)

Table. 2. Max Loading Ratio for Subsurface and Surface Systems

System type	Max Loading ratio
Subsurface	10:1
Surface systems	25:1

i) Infiltrating systems near buildings

- Maintain at least 3m (3000mm) of separation between infiltrating systems and buildings or structures.
- Review boring logs near the proposed system to identify soil conditions, changes in stratigraphy.
- Additional lining with an impermeable geomembrane may be required if certain conditions are present.
- If the system is within the area directly beneath a building, the storage part of the system should be lined with an impermeable geomembrane.
- Where building information is unavailable and the system is closer than 3m (3000mm) to a building, line the bottom and sides of the system with an impermeable geomembrane, extending it at least 4.5m (4500 mm) beyond the end of the building. Cover the end of the trench if it does not reach the building's end.
- If there's a trench break and the next segment is at least 3m (3000mm) away from the building, the lining does not need to continue to the next segment.

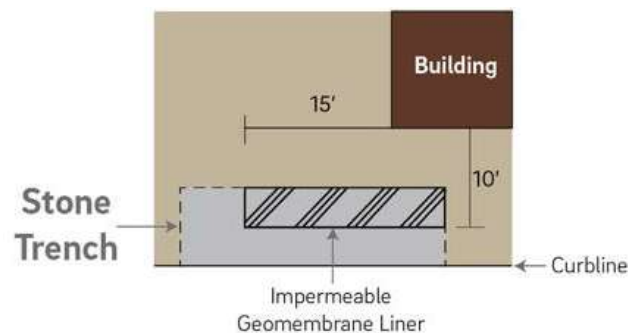


Fig 2. Extent of impermeable geomembrane liner for trenches near buildings.

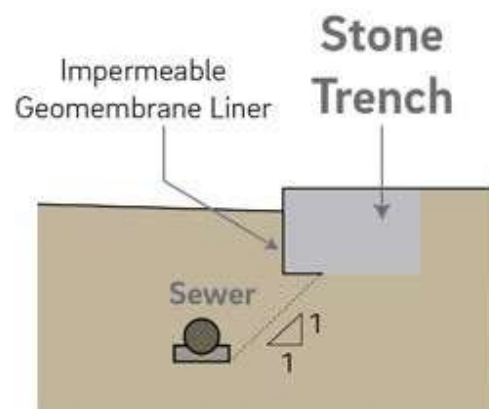


Fig 3. Impermeable geomembrane liner offset near sewers.

ii) Minimizing Infiltration into sewer infrastructure

- Ensure adequate separation to prevent infiltration into nearby sewer infrastructure, including sewer mains, active and inactive laterals (including stubbed laterals and slants), and sewer-connected inlets.
- Review boring logs near the proposed system to identify any conditions like seams, soil changes, or limiting layers above the sewer cradle that could promote lateral water movement into the sewer. Additional lining with an impermeable geomembrane may be required based on these conditions.
- If the system is within a defined area projecting vertically from the bottom of the sewer cradle to the top of the provided storage, that part of the system storage should be wrapped with an impermeable geomembrane liner.
- For active and inactive laterals, including stubbed laterals, line the bottom and sides of the trench within a specific projection from the invert of the lateral or a minimum distance.
- Guidance on lining standards near stubbed laterals to be abandoned will be provided by the PWD project manager
- When lining the trench with impermeable geomembrane due to proximity to sewer infrastructure, ensure that the geomembrane covers the ends of the trench as well

iii) Impermeable Geomembrane Lining Guidelines for Sensitive Structures

- The evidence of loose or miscellaneous fill with debris, fine-grained silt or clay layers beneath granular sand layers, or dense, horizontally bedded soils is observed
- Lining of the sides of the system is sufficient if observed in the upper stratum (surface to 3m above the bottom of the system).
- The system should be fully lined if observed anywhere within the zone from one foot above the bottom of the system to the invert of the sewer or basement.
- Consider additional impermeable geomembrane lining where the water table is less than 4.5m (4500) below grade, especially for systems with higher loading ratios (>20:1).
- Ensure that the bottom elevation of an infiltrating system is a minimum of 610mm above any infiltration-limiting layer, such as bedrock or seasonal high groundwater.
- Media Separation with Sand Layer:
- Use a 152mm sand layer as media separation between the bottom of stone storage and the sub-grade for infiltrating systems.
- Geo-textile should be used along the sides and top of the system, tucked 152mm under the bottom of the stone layer.

The above information is sourced from "GSI planning and designing manual"

d. Detention / slow release systems :

i) Requirements

- Detention/slow-release systems should be designed to release water at a maximum rate of 0.05 cubic feet per second (cfs) per acre of contributing impervious drainage area.
- Release rates should be rounded to the nearest hundredth (two decimal places).
- Slow-release rates and orifice sizing should be calculated using the orifice equation.

$$Q = C_d A_o 2gh$$

Where,

Q = Peak Release Rate

Cd = Discharge Coefficient = 0.62

Ao = Area of Orifice (ft²) = πr^2

g = Gravity (ft/s²) = 32.2

h= Slow-Release Hydraulic Head (ft)

- For constructibility, orifice diameters must be sized for common drill bits (must be a multiple of 3.1mm).
- Orifice diameters must not be less than 12.7mm to minimize the potential for clogging.

ii) Guidelines

- If design infiltration rates are less than 6.35mm per hour, or if the system is fully or mostly lined, the system should be designed for detention/slow-release.
- Systems may also be lined and designed for detention/slow-release if geotechnical findings or contamination issues make infiltration inadvisable.
- Detention/slow-release systems should route ground-level runoff through a SWD- approved pollutant reducing Storm water Management Practice (SMP) where possible and cost-effective.
- Pollutant reducing SMPs include basins, planters, rain gardens, bumpouts, green gutters, storm water trees, or other SMPs that route runoff through a soil profile or equivalent porous media.
- Model calculations may be used in lieu of the equations shown at the discretion of the PWD project manager.
- Ponding areas for surface features should drain completely in less than 24 hours. The drain down time for detention/slow-release systems with a uniform horizontal cross section can be calculated using a modified equation derived from the submerged orifice discharge formula. This equation accounts for volume draining through porous media, typical in SWD Blue-green Infrastructure (BGI) systems.

$$t = \frac{2V}{C_d A_o \sqrt{2gh} * 3600}$$

Where,

t = Time (hrs)

V = Storage Volume (ft³)

h = Slow-Release Hydraulic Head (ft)

Cd = Discharge Coefficient = 0.62

Ao = Area of Orifice (ft²) = πr^2

g = Gravity (ft/s²) = 32.2

- The drain down time for detention/slow-release systems like rain gardens, bumpouts, and planters with varying cross-sectional areas should be calculated using a specific equation.

$$t = \frac{2V}{C_d A_o \sqrt{2g} * 3600} [A_1 \phi_1 (\sqrt{h_1} - \sqrt{h_2}) + A_2 \phi_2 (\sqrt{h_2} - \sqrt{h_3}) + A_n \phi_n (\sqrt{h_n} - \sqrt{h_{n+1}}) \dots]$$

Where,

t = Drain down time from the top of storage to the orifice elevation (hr)

Cd = Orifice discharge coefficient

A o = Area of the orifice (ft²)

g = Acceleration due to gravity (32.2 ft/s²)

ϕ_n = Cross-sectional area of specified drainage layer (ft²)

= Effective porosity of specified drainage layer

h n = Head above the orifice at top and/or bottom of specified drainage layer (ft)

2. Bioswales and Raingarden

a. General Considerations

- Swale design integrates storage, treatment, and infiltration aspects, balancing these functions for varying storm events.
- Hydraulic and treatment design are closely interconnected and are addressed together in this section.
- Ensure swale capacity is sufficient to convey and store the design return period event (component level of service), accounting for potential wet conditions.
- Safely manage extreme event flows, either by conveying excess flows to temporary storage areas or conveyance paths.
- Design event runoff volumes should reduce by half within 24 hours to maintain storage and treatment capabilities for subsequent events and protect vegetation.

i) Conveyance Swales:

- Maintain vegetation height between 75-150 mm to prevent flattening during flow events.
- Ensure effective pollutant removal for runoff events up to the 1:1 year event, with appropriate depth of flow and flow velocity.
- Depth of flow should be maintained below vegetation height (<100 mm).
- Maximum flow velocity should be limited to 0.3 m/s to ensure adequate runoff filtration.
- Residence time (time of travel along the swale) should be at least 9 minutes (or 18 minutes from the top of the swale with lateral inflows).
- Use Manning's equation to calculate average flow velocity, considering the roughness coefficient ("n" value) based on vegetative cover and flow depth.
- Keep flow velocities for extreme events below 1.0 m/s (or 2.0 m/s under specific conditions) to prevent erosion.
- Estimate Manning's "n" value based on flow depth and vegetative cover.
- Implement check dams and pre treatment systems to reduce velocities, increase residence time, and enhance infiltration and storage capabilities.
- Design conveyance capacity without assuming volume loss allowances.
- For systems designed for significant volume discharge via infiltration, consider designing as soakaways or infiltration basins.
- Improved flow and storage capacity
- Enhanced interception performance

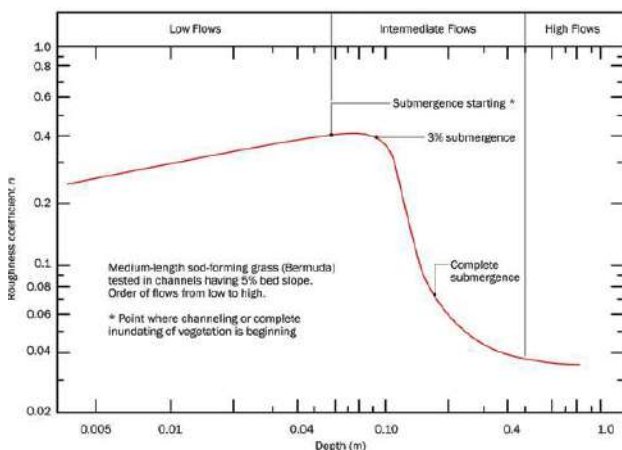


Fig 4. Impact of flow depth on hydraulic roughness (from Wong, 2006)

- Reduced risk of ponding and marshy areas on flat gradients
- Better infiltration under suitable ground conditions

ii) Dry Swales with Under drains:

- Act as connected detention basins without above-ground outfall
- Hydraulic performance influenced by relative head in each swale serving the under drain
- Careful design required to manage performance and prevent downstream flooding
- Velocity Limits and Under drain Capacity:
- Focus on conveyance and storage over velocity due to system suitability in flat areas
- Under drains should have flow capacity of at least 2 l/s/ha for multi-event scenarios
- Flow control needed if filtration into under drain exceeds discharge limit

iii) Wet Swales:

- Determine conveyance capacity similarly to dry swales
- Shallow slopes ensure suitable retention times, reducing need for velocity constraints
- Permanently wet base acts as small wetland system, suitable for poorly drained sites
- Prevent rapid sediment buildup in wetland surfaces
- Ensure permanent water areas receive uncontaminated runoff for amenity and biodiversity
- Minimum 150 mm depth to protect wetland vegetation and system resilience
- Maximum depths site-specific, considering technical, safety, and biodiversity criteria

b. Interception Design for Swales:

- Swales intercept runoff by soaking into soil layers and underlying media
- Design considers infiltration rate, vegetation, catchment area, and climate for volumetric reduction

c. Peak Flow Control and Storage Design:

- Swales reduce flow rates via infiltration and attenuation storage
- Infiltration included for suitable swales with <1.5% slopes and explicit peak flow reductions
- Additional storage provided beneath swale base using gravel or geocellular systems

d. Volume Control Design:

- Swales typically don't reduce runoff volume for the 1:100 year, 6-hour event.
- If significant infiltration rates occur for this scale of event, the design should explicitly consider this.

e. Exceedance Flow Design:

- For rainfall events exceeding swale design capacity, an exceedance flow route is necessary.
- Install overflow structures like pipes or weirs above design water storage levels to convey excess flows downstream.
- Multiple overflows may be needed due to the length of swales. Confirm exceedance flow capacity using standard hydraulic assessment methods (weirs, orifices, pipe flow).
- Review capacities for flows beyond overflow limits.
- Place overflow structures close to swale inlets to minimize flow path length and reduce scouring risk.
- Wet swale vegetation is vulnerable to damage from high flows; consider alternative flow diversion routes.

2. Retention Ponds

a. General Considerations

- Runoff should be delivered onto the filter medium surface without causing scouring and should be uniformly distributed.
- Inflow velocities should be below 0.5 m/s (or 1.5 m/s for the 1:100 year rainfall event).
- Terraced Bed Design for Full-Length Conveyance Swale:
- Bio retention beds running along conveyance swales should be terraced.
- In other applications, bio retention zones should ideally have a horizontal or near-horizontal gradient to ensure uniform runoff distribution and efficient storage before bypass.

b. Use of Check Dams in Steeper Areas:

- Check dams can be employed at the end of swales in steep areas to reduce flow velocities onto the bio retention filter medium.
- Check dams can range from natural ponding areas to small weir structures.

c. Design Approach for Bio retention Systems:

- Provide sufficient surface area and depth to contain the treatment volume and allow infiltration between storm events (typically 150-300 mm).
- Ensure adequate hydraulic residence time for sediment and pollutant retention through suitable planting and filter media.
- Include extra storage in the drainage layer if needed for attenuation.

d. Selection of Bio retention Filter Medium:

- Consider saturated hydraulic conductivity, depth of extended detention, and suitability for vegetation growth.
- Permeability of generic soil filter media should be between 100-300 mm/h (adjust based on clogging rates).
- Verify performance of proprietary filter media with independent test results.

e. Pollutant Removal Performance:

- Ensure effective pollutant removal for all runoff events up to the 1:1 year event.
- Design to temporarily store treatment volume as a shallow layer (150-200 mm) to enhance evaporation and prevent water logging.
- Aim for de-watering within 24-48 hours after a design storm.
- Calculating required bio retention surface area is stated below:

$$A_f = \frac{V_t L}{k(h + L)t}$$

Where, A_f = surface area of filter bed (m²)

V_t = volume of water to be treated (m³) (for a 1:1 year critical duration rainfall event)

L = filter bed depth (m)

k = coefficient of permeability of filter media for water (m/s)

h = average height of water above filter bed (half maximum height) (m)

t = time required for water quality treatment volume to percolate through filter bed (s)

- To facilitate design, the surface area and depth of the filter bed are typically determined first, and then the equation is rearranged to calculate the time needed for water to pass through the system, which should ideally be 24-48 hours. It's important to note that an overflow or alternative flow route is necessary for events that surpass the system's capacity.

f. Filtration System Considerations:

- Filter medium permeability dictates infiltration rate into surrounding soils.
- Use impermeable liners if filter medium permeability is significantly lower than local soils to prevent infiltration and short-circuiting of treatment.
- Impermeable liners may also be needed on the sides of the filter medium to prevent horizontal ex-filtration and maintain treatment effectiveness.

g. Interception Design:

- Bio retention systems achieve interception because they do not produce runoff during most small rainfall events. Water infiltrates the filter medium and is removed through evapotranspiration and infiltration (if permissible).
- The degree of runoff reduction depends on various factors including soil infiltration rate, catchment area, system size (area and depth), vegetation type, and climate.

h. Peak Flow Control Design:

- Bio retention systems contribute to flow rate reduction by offering attenuation storage and decreasing storage volume requirements where infiltration occurs.
- Designing peak flow control for bio retention systems and rain gardens involves assessing surface storage volume using standard hydraulic methods, treating the system surface as an infiltration basin, and using the permeability of the filter medium as the infiltration rate.
- Subsurface storage is provided by the void space in the filter medium and/or drainage layer:
- Attenuation storage in the filter medium and drainage layer = System volume x porosity in the soil/drainage layer.
- The drainage layer typically has a porosity of at least 30%, while porosity of filter layer materials can be measured through simple tests
- A flow control structure might be necessary to regulate water discharge from the system, and linking adjacent systems together can reduce blockage risk due to small runoff areas.

i. Volume Control Design:

- The contribution of bio retention systems to volume control should be assessed using standard methods based on expected infiltration rates, available attenuation storage, and specified flow controls.

j. Exceedance Flow Design:

- For rainfall events exceeding the bio retention system's design capacity, an exceedance flow route is necessary.
- This can be achieved by installing an overflow pipe, weir, or overflow structure above the reservoir layer's design water storage level to convey excess flows downstream.
- The capacity of the overflow for exceedance flows should be verified using standard hydraulic assessment methods (weir, orifice, and pipe flow). Exceedance flows beyond the overflow's capacity must also be addressed.
- Any exceedance flow structure should be situated within the bio-filtration basin and close to the inlet to minimize flow path length for above-capacity flows, thereby reducing scouring risk

The above information is sourced from "SUDS Manual"

3. Infiltration systems

a. General Considerations

- Infiltration systems must be designed to handle storms up to the specified design standard for the contributing catchment area, such as the 1:10 or 1:30 year storm or larger events. Since discharge criteria from development sites are typically based on a 1:100 year event with a climate change allowance, it's crucial to understand the performance of infiltration systems under these conditions.
- To simplify design and minimize surface flooding within developments, soakaways may be designed to manage the 1:100 year event (plus climate change allowance).
- Infiltration components should discharge from full to half-full within a reasonable time to minimize the risk of being overwhelmed by subsequent rainfall events.
- For systems designed for the 1:10 or 1:30 year event, it's common to specify half-emptying within 24 hours. However, for events larger than the 1:30 year event, longer half-emptying times might be necessary, subject to approval from the drainage authority, based on system performance assessment and risk evaluation.

b. Hydraulic Design of Infiltration Components:

- Typically, the area designated for infiltration is much smaller than the impermeable area being drained. For most soils, the rate of water entering the infiltration system (inflow) exceeds the rate at which water infiltrates into the soil (outflow).
- Due to the imbalance between inflow and outflow rates in infiltration systems, it's crucial to provide sufficient water storage on-site or within the infiltration unit. This storage allows adequate time for water to infiltrate into the soil.
- Adequate storage capacity is essential for infiltration systems to meet their design standard of service. The hydraulic design aims to determine system dimensions that can store and infiltrate runoff from the design storm. Overflows or additional discharge points are necessary if total infiltration cannot manage all return period events, and consideration of exceedance flow management is crucial.
- Infiltration devices are typically designed for return periods up to 1:100 years, with an allowance for climate change. Specific advice on suitable return periods for different components is provided in respective technical chapters.
- One of the primary uncertainties in infiltration system design is the infiltration coefficient, which may decrease over time, especially without effective pre-treatment or maintenance. To address this uncertainty, a safety factor is incorporated into the design process, reducing the observed infiltration coefficient value.
- Subsequent sections outline the calculation methods used to determine the appropriate sizing of infiltration systems, considering factors like inflow rates, soil characteristics, and design standards.

i) Plane Infiltration system

Plane infiltration systems are characterized by their thin profile and wide coverage over a specific area. The side area relative to the base area is considered negligible in these systems.

Determination of maximum depth of water for plane infiltration systems

$$h_{max} = \frac{D(Ri - q)}{n}$$

where,

h max = maximum head of water above base of infiltration

component

R = ratio of the drained area to the infiltration area,

q = infiltration coefficient, from percolation test (m/h), adjusted by the appropriate factor of safety,

D = intensity and duration of rainfall events with the required return period at the site location (m/h, h)

Ab = base area of infiltration system (m²)

AD = area to be drained (m²)

n = porosity of fill material (voids volume/total volume)

This may be obtained from laboratory tests, or else the guide values provided in the following table may be used. If a value of porosity greater than 0.3 is used, the material delivered to site should be tested to ensure that it meets the design requirement

Material	Porosity, n
S geocellular systems	0.9–0.95
uniform gravel	0.3–0.4
graded sand or gravel	0.2–0.3

A perforated concrete ring soak away may be installed in a square or rectangular plan excavation and the gap between the rings and the soil filled with clean stone. Under these circumstances an effective porosity, n, applies.

$$n' = \frac{\pi(r')^2 + n[WL - \pi(r')^2]}{WL}$$

where,

r= radius of the ring sections (m)

W = width of the excavation (m)

L = length of the excavation (m)

ii) Three-Dimensional Infiltration Systems Overview:

These systems are characterized by their cuboid or trench-like shape, where the surface area of the sides is notably larger compared to the base area

Procedure to determine the base area required for a given maximum depth:

The equation for the base area Ab (m²) is given by:

$$A_b = \frac{A_D i D}{n h_{max} + q D}$$

- Step 1 : Obtain the infiltration coefficient, q, by dividing the infiltration rate found from field tests by the appropriate factor of safety

$$h_{max} = \frac{D(Ri - q)}{n}$$

where,

R is the ratio of the drained area to the infiltration area,

R = AD/Ab

- Step 2 : Find the porosity of granular fill material
- Step 3 : Decide on the area to be drained, AD (m²), Decide on the maximum allowable water level, h max (m)
- Step 4 : Select a storm duration, D (h) and Determine the corresponding rainfall intensity, i (m/h)
- Step 5 : Calculate AD. i. D, n, hmax, and q. D and Calculate Ab (m²)
- Step 6 : Repeat steps 4 and 5 for a range of rainfall durations constructing a spreadsheet or a table of results

- Step 7 : Find the largest infiltration surface area required, If this area is unacceptably large then increase h_{max} or decrease AD and repeat step 3

iii) Vertical-sided structures

This procedure can be applied to soakaways and infiltration trenches. Determination of maximum depth of water for 3D infiltration systems:

$$h_{max} = a[e^{(-bD)} - 1]$$

Where,

$$a = \frac{A_b}{P} - i \frac{A_D}{P q}$$

P = perimeter of the base of the infiltration system (m).

$$b = \frac{P q}{n A_b}$$

c. Interception Design:

- Infiltration can significantly contribute to interception, which involves capturing and retaining the initial 5 mm of any rainfall event, even on sites with low infiltration rates.

d. Peak Flow Control Design:

- Infiltration reduces required attenuation storage volumes.
- The degree of reduction depends on the design standard of service, provided storage volume, and surrounding soil's infiltration capacity.

e. Volume Control Design:

- Infiltration reduces runoff volume. The reduction extent for any return period depends on the design standard of service and the infiltration capacity of surrounding soils.

f. Exceedance Flow Design:

- Infiltration components should effectively manage exceedance flows.
- An exceedance flow route or temporary storage area (e.g., open space or external area) is required for rainfall events exceeding the infiltration system's design capacity.
- This can be achieved by installing an overflow pipe above the infiltration system's design water storage level to convey runoff downstream or managing water volumes that exceed system capacity appropriately.

4. Constructed ponds and wetlands

a. General Considerations

- Temporary storage volume in ponds/wetlands should be sized to manage flood attenuation for various return periods (10, 30, 100/200 years), considering climate change and urban development allowances.
- Larger events should be safely routed downstream, and additional storage may be required for adequate volumetric control.

b. Interception Design:

- Interception delivery, which prevents runoff for small rainfall events, may occur when infiltration happens as the water level rises above the permanent pool level.
- However, the volumetric reduction achieved this way is typically limited and requires careful assessment.

c. Peak Flow Control Design:

- Ponds/wetlands can help control flow rates by regulating discharge and allowing temporary storage volume to fill during storm events.
- Required peak flow control and storage volume can be determined using standard hydraulic assessments.

d. Volume Control Design:

- Ponds/wetlands generally do not contribute to volumetric runoff control but can provide additional attenuation where long-term storage is not feasible.
- Assessment of volumetric control should follow standard hydraulic assessment methods.

e. Exceedance Flow Design:

- An exceedance flow route is needed for rainfall events surpassing the design capacity of the pond/wetland.
- This can be achieved with overflow pipes, weirs, or spillway structures to convey excess flows downstream.
- Structures should be designed to prevent embankment overtopping, ensuring downstream safety.
- Exceedance flow capacity should be confirmed using hydraulic assessment methods.
- Structures should be located close to the inlet to minimize flow path length for above-capacity flows, reducing the risk of scouring.

5. Attenuation Storage tanks (Water plaza & sunken court)

a. General Considerations

- Attenuation storage systems play a critical role in managing storm water by providing attenuation storage and requiring careful design considerations for peak flow and exceedance events. Proper maintenance and sediment management are essential for long-term effectiveness.

b. Interception Design:

- Impermeable attenuation tanks do not provide interception as all runoff flows through and is discharged.
- Appropriately designed tanks that allow some water to leak into surrounding soil can provide interception if the soil has sufficient infiltration capacity.

c. Peak Flow Control Design:

- Attenuation tanks reduce flow rates by providing storage volume determined by tank porosity.
- Tank size is determined using hydraulic design methods to attenuate rainfall events. Flow control structures are necessary to regulate discharge rates.

d. Sedimentation and Maintenance:

- Tanks susceptible to sedimentation are commonly oversized by 10% to account for storage loss due to sediment buildup.
- Effective sediment management upstream of the tank is crucial.

e. Volume Control Design:

- Contribution of storage tank systems to volume control should be assessed based on expected infiltration rates and available storage.

f. Exceedance Flow Design:

- Overflow pipes or overland flow routing is required for rainfall events exceeding the tank system's capacity.

The above information is sourced from "SUDS Manual"

B.3. Detailed Notes on BGI components

B.3.1. Sizing of BGI Components

The primary reporting metric used by PWD GSI is the Greened Acre (GA), which measures the volume of storm water managed by Blue-green infrastructure (BGI) in acre-inches. The calculation for Greened Acre (GA) is based on a specific equation determined by PWD GSI. This metric helps quantify the effectiveness of GSI in managing storm water runoff within a given area, providing a standardized measure for reporting and evaluating the impact of green infrastructure projects.

$$GA = I C * W d$$

Where:

- I C (acres)** = the impervious cover (formerly tributary to the combined sewer system) utilizing green storm water infrastructure. This quantity can include the area of storm water management feature itself, plus the area that drains to it.
- W d (inches)** = the depth of water over the I C that can be physically managed in a facility

1. General Considerations

a. Requirements

- Systems must have static storage capacity to hold at least one inch of runoff from the directly connected impervious drainage area.
- Storage above the overflow elevation of the Blue-green infrastructure (BGI) cannot be considered in the storage calculation.
- For detention or slow-release systems without a complete impermeable liner, storage volume below the orifice should be included in calculations.
- When calculating storage, use specified void percentages.
All systems must manage runoff from a 10-year design storm, which may involve safely bypassing runoff if it can be treated downstream.
- This requirement is particularly important for off-street systems or modifications affecting existing inlet infrastructure.
- Systems must be designed to prevent erosive conditions internally or at any outfall location.
- Separate storage calculations are required for each individual system.

Table 3. Maximum Allowable velocities based on soil type

Storage Medium	Void space	Notes
Open graded aggregate	40%	Frequently referred to as "stone"
Soil storage	20%	Soil storage up to a depth of 1m can be counted in surface systems, such as bumpouts and planters.
		Soil within a tree pit should be considered storage.
Sand	30%	-
Pipes embedded in systems	9 Product-specific 2%	Assumes outside diameter of pipe.
Modular storage products	-	-

b. Guidelines

- Where feasible and economical, systems should be designed to store runoff equivalent to up to 38mm from directly connected impervious areas.
- The storage volume should generally not exceed the equivalent of 51mm of runoff, unless approved by PWD for anticipated future connections to the BGI system.
- To ensure cost-effectiveness, systems should manage a minimum drainage area of 743 sq m.
- Each drainage area to an inlet should ideally be at least 465 sq m.
- If a drainage area is smaller than 465 sq m and adjacent to the system excavation area, smaller thresholds may be considered.
- Only BGI components within the right-of-way, from alleys, or on public lands should be considered for sizing.
- Alleys with significant drainage contributing to the right-of-way can be included if verified and mapped, though priority should be given to right-of-way drainage in system sizing due to its stability.
- Designers should assess topography, land use, and discuss potential issues with the SWD project manager.
- Grass strips or heavily compacted areas within the right-of-way should be assumed impervious unless modified with soil improvements as part of the proposed project.
- Clean-washed stone used as sidewalk or street sub-base can count towards storage calculations if elevations allow.
- Modular storage options may be considered if they are cost-effective for sites with limited storage opportunities.

c. BGI Rules to be followed

- Each surface feature like rain gardens, bumpouts, and planters should be considered a separate BGI component. **(Refer image xx)**
- Subsurface storage with maintenance access below a surface of the BGI should also be counted as a separate system. **(Refer image xx)**
- Any subsurface feature connected by an open pipe (without an orifice) should count as one BGI component. **(Refer image xx)**
- BGI s should not be created due to breaks in trench work or when trench sections are on different blocks. For example, if part of a trench includes trees but another part does not, it's still coded as a tree trench. **(Refer image xx)**
- Sections of subsurface features separated by an orifice (like in a water level control structure) should be counted as separate BGI components. **(Refer image xx)**

The above information is sourced from "GSI planning and designing manual"

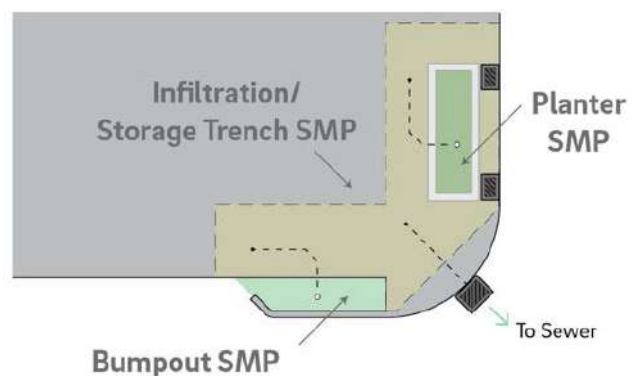


Fig.5 Example of two separate surface BGI with a common underlying subsurface BGI

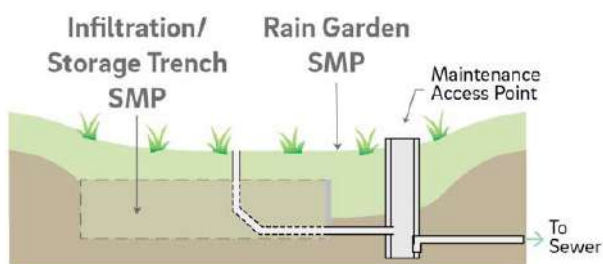


Fig 6. Eg. of a surface BGI over a separate subsurface BGI with maintenance access.

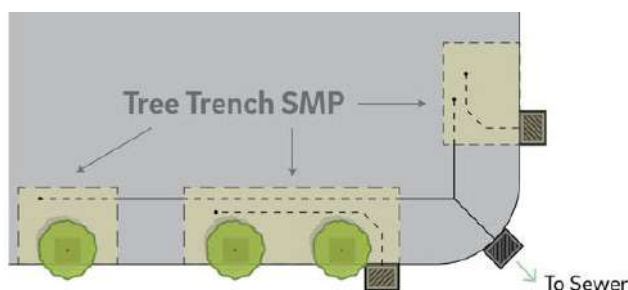


Fig 7. Eg. of a tree trench with separate hydraulically connected sections

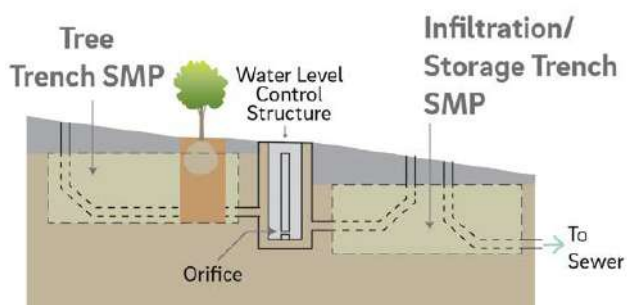


Fig 8. Example of two (2) separate BGI, a tree trench and infiltration trench.

2. Inlets and Selection

- Inlets serve as entry points for storm water runoff into BGI, often using green inlets, dual catch basins, curb cuts, and trench drains.
- Each inlet and system requires determination of the drainage area, which is the surface area where runoff converges to a single low point.
- Capacity calculations must be separately completed for each routing component, particularly when considering removal of non-green inlets.

$$Q = C i A$$

Where,

Q = Peak Runoff Rate (cfs)

C = Runoff Coefficient

i = Average Rainfall Intensity (in/hr)

A = Drainage Area (acre)

- The design of required inlet capacity follows the Rational Method, utilizing the average peak 1-year, 15-minute intensity.
- Grated inlets incorporate a clogging reduction factor of 0.5, accounting for the reduced conveyance capacity due to potential clogging.
- Trench drains typically use a standard 1.37m curb opening length without independent calculations if drainage area is less than 15,000 SF and longitudinal slope is under 6%.

a. Inlet selection

- Green inlets for conveying runoff to BGI systems are typically positioned 1.5m upstream of existing sewer-connected inlets.
- Off-street applications or surface systems may use other inlet types like shallow green city inlets or trench drains based on SWD project guidance.
- Dual catch basin inlets are an option where space is limited; they connect to both BGI systems and sewers, diverting flow over an overflow weir.
- Trench drains can convey runoff to surface features, but shallow inlets are preferred; SWD specifies typical trench drain details and installation guidelines.
- Energy dissipation at inflow points is essential to minimize erosion.
- All green inlets require permanent inlet protection for pretreatment, meeting specifications.

b. Inlet Replacement

- Any inlet with a brick inlet box must be replaced, identified during survey by visual inspection, regardless of its top style.
- Replace inlets in poor condition or with a history of problems, as determined by the PWD project manager.
- Inlets may not require replacement if under drain connections aren't being made and surrounding foot way/paving isn't being replaced.
- If inlet replacement is necessary, seek guidance from the SWD on proposing new sewer connections or reconnections to existing laterals.
- Discuss designs proposing inlet abandonment to increase drainage area directed to a system with the SWD authority; inlet removal requires review by SWD Collectors Systems and Water/Sewer Design Utility Engineering.

The above information is sourced from "GSI planning and designing manual"



Fig 9. Reference - Inlet showing conveying to BGI Component

B.3.2. Detail construction notes of BGI

1. Swales

- Swales are shallow, flat-bottomed, vegetated open channels designed to manage surface water runoff by conveying, treating, and sometimes attenuating it.
- They are integrated into site designs to enhance the natural landscape, providing aesthetic and biodiversity benefits.
- They can also serve as surface conveyance systems while enhancing access corridors or open spaces.
- Swales come in various profiles and can incorporate different planting strategies based on site characteristics and objectives.
- Swales can replace traditional pipework for runoff conveyance, and the use of adjacent filter strips or flow spreaders can eliminate the need for kerbs and gullies.
- Typically, swales are broad and shallow, covered with vegetation like grass to slow down water flow, promoting sedimentation, filtration, evapotranspiration, and infiltration into the soil below.
- Check dams or berms can be added to temporarily pond runoff, enhancing pollutant retention and infiltration, particularly beneficial for sites with steeper gradients.

a. Different Typologies of Swales

i) Conveyance Swale:

- A shallow vegetated channel used to collect and convey runoff to another stage of the BGI Management Train.
- Can be designed for treatment and/or attenuation based on flow constraints and ponding depths.

ii) Mini-Swales:

- Small swales designed to manage small runoff events, with effective overflow facilities to redirect overflow to alternative components.

iii) Dry Swale (or “Enhanced” Swale):

- A vegetated conveyance channel with a filter bed of prepared soil overlaying an under drain system.
- Under drain system provides additional treatment and conveyance capacity, preventing water logging.
- Liner may be used at the base to prevent infiltration or manage high groundwater levels.

iv) Wet Swale:

- Similar to a conveyance swale but designed to maintain wet and/or marshy conditions in the base.
- Suitable for flat sites with poorly drained soils or to meet specific functional, amenity, or biodiversity requirements.
- Requires specific wetland planting for the swale base.

b. General Design Considerations

i) Cross-Section Design:

Swales are best designed with a trapezoidal or parabolic cross-section for ease of construction, maintenance, and hydraulic performance.

ii) Bottom Width:

Grass swales typically have a bottom width of 0.5-2.0m, allowing for shallow flows and adequate water quality treatment. Widths exceeding 2 m may require flow dividers to prevent flow channelling.

iii) Longitudinal Slopes:

Slopes should range between 0.5-6%. Check dams are needed

on slopes > 3%, and reinforcement matting may be necessary for higher velocities.

iv) Under drains:

Conveyance swales with slopes < 1.5% require under drains, or wet swales can be considered for such scenarios.

v) Side Slopes:

Side slopes should be as flat as possible (maximum 1 in 3 or 33% slope) to enhance safety, mowing access, and lateral flow pre-treatment. Steeper slopes may experience erosion.

vi) Swale Length:

Swale length should match or exceed the contributing roadway length. Maintenance sections between culverts should be at least 5 m.

vii) Maximum Depth:

Normal swale depth ranges from 400-600 mm. Deeper depths may require health and safety assessments and consideration of inflow pipework depths.

viii) Alternative Considerations:

Deeper swales entail higher land requirements, excavation costs, and deeper water, necessitating alternative surface water management solutions.

ix) Low Infiltration Swales:

Swales designed for conveyance with low infiltration levels can be acceptable if soils between the swale and groundwater provide sufficient protection, with appropriate organic and clay content. Pollution risks to groundwater are generally acceptable for non-high-hazard sites,

x) Preventing Infiltration:

For areas where underlying groundwater sensitivity or vulnerability requires prevention of infiltration, swales can be designed above an impermeable geomembrane liner, at least 0.5 m deep. Consider construction risks and potential water logging issues.

xi) Guidance Compliance:

Determine the acceptability of infiltration from the swale base, ensuring compliance with relevant requirements for ground stability, water table depth, and groundwater protection



Fig 10. Reference - Bioswales design

x) Groundwater Level:

Ensure that the maximum expected groundwater level is at least 1 m below the lowest point of the swale where infiltration occurs.

c. Selection and siting of Swales

i) Versatile Application:

Swales are suitable for managing runoff from roads, car parks, and other impermeable or permeable areas due to their linear nature and ease of incorporation into existing spaces.

ii) Land Use Considerations:

- Swales require significant land take due to their shallow side slopes, making them suitable for incorporation into landscape and public open spaces.
- They are challenging to integrate into dense urban developments with limited space, but steeper side slopes or specialized designs can be considered in certain situations.

iii) Industrial Site Use:

Swales are ideal for industrial sites when lined and complemented with downstream treatment components, allowing visible pollution management and easier maintenance with high sediment loads.

iv) Location Restrictions:

- Avoid placing swales in areas with high risk of excess fertilizer or weed-killer application to prevent pollution of runoff.
- Unlined swales should not be used on brown field sites unless contaminant leaching risks are managed effectively.
- Swales should not treat runoff from areas with high contaminant loadings if there is an unacceptable risk of groundwater pollution due to infiltration.

v) Groundwater Level:

- If a liner is used to prevent infiltration, ensure the seasonally high groundwater level is below the liner level.
- For systems allowing infiltration, ensure the maximum likely groundwater level is at least 1 meter below the systems base.

vi) Shading Considerations:

Avoid locating swales in areas with extensive tree cover or overhead structures that could limit grass or vegetation growth due to shade conditions.

d. Treatment Design

i) Pollutant Removal Methods:

Swales can remove pollutants from runoff through various methods based on their design:

1. Conveyance and Dry Swales:

- Coarse to medium sediments and associated pollutants are filtered through surface vegetation and ground cover.
- Fine particulates and contaminants are removed by infiltration into underlying soil or filter layers.
- Organic contaminants can be eliminated through photolysis and volatilization.

2. Wet Swales:

- Fine particulates are removed by adsorption and sedimentation.
- Nutrients and dissolved metals are removed via bio degradation and plant uptake.

ii) Design Characteristics:

- Good pollutant removal performance depends on design characteristics outlined above as well as linked with hydraulic performance.
- Previous recommendations to keep grass short in swales for pollution removal improvement are now considered minimal, with no blanket requirement.

iii) Infiltration Acceptability:

The acceptability of infiltration from swales depends on likely runoff contamination and site characteristics, as detailed in **(cross refer to infiltration)**

iv) Pollutant Mass Removal Rates:

- Pollutant mass removal rates from grass swales vary widely based on influent pollutant concentrations and site-specific factors.
- Median removal rates are reported as 76% for total suspended solids, 55% for total phosphorus, and 50% for total nitrogen.
- Significant reductions in total zinc and copper concentrations have also been observed, with variability in results influenced by site-specific factors.

v) Removal Mechanisms:

In grass swales, infiltration is the dominant pollutant removal mechanism over filtration, as pollutants trapped on the swales surface are not permanently bound.

e. Amenity Design:

- Swales can be aesthetically integrated into various landscape types, enhancing street scape and road/parking corridors.
- Avoid sharp bends in swale design to prevent erosion; gradual meandering bends can be used for aesthetic purposes and to slow flows.
- Consider orientation, aspect, and proximity to other landscape features or buildings for appropriate scale and form.
- Design should contribute to the amenity of local communities, with natural-feeling soft edges in green spaces and more structured lines in dense urban areas.
- Select plant species based on site characteristics and design intent to complement the existing landscape.

i) Information and Interpretation:

Provide small interpretation boards near swales to educate about their function, local flora, and fauna.

ii) Safety Considerations:

- Swales are generally shallow surface features with low risk to public safety.
- Mitigate any residual risks with shallow side slopes and flow depths.
- Follow safety measures for wet swales

iii) Physical Barrier Considerations:

- Use physical barriers like structural planting, bollards, or low railings to prevent vehicle parking on swale edges.
- Avoid large rocks or boulders to prevent grass damage and scouring; reinforce swale edges to withstand vehicle impact.

f. Biodiversity Design:

Include diverse planting, including wildflower grass seed mixes, to support urban biodiversity by providing habitat and food for insects, invertebrates, and birds. Use native plant species for dense, durable vegetation.

g. Physical Specifications

i) Pre-treatment and Inlets:

- Preferably direct water laterally into swales to minimize erosion and disperse pollution in surface vegetation.
- Use drop kerbs or flow spreaders to transition runoff into swales, ensuring vegetation behind kerbs does not obstruct flow.
- Mitigate erosion and silting risks from flow-concentrating devices with flow spreaders, erosion control, and appropriate pre-treatment.
- Minimize catchment area draining to a single inlet.
- Install lateral gravel-filled drains along road edges to prevent water seepage into pavement layers.

ii) Shallow Side Slopes and Vegetated Strips:

- Use shallow side slopes or vegetated filter strips at impervious surface edges for pre-treating runoff entering swales.
- Ensure a drop of at least 50 mm from pavement edges to vegetated surfaces to prevent sediment accumulation.

iii) Under drains and Outlets:

- Use PVC perforated pipes (minimum diameter 100 mm) with 150 mm clean gravel above, enclosed by geo-textile fabric for under drains.
- Under drains should infiltrate into subsoils or drain freely to an acceptable discharge point.
- Provide outlet pipes from swale channels or under drain systems to discharge points.
- Include overflow structures and non-erosive overflow channels to safely manage flows exceeding swale storage capacity.
- Install inspection pipes for under drains to allow performance observations and cleaning.

h. Materials

i) Check Dams:

- Typically provided at 10 to 20 m intervals.
- Water level at the toe of the upstream dam should be the same as the crest of the downstream dam.
- Constructed from materials such as coarse aggregate, wooden boards, gabions, rip-rap, or concrete.
- Use pressure-treated logs or water-resistant tree species for wooden check dams.
- Energy dissipation and erosion protection materials should extend 1 to 2 m downstream of the dam.
- Include a small orifice or pipe at the base of the dam to convey low flows downstream.

ii) Gravel Flow Spreader:

- Comprise washed stone of 3-10 mm diameter.
- Diaphragm should be at least 300 mm wide and 600 mm deep.

iii) Flow Dividers:

- Constructed of firm materials resistant to weathering and erosion, such as concrete, recycled plastic, or compacted soil berm.
- Ensure materials used do not leach chemicals into the swale.
- Use erosion control fabrics, coir blankets, or geotextiles if erosion is a concern.

i. Landscape design and Planting

- Use grasses and herbaceous plants with strong root systems and dense cover at the bottom of the swale to improve infiltration, stabilize soil, filter pollutants, and retain

suspended solids.

- Select plant species for the sloped areas of grass channels that can tolerate occasional flooding and extended dry periods, such as robust grasses, groundcovers, and low shrubs.
- Including trees in the design is possible but ensure they won't shade out ground cover plants needed for proper growth.
- Avoid fertilizing swales, especially in environments sensitive to nutrient loads.
- In wet swales, plant emergent vegetation or spread wetland soils for seed stock, but avoid dense planting to allow for natural colonization. Use multiple species to increase favorable growing conditions.
- For dry swales, plant with turf, seeds, or individual plants like plug plants. Lay turf perpendicular to water flow and secure with pegs for areas with high flow velocities or steep slopes.
- Seed swales in spring or early summer to establish vegetation over a full growing season. Maintain grasses between 75-150 mm to ensure performance during regular events.

The above information is sourced from "SUDS Manual"



Fig 11. Reference - Timber check dams, Rednock School, Gloucestershire



Fig 12. Reference - Check dam wall using local materials, Sheffield

2. Bio retention Systems

- Bio retention systems, like rain gardens, are shallow landscaped depressions used to reduce runoff rates, volumes, and treat pollution through engineered soils and vegetation.
- They offer various benefits including self-irrigation, attractiveness, habitat creation, biodiversity support, and micro climate cooling.
- Bio retention systems are flexible and can be integrated into different development landscapes with various shapes, materials, planting, and dimensions.
- They are effective for managing and treating runoff from frequent rainfall events but may require consideration for extreme event impacts, redirecting overflow downstream if needed.
- Runoff collected by the system ponds on the surface, filters through vegetation and soil, and is managed through under drain systems or infiltration into surrounding soil.
- Engineered soil mixes enhance treatment performance, and designs can include submerged anaerobic zones for nutrient removal.
- Bio retention systems primarily benefit from Interception but can also manage runoff rates through surface storage or drainage layer attenuation.
- Key components include drainage layers, perforated pipes for water collection, and overflow mechanisms like standpipes or weirs.
- Impermeable liners are generally avoided unless needed for specific reasons like near structural foundations or groundwater protection.

a. Different Typologies of Bio retention systems

i) Raingarden:

- Small systems for managing runoff from specific property areas like roofs or driveways.
- Often less engineered compared to full bio retention systems, using compost/sand-amended native soils or engineered soil mixes.
- Typically have a simple inflow for rainwater and a maximum depth of standing water of 150 mm.
- Can include aboveground overflow or under drain for excess water management

ii) Raised planter:

- Boxed systems constructed above ground level with planted soil mix and under drain for collecting filtered water.
- Used for managing runoff from adjacent roofs, especially in urban settings.
- Not typically used for infiltration purposes.

iii) Bio retention Tree Pit:

- Tree pits enhanced for better performance through additional surface planting.
- Trees and shrubs aid in precipitation interception, energy dissipation, infiltration, and groundwater recharge.
- Provide shade, reduce runoff temperatures, and offer amenity and biodiversity benefits.

iv) Bio retention Swale or trench :

- Bio retention systems integrated within swales or bioswales.
- Designed to manage flows up to certain design events through filtration and under drain collection.
- Vegetation and flow velocities are carefully designed to prevent erosion of filter material.

v) Anaerobic Bio retention System :

- Outlet pipe design maintains a permanent water level within the drainage layer.
- Water storage assists vegetation access during dry periods and aids in pollutant treatment.
- Can include a carbon source in the submerged zone to improve pollutant removal.
- Requires careful design to prevent water logging of rooted soils above and ensure effective treatment



Fig 13. Reference - Rain garden under construction



Fig 14. Reference - Rain garden Planted

b. General Design Considerations

- Bio retention systems are effective for managing a wide range of rainfall events but are limited by catchment size and available space.
- They are designed to drain relatively small areas close to the source of runoff, and large catchments should be divided into smaller parcels with multiple bio retention zones.
- The maximum recommended area draining to a bio retention system is 0.8 hectares.
- Inflow velocities should be considered to implement suitable flow distribution and erosion protection measures.
- The surface area of the bio retention system should ideally be 2-4% of the overall site area to prevent rapid clogging.
- Bio retention areas are designed for intermittent flow to prevent the growth of moss, algae, and bio-films that can clog the surface.
- They can be used in various ground conditions but may require small retaining structures on steeper slopes.

- If groundwater is at risk of contamination, impermeable geomembrane liners should be used, and infiltration should be prevented.
- Bio retention systems can be integrated with water harvesting systems but may reduce available runoff volumes.
- Systems with under drains require cleaning access to maintain functionality.

c. Selection and siting of bio retention ponds:

- Bio retention systems are versatile and can be used in various types of developments, including residential and non-residential areas, to manage polluted runoff from roads.
- They are suitable for private properties, small shared public areas, car park islands, roundabouts, footpaths, traffic calming zones, and street scape.
- Bio retention systems can serve multiple purposes such as buffering structures, enhancing privacy, and providing aesthetic features.
- Linear bio retention systems along roads, central reservations, and build-outs help control flooding on the carriageway.
- They are cost-effective retrofit options due to their size flexibility and can be integrated into existing landscaped areas or underutilized spaces during planned street works.
- Bio retention systems should be designed within landscaping requirements to avoid extra land-take, with a width greater than 600 mm and less than 20 m for maintenance access.
- The total filter area of bio retention systems should not exceed 800 m², and lengths should not exceed 40 m to ensure even distribution of water over the surface.
- Thicker filter mediums and saturated drainage layers are suitable for tree planting and less drought-tolerant vegetation.
- Infiltration from the base of bio retention systems should follow specific guidelines to ensure ground stability, depth to the water table, and groundwater protection.
- Rain gardens located within 5 m of building foundations may require assessment by geotechnical engineers, especially if they manage water from larger areas or deeper depths.
- Building control departments may have specific requirements for rain gardens depending on local conditions and risk factors.

d. Treatment Design

- Bio retention systems effectively treat pollutants through sediment removal, including fine sediments and associated pollutants like nutrients, oils/grease, and metals, filtered through surface vegetation and ground cover.
- Fine particulates and contaminants are removed through infiltration into underlying filter medium layers, offering filtration, extended detention, and biological uptake by vegetation and subsoil biotic.
- Dissolved pollutants are removed through the filter medium.
- The acceptability of infiltration from bio retention depends on runoff contamination levels and site characteristics
- Well-designed and maintained bio retention systems retain pollutants even from snow melt containing de icing salts
- Pollutant removal efficiencies of bio retention systems following FAWB (2009) guidelines are summarized in
- Vegetation within filter medium enhances system function by trapping pollutants, preventing erosion, and breaking up soil to prevent clogging. Denser and taller vegetation improves filtration efficiency.
- Plant selection in bio retention systems influences treatment effectiveness, with considerations for adaptability to wet/dry conditions, root system extent, and nitrogen removal

capabilities.

- Soil filter media should adhere to the guidelines for effective pollution removal, although requirements may be adjusted for smaller-scale rain gardens collecting roof water.

Table. 4. Pollution removal for bio retention systems designed to FAWB guidelines (after FAWB, 2009)

Pollutant	Typical removal efficiency
TSS	> 90%
Total phosphorous	> 80%
Nitrogen	50% on average
Metals (zinc, lead, cadmium)	> 90%
Metals (copper)	up to 60%

e. Amenity Design:

- Bio retention systems are highly versatile in size and appearance, offering significant aesthetic benefits by incorporating vegetation into various urban spaces such as car parks, pedestrian areas, street scape, plazas, and forecourts.
- They can be integrated as unobtrusive landscape features or prominent elements, contributing to urban design while enhancing community areas.
- Rain gardens can manage roof water in small areas and can be located in green spaces or as hard features like raised planters on patios.
- Bio retention swales along road edges define boundaries and contribute to green street corridors.
- Bio retention systems treat runoff for non-potable uses and support water-efficient landscaping by storing runoff beneath the system for plant use.
- They can help cool the local micro climate through evapotranspiration.
- Fencing around bio retention systems is generally discouraged to preserve amenity benefits and facilitate maintenance.

f. Biodiversity Design:

Bio retention systems promote biodiversity by providing habitat conditions for wildlife, accommodating a range of plantings, including native species to support local biodiversity initiatives when working with ecologists and horticultural/ arboricultural experts.

g. Physical Specifications

i) Pre treatment and Inlets:

- Inlets should be designed to allow water onto the filter medium surface without causing scour or vegetation damage, ensuring uniform distribution over the treatment area and minimal risk of blockage.
- Simple rain garden inlets often use shallow channels lined with granite or similar materials.
- Bio retention systems for larger areas can be on-line or off-line with specific point inlets or over-the-edge flow.
- Kerbs cuts are ideal inlets from roads, at least 500 mm wide with a large radius to promote flow.
- Sediment forbays should trap sediment to prevent blockage and maintain inlet efficiency.

- Dense vegetation around inlets aids sediment management.

ii) Pre treatment:

- Usually needed for high sediment or gross pollutant loadings, achieved with filter strips, gravel strips, or two-cell designs with forbays for sediment removal.
- Inlet ponds can serve as submerged forbays for larger systems.

iii) Under drains and Outlets:

- Under drains and outlets must handle filtered water and prevent soil saturation. Perforations in pipes should pass maximum filtration rates, and pipe capacity should exceed design flows.
- Ensure drainage layer particles are larger than pipe perforations to prevent clogging. Use slotted pipes or geocellular units for under drains connected to positive outflows.
- Shape the base to guide flow towards under drains for water collection or keep it flat for infiltration.
- Simple rain gardens with no under drains require a basic outfall for roof water.
- Provide overflow structures and non-erosive channels to manage flows exceeding storage capacity.
- Overflows should be close to inlets to minimize flow path across the filter medium for larger flows.
- Inspection pipes should allow access for under drain



Fig 15. Reference - Inlet of Bioretention pond



Fig16. Reference - outlet from Bioretention system

cleaning

h. Materials

i) Mulch Layer:

- Organic mulch should be avoided in systems with overflow pits to prevent clogging.
- Infiltration systems may use mulch, but high flows can cause material movement.
- Consider alternatives like degradable organic matting, bonded fiber metric mulches, or gravel mulches (max depth 75 mm) for soil moisture retention and erosion protection.
- Use high planting densities with gravel mulch to compensate for reduced plant spread.

ii) Filter Media:

- Should be permeable to prevent water logging and support vegetation.
- Specify filter media correctly based on site-specific needs.
- Consider alternative specifications to ensure continuity in material supply.
- Incorrect specification can reduce hydraulic conductivity, treatment capacity, and cause vegetation loss.
- Compaction during installation is critical to maintain hydraulic conductivity.

iii) Transition Layer or Geo-textile Separator Layer:

- Specify based on geotechnical filter criteria to prevent soil particle washout.
- Geo-textile separators can meet filter criteria and ensure layer integrity.

iv) Drainage Layer:

- More permeable than filter medium.
- Use materials like filter drain materials, sub-base materials (e.g., 4/20 aggregate), or geocellular units.
- Ensure drainage layer materials are free from fine particles that could contaminate runoff or block under drain pipework.
- Test crushed concrete to ensure it won't leach contaminants into water.

i. Landscaping and design

i) Plant Selection Criteria:

- Consider surrounding landscape characteristics.
- Decide between native or introduced species based on appropriateness.
- Check local nursery availability for chosen plants.
- Ensure drought tolerance for survival during dry periods.
- Evaluate tolerance to free-draining sandy soil and occasional inundation.
- Consider tolerance to expected pollution loads.
- Favor plants with fibrous root structures and spreading growth forms.
- Evaluate shade tolerance and height restrictions for specific locations.
- Factor in maintenance requirements when selecting plants.

ii) Types of Planting Areas:

1. Ornamental Planting Areas:

- Mass bed planting for complete foliage coverage.
- Use a variety of species for year-round interest.
- Prioritize low-maintenance ornamental species.

2. Open Space Meadows:

- Incorporate native grasses and wildflowers.

- Require significantly reduced maintenance.

iii) Key Aspects for Successful Establishment:

- Optimize root density with dense planting, incorporate diverse plant species for varied hardiness and pest resistance, utilize shrubs for effectiveness, avoid turf in dry conditions, and ensure at least 200 mm of topsoil meeting standards.
- Avoid irrigation pipes that extend into filter medium to prevent short-circuiting.



Fig 17. Reference – landscaping in Ribblesdale Road, Nottingham



Fig 18. Reference – landscaping in Portland, Oregon

3. Infiltration Systems

- Infiltration can contribute to reducing runoff rates and volumes while supporting baseflow and groundwater recharge processes.
- The rate at which water can be infiltrated depends on the infiltration capacity (permeability) of the surrounding soils
- Soakaways, infiltration trenches, infiltration blankets, and infiltration basins facilitate infiltration.
- Bio retention systems and pervious pavement can also allow infiltration from their bases.
- Infiltration reduces runoff rates and volumes, supporting baseflow and groundwater recharge.
- Water infiltration rate depends on the permeability of surrounding soils.

a. Different Typologies of Infiltration systems

i) Soakaways:

- Small soakaways historically used rubble or brickwork; now, geocellular units are preferred for better storage capacity.
- Larger soakaways may use perforated precast concrete manhole rings or geocellular structures

ii) Infiltration Trenches:

- Linear soakaways that can be shallower and distribute infiltration area in variable soils.
- May include a perforated pipe to distribute water along the trench.

iii) Infiltration Basins:

- Flat-bottomed, shallow landscape depressions that store runoff and allow pollutants to settle before infiltration into soils.
- Schematics for infiltration basins are available.

iv) Infiltration Blankets:

- Large shallow systems using permeable aggregate or geocellular units, integrated into pavement or below playgrounds.

b. General Design Considerations

The importance of effective design and management practices to ensure the functionality, safety, and longevity of infiltration systems while minimizing risks associated with groundwater contamination, flooding, and maintenance.

i) Purpose of Infiltration Systems:

- Infiltration systems discharge surface water runoff into the ground and groundwater.
- Runoff must be adequately clean before entering to avoid contaminating groundwater.

ii) Performance Factors:

- System performance depends on soil infiltration capacity and depth to groundwater.
- Upstream pre treatment is essential to remove sediment and prevent system clogging.
- Construction best practices are crucial to maintain subsoil structure and permeability.

iii) Design Considerations and Risks:

- Minimum distance (1 m) between infiltration system base and groundwater level is recommended.
- Design process should assess risks including ground instability, pollution, flooding, and leakage.
- Evaluation and management of risks must ensure acceptable residual risks post-construction.

iv) System Design Details:

- Infiltration system base should be flat for uniform ponding and infiltration.
- Side slopes of infiltration basins should be gentle (1 in 3) for stability, access, and safety.
- Open surface water storage features should minimize risks to site users and operators.

v) Maintenance and Safety:

- Adequate access to infiltration basins is essential for maintenance activities.
- Inspection chambers should allow surface-level maintenance without requiring man entry.
- Health and safety risk management guidance should be followed during system design.

c. Selection And Siting Of Infiltration Components

The versatility and practical applications of infiltration components like soakaways, highlighting their effectiveness in managing small-scale runoff while considering design constraints and urban development scenarios.

i) Suitability of Soakaways:

Soakaways are ideal for infiltrating runoff from small areas like residential roofs.

ii) Retrofitting and Design Flexibility:

- Infiltration components can be retrofitted into existing developments to drain small areas like driveways and roof drainage.
- On sloping sites, they can be designed as a series of smaller units located on plateaus within the site.
- They can manage overflows from rainwater collection systems and require no net land-take.

iii) Urban Development Considerations:

- Infiltration components come in various shapes and sizes suitable for high-density urban areas.
- Avoid using open-access infiltration basins in heavily trafficked public spaces to prevent surface soil compaction.

iv) Constraints and Situational Considerations:

- Avoid using infiltration systems to drain landscaping or erosion-prone areas due to the risk of sediment blockage and soil clogging.

d. Treatment Design:

- The acceptability of infiltration design for groundwater protection depends on runoff contamination and site characteristics.
- A depth of at least 1 meter of unsaturated soils with organic and clay content provides good protection to underlying groundwater.
- Sedimentation occurs within the storage area, so allowances should be made for this or upstream SuDS components to remove sediment.
- Shallow and dispersed systems are usually preferred to minimize the risk of groundwater pollution.
- Geo-textile layers within infiltration components can trap surface water runoff particulates and hydrocarbons.

e. Amenity Design:

- Soakaways and trenches typically lack inherent amenity value, but subsurface systems can allow overlying surfaces to be used for recreation.
- Use of infiltration basins as amenity features should balance

against increased maintenance needs due to pedestrian use.

- Engineered soils, tree planting, and mulching help maintain infiltration rates and reduce maintenance requirements.
- Design basins with shallow side-slopes and benching for safety, biodiversity, and habitat creation.
- Avoid fencing around infiltration facilities to preserve amenity benefits and facilitate maintenance.

f. Biodiversity Design:

Enhance ecological value by diversifying planting with trees, shrubs, and wildflower mixes. Include bio retention areas within the design to further enhance biodiversity.

g. Physical Specifications:

- Soakaways should use suitable geotextiles to support surrounding soil and prevent backfill ingress.
- Strength and durability of materials for soakaways should be considered for construction and service life.
- Follow structural design and material specification guidance for geocellular soakaways and precast concrete manholes.

i) Pre-treatment and Inlets:

- Effective pre-treatment is crucial to remove suspended solids and fine silts to prevent infiltration system clogging.
- Incorporate multiple pre-treatment practices such as swales, sediment basins, and filter strips to minimize risks.
- Design offline infiltration components to provide volume control in larger events.
- Stabilize inlet channels with erosion control measures and provide a level spreader for shallow sheet flow into basins.

ii) Outlets:

- Manage excess runoff overflow via piped outlets, overflow weirs, or from top of soakaways as appropriate.
- Ensure overflow systems do not impede access to inlet/outlet/control structures.

h. Materials:

Mainly use aggregate, geotextiles, and engineered soils (e.g., root zone or amended soils) for infiltration components. Ensure soils used are sufficiently permeable and meet design specifications.

i. Landscape Design and Planting:

- Infiltration basins are typically grassed; additional vegetation enhances appearance, stabilizes slopes, and serves as wildlife habitat.
- Choose planting suitable for site conditions, using native plants that can survive wet to dry conditions.
- Vegetation slows flows, maintains/enhances pore space, and minimizes surface soil clogging.
- Select plants that can withstand ponding and dry periods to reduce maintenance and enhance biodiversity.
- Avoid excessive root intrusion to prevent void space reduction and structural damage.
- Avoid fertilizing and herbicide application to minimize groundwater pollution risk.

The above information is sourced from "SuDS Manual"

4. Constructed ponds and wetlands

- Ponds and wetlands are permanent water bodies that provide attenuation and treatment of surface water runoff.
- They support aquatic vegetation, enhancing treatment processes and providing amenity and biodiversity benefits.
- Vegetation helps adhere contaminants, facilitates decomposition, stabilizes sediment, and prevents resuspension.
- Wetlands have larger proportions of surface area covered by aquatic planting and may include shallow islands.
- Attenuation storage is above the permanent pool, controlled by a flow system at the outfall to regulate discharge rates.
- Larger pond volumes allow for more effective settlement of pollutants and biodegradation.
- Always include suitable upstream pre-treatment systems to prevent silt accumulation and maintain water quality.
- Pre-treatment systems prevent ponds from becoming unsightly, odorous, or accumulating rapid silt deposits.
- Well-designed and maintained ponds/wetlands offer aesthetic, amenity, and wildlife benefits.
- They can enhance economic value of developments, attract business, tourism, and increase property values.
- Public acceptability depends on aesthetic quality, integration with landscape, and community performance.
- Design ponds with shallow, grassed side slopes or hard landscaping to complement urban environments.
- Landscape architects should typically design the form, layout, and planting of ponds and wetlands for optimal integration.
- Ponds/wetlands can be created by excavating new depressions, constructing embankments, or using existing natural depressions.
- Avoid using existing natural water bodies for runoff disposal if it risks disturbing natural morphology or ecology.
- Consider creating ponds/wetlands close to existing ones to benefit biodiversity and ecological connectivity.

a. Key considerations

i) Sediment Forebay:

- Optional but recommended for effective pre-treatment.
- Allows settling of coarse sediments and floating oils before entering the permanent pool.
- Facilitates easy monitoring and removal of sediment buildup.

ii) Permanent Pool:

- The main treatment zone that remains filled throughout the year.
- Protects fine sediments from resuspension.
- Top water level typically at the invert level of the outlet structure.

iii) Attenuation Storage Volume:

- Temporary storage above the permanent pool for flow attenuation during rainfall events.

iv) Aquatic Bench:

- Shallow water zone along the edge of the permanent pool.
- Supports wetland planting, acts as a biological filter, and provides ecology, amenity, and safety benefits.
- May include islands with additional vegetated areas within the permanent pool.

v) Water Loss Consideration:

- Account for water loss by evapotranspiration, especially in areas with a high proportion of shallow water.

vi) Design Features:

- Include safe exceedance routes, maintenance access to all areas, and flat safety benches around the perimeter.
- Access for maintenance should be provided, potentially using easements or pathways for equipment.

vii) Zone Division for Larger Ponds:

- Preferably divide larger ponds into zones to enhance water quality and quantity storage.
- Independent cells allow for increased attenuation, longer pollutant removal pathways, easier maintenance, and varied ecology.
- Zones facilitate enhanced biodiversity and more effective maintenance programs through staggered maintenance schedules.

b. Design Considerations

i) Flow Optimization:

- Design to ensure that flow enters gradually and spreads out, avoiding dead zones caused by corners.
- Use baffles, pond shaping, and islands within the permanent pool to increase flow path length and enhance water quality treatment.

ii) Inlets and Outlets:

- Position inlets and outlets to maximize the flow path through the facility.
- Maintain a length-to-width ratio of at least 3:1 (ideally 4:1 or 5:1) to avoid hydraulic short-circuiting.

iii) Depth Balance:

- Limit the maximum depth of the permanent pool to avoid stratification and anoxic conditions (not exceeding 2 m, ideally 1.2 m).
- Shallow water allows oxygen to reach the bottom for biodegradation but avoid very shallow depths prone to algal blooms.
- Greater depths near the outlet reduce sediment re-entrainment and yield cooler discharges.

iv) Temporary Storage:



Fig 19. Reference - Wetland, India

- Limit the depth of temporary storage above the permanent pool (0.5 m for small to medium ponds, more for larger systems with managed risks).

v) Aquatic Bench:

- Provide an aquatic bench extending inward from the pond edge (maximum depth of 0.4 m below normal water surface).
- Width varies based on pond size and vegetation needs for safety and aesthetics.

vi) Soil Amendment:

Amend soil before planting, especially in poor soils, to support vegetation without excessive nutrient additions.

vii) Embankment Design:

- Design embankments according to best practice and statutory requirements (Reservoir Act 1975, Flood and Water Management Act 2010).
- Consider safety, flood routing, and mitigating risks of embankment failure.

h. Safety Bench and Access:

- Ensure safety benches and maintenance access routes are positioned above the permanent pond level, with specific width and slope requirements, while maintaining safe side slopes between the aquatic area and safety bench.
- Establish suitable slopes and depths for ponds in dense urban environments, harmonizing with landscape aesthetics and wildlife requirements.



Fig 20. Reference - Embankment stabilization and restoration



Fig 21. Reference - Pond with baffles

c. Selection and Siting of Wetlands

- Ponds and wetlands are suitable for various types of new development and can be incorporated into residential and non-residential areas. They are also suitable for retrofitting if land is available near the drainage outlet.
- Wetlands can be designed as discreet features that blend naturally with the landscape, especially when upstream source control measures are effectively employed. Large open water bodies require careful consideration due to their scale.
- Ponds and wetlands can be seamlessly integrated into site contours and offer a range of design options that enhance urban settings.
- Its recommended to place these features where they are visible and valued, either within developments but not hidden, or in larger open spaces.
- Steeply sloping sites are challenging for pond placement, and unstable ground should be avoided. Ground stability should be verified by examining soil and groundwater conditions. Ponds should not be constructed on waste-fill, uncontrolled fill, or non-engineered materials.
- The soil beneath a wet pond should be impermeable to maintain water levels. In permeable areas, a liner like puddled clay is needed to prevent water loss. Evaluation should be based on soil investigations and permeability tests.
- Ponds can be used in contaminated areas if fully sealed to prevent water exchange with groundwater. Excavation or earthmoving should be carefully managed to prevent contamination mobilization.
- Hydraulic connectivity between pond water and groundwater should be avoided unless infiltration water quality requirements are met. Ensure the outfall operates effectively at the annual maximum water table level, with the groundwater level always below the temporary detention zone.
- Ponds and wetlands are not suitable for managing construction site runoff or during the construction phase when sediment levels are high.

d. Treatment Design

- Ponds and wetlands do not significantly reduce contaminant load through volumetric runoff control, mainly due to their limited ability to intercept runoff.
- These features treat incoming runoff primarily by settling out silts and suspended sediments, and by biological processes that uptake nutrients.
- Aquatic vegetation along the shoreline supports microbial activity that consumes dissolved pollutants.
- The effectiveness of a pond's treatment is primarily determined by the volume of its permanent pool. Research suggests that ponds larger than 2 times the mean annual storm volume do not notably enhance treatment.
- Smaller ponds may suffice when placed downstream of sediment removal systems like permeable pavements or bio retention systems, depending on the effectiveness of the upstream components.
- Larger ponds do not necessarily provide better treatment and should not directly receive contaminated runoff to avoid performance failure and increased maintenance.
- Wet pond systems work best when water flows through them in a continuous wave (plug flow), maximizing hydraulic retention time and sediment settlement. Treatment efficiency improves with multiple treatment cells, longer flow paths, and complex micro topography.
- To prevent sediment erosion during storms, ponds require a permanent structure like an impermeable liner to retain their functionality.

- Deeper ponds (>1.5 m) may require recirculation systems like fountains or aerators in summer to prevent stagnation and low oxygen conditions.
- Planting trees on the west and south sides of ponds (away from embankments) can reduce thermal heating in urban areas and deter waterfowl, which can cause phosphorus enrichment.
- Trees should be set back to prevent overhanging branches.

e. Amenity Design

- Pond and wetland design should enhance local community amenities and be suitable in scale and appearance for the surrounding landscape. In green spaces, they should blend naturally, while in urban areas, more structured edges may be appropriate, considering wildlife access.
- The design's amenity value depends on inflow contamination levels; higher contamination may limit amenity potential. Ponds can serve as educational resources and recreational focal points for schools and community groups.
- Collaboration among engineers, hydrologists, ecologists, and landscape architects is essential for effective pond design, considering local landscape, environmental factors, community needs, and biodiversity goals.
- High fencing isolates ponds, reducing amenity benefits and possibly increasing safety risks.
- Toddler-proof fencing can be combined with landscaping to manage public access and wildlife movement.
- Access to shallow areas with wetland vegetation can make ponds more accessible without compromising safety. If fences are necessary, they should be set back from the pond's edge to avoid negative perceptions.
- Picnic areas and walking trails around ponds can be integrated into the design for community enjoyment. Clusters of trees and shrubs are preferable for visual aesthetics, placed away from the water's edge to prevent shading and debris in the water.
- Safety measures are crucial; access to spillways and steep drops should be restricted. Fishing in large ponds should be considered carefully, with appropriate signage to manage risks.
- Interpretation boards can educate the public about pond functions, local flora, and fauna.

f. Biodiversity Design

- Ponds and wetlands should ideally be situated within or near natural, less intensively managed landscapes to benefit from native species and ecological connectivity. The surrounding habitat should offer diverse approaches to water, catering to different species' preferences.
- Ponds should vary in depth to create different habitats, including deep areas (around 1 meter) for wildlife refuge during harsh winters.
- Encouraging a mix of marginal plants rather than single-species stands enhances habitat diversity.
- Avoid placing ponds near artificial light sources to preserve their value for foraging bats. Minimize new lighting installations near ponds.
- Design ponds to prevent the introduction of fish and wildfowl if the goal is to support amphibians like great crested newts.
- To deter wildfowl in nutrient-sensitive areas, consider dense planting on slopes. Conversely, if wildfowl use is desired, integrate bird-friendly "bays" into larger pond designs, keeping breeding islands at least 3 meters from pond edges to deter foxes.
- Enhance pond ecology through a two-phase approach: Phase 1 establishes basic structure, followed by Phase 2

refinement (1-2 years later) to fine-tune the design. This includes adjusting pond margins for seasonal water level variations and utilizing unplanned habitats like runoff areas and natural seepages.

- Create small pools around larger ponds fed by clean runoff from nearby grassland, scrub, or woodland to enhance ecological diversity. These pools should be above the main BGI pond level, allowing a broader range of plants and animals to thrive.
- Contaminated systems can support diverse wildlife in shallow water and wetland areas less affected by pollutants compared to submerged plants and permanent aquatic species.
- Additional guidance on maximizing BGI ecological benefits can be found in relevant literature.

g. Physical Specifications

i) Pre treatment and Inlets:

- Ideally, limit inlets to one per feature and maximize flow path length from inlet to outlet for effective treatment.
- Implement pre treatment for all inlets using source control measures and upstream BGI components to remove sediment and ensure cleaner water in the main pool.
- For sites with sediment risks, consider a sediment forbays to allow heavier sediments to settle out before entering the main system.
- Sediment forbays should comprise at least 10% of the total basin area, designed to monitor sediment buildup and concentrate removal activities.
- Use structures like earth berms, gabions, or rip-rap to create sedimentation bays for efficient sediment management.
- Install sediment depth markers in forbays with high sediment loads to track sediment deposition for future maintenance planning.
- Reinforce forbays bases for easier sediment removal operations, especially if using a membrane liner.
- Dissipate incoming flow energy to minimize scouring and prevent disturbance to the permanent pool volume.
- Use rip-rap or submerged inlet pipes to stabilize inflow channels and protect against erosion.
- Ensure inlet infrastructure is designed to avoid the need for safety grilles, which can increase blockage risks and hazards.
- Implement upstream bypass structures to divert untreated events and optimize contaminant removal processes.



Fig 22. Reference - Energy dissipating inlet channels for ponds

ii) Outlets:

- Outlets require flow control systems, typically accommodated by manhole-type outlet structures with variable flow rate controls and emergency overflow provisions.
- Use protected orifices for low flow controls, combined with overflow channels or culverts for larger events.
- Multiple orifices or pipe outlets can achieve the desired flow control objectives.
- Avoid using trash screens unless necessary to prevent access into pipework, ensuring they do not obstruct flow rates excessively.
- Discuss the design of exceedance flow management components to handle higher flow events effectively.
- Design outlet areas to be the deepest point for final settling and to prevent sediment resuspension.
- Implement energy dissipation downstream of outlets to prevent scouring and erosion, depending on discharge rates and watercourse vulnerability.
- Provide seepage control collars for outlet pipes through embankments to manage seepage effectively.

h. Materials

i) Pond/Wetland Liner Materials

- Pond liners can be made from various materials, including geosynthetic clay liners (GCLs) and geomembrane liners like butyl.
- Consider benching to prevent layers of saturated subsoil from slipping off the liner; alternatively, soil containment systems can be used.
- GCLs are less prone to stability issues due to their sandwich structure of bentonite between geotextiles, but stability of overlying soil layers should still be assessed.
- Geomembrane liners, such as butyl, should be protected with geo-textile fleece layers to prevent damage and ensure longevity.
- Clay liners should be protected from drying out to maintain impermeability.
- The thickness of compacted clay required for impermeability should be at least 500 mm, ideally 1 meter.
- The minimum permeability of compacted clay should be $1 \cdot 10^{-9}$ m/s to ensure effective barrier properties.

ii) Embankment fill material

- Use inert natural soils for embankment fill material to avoid leaching contaminants into stored runoff.
- Design embankments to ensure stability and watertightness, following detailed guidance provided in resources like Kennard et al. (1996).

h. Landscaping

- In natural landscapes, ponds should mimic organic forms with curved boundaries and undulating margins. In urban areas, a more linear and functional structure is often appropriate.
- Vegetation plays a crucial role in pond design by enhancing appearance, stabilizing side slopes, preventing erosion, providing wildlife habitat, and concealing debris temporarily.
- Aquatic vegetation assists in nutrient uptake, stabilizes sediments, and enhances sediment settling effectiveness during heavy storms by slowing flows across the pond.
- Vegetated aquatic benches can prevent children from entering open-water areas and discourage geese from using adjacent grassed areas. Open areas should be maintained for wildlife access.
- Incorporating Wetland Plants
- Wetland plants should be encouraged along aquatic

benches, safety benches, side slopes, and within shallow areas of the pond, ideally within 150 mm of the normal water level.

- Avoid dense initial planting to allow natural colonization by local species, maximizing ecological value. Mono cultures should be avoided in favor of diverse plant populations tolerant of fluctuating water levels.
- Plant Selection and Timing
- Develop a plant list comprising species found within 30 km of the site, considering design and landscape objectives.
- Wetland planting density ranges from 4 to 8 plants per square meter. Planting should occur between early April and mid-June to establish root reserves before winter.
- Compacted soils around pond buffers may hinder root penetration and require deep, uncompensated topsoil backfill for planting sites.
- If subsoils lack nutrients, add topsoil or wetland mulch to planting areas while controlling ongoing nutrient loadings to the water body.

The above information is sourced from "SUDS Manual"



Fig 23. Reference - Landscaping near wetlands



Fig 24. Reference - Landscaping near wetlands

B.4. Detailed Notes on Planting

B.4.1. Construction Tree Protection

1. General considerations

- Existing trees and vegetation must be accurately depicted on plans, including canopy size and trunk diameter.
- Preservation of healthy existing trees is prioritized, following specific construction tree protection guidelines.

a. Critical Root Zone (CRZ) and Prohibited Root Zone (PRZ):

- Designers must identify and establish the CRZ and PRZ for trees near construction zones to determine permissible activities.
- The critical root zone (CRZ) shall be a zone surrounding a tree equal to one (1) foot in radius for each one (1) inch DBH of the tree to be protected.
- Excavation within the CRZ by mechanical means is prohibited; all excavation shall be performed with hand tools and care taken to disturb as little of the existing root formations as possible.
- The CRZ shall be delineated using tree protection fencing. Tree protection fencing shall be as indicated on the Drawings.
- If no tree protection fencing is identified on the Drawings, the tree protection fencing shall be as depicted in the Erosion and Sediment Control Detail attached to these Specifications.
- The prohibited root zone (PRZ) shall be a zone surrounding a tree equal to one-half (1/2) foot in radius for each one (1) inch DBH of the tree to be protected.
- Excavation within the PRZ is prohibited, unless specifically authorized by the City/ Project Arborist.
- In no instance shall excavation within six (6) feet of the base of a tree be authorized.
- Tree replacement or equivalent compensation may be required for any extensive root system damage caused by construction activities.
- Trees with a DBH (Diameter at Breast Height) of 12 inches or less are exempt from CRZ consideration but require protection of the PRZ.

b. Tree Protection Zone (TPZ):

- The tree protection zone (TPZ) refers to the arborist defined area surrounding the trunk intended to protect the roots and soil to ensure future tree health and stability.
- The TPZ is comprised of tree protection fencing using the dimension of the CRZ, unless otherwise authorized by PWD or the PP&R Arborist.
- The tree protection zone (TPZ) refers to the arborist defined area surrounding the trunk intended to protect the roots and soil to ensure future tree health and stability. The TPZ is comprised of tree protection fencing using the dimension of the CRZ, unless otherwise authorized by PP&R Arborist.

c. Diameter at Breast Height (DBH):

- The diameter at breast height (DBH) refers to the diameter of the tree trunk at 1.3m (4 1/2 ') from ground surface.
- This is a standard measurement used by tree professionals.

d. Root buffer zone (RBP):

- For access roads that must go through the CRZ, a temporary protective root buffer is required.
- The temporary protective root buffer shall consist of shredded wood chips spread on a non woven geo-textile drainage fabric over the roots of 152 mm depth and covered by 19mm plywood.

- Wood chips shall be 50mm unpainted, untreated shredded wood or approved material.

e. Tree Protection fencing:

- If clustering of trees are within or adjacent to the LOD, then the TPZ should be established around all the trees
- Such things as limits of excavation, staging of materials and access construction entrance should also be considered when determining the extents of tree protection fencing for the TPZ

f. Permission and Additional Protection:

- Permission from relevant authorities and landowners is required if disturbing trees within the TPZ.
- Additional protections like mulch layer and planking may be necessary within the Critical Root Zone (CRZ).

The above information is sourced from "GSI - Landscape design guidebook"

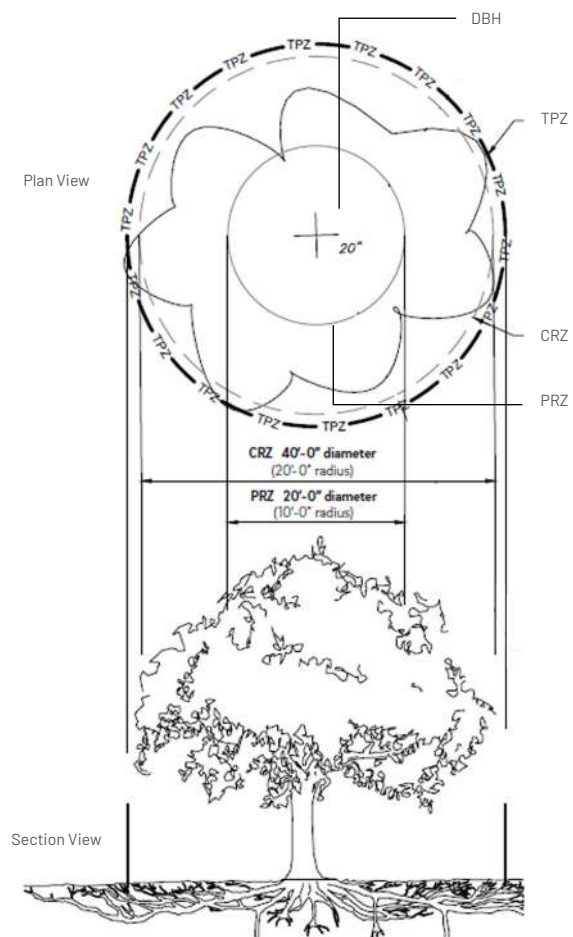


Fig 25. Typical construction tree protection

B.4.2. Hydrology of Trees

a. Infiltration Opportunity and testing

i) Tree Pit Infiltration Testing

- In city center environments, tree pits may offer infiltration opportunities.
- Conducting infiltration testing is advisable to confirm likely rates.

ii) Subsoil Saturation and Geotechnical Considerations

- When using structural soil or tree pits for storing surface water runoff, subsoil saturation can occur, potentially reducing soil strength.
- Consult a geotechnical engineer to assess if a separation geotextile or geomembrane is needed.

iii) Rapid Lateral Flow and Design Implications:

- Lateral flow through structural soils can be rapid.
- If surrounding areas are impermeable, overflow and under drain outlets are necessary to prevent ponding and manage flood risks effectively.

b. Tree Systems and Interception Design

i) Integrated Tree Systems for Runoff Control

- Integrated tree systems are more effective than individual trees in controlling surface water runoff due to their greater capacity, flexibility, and ability to utilize exceedance flows effectively.

ii) Interception by Tree Canopies

- Interception by tree canopies varies with tree type and increases over the tree's lifespan.
- Initial interception may be negligible but will benefit hydraulic design in the long term by reducing runoff.

c. Peak Flow and Volume Control Design

i) Storage Volume Calculation

- Tree pit attenuation storage is calculated based on the volume of the tree pit multiplied by the void ratio in the soil or aggregate layer designed for storage

ii) Flow Control and Drainage Requirements

- A flow control structure is needed to constrain water discharge rates from the tree pit, ensuring healthy tree growth and proper drainage within 48 hours.

iii) Volume Control Assessment:

- Evaluate the contribution of tree pit systems to volume control using standard methods, considering expected infiltration rates, attenuation storage, and specified flow controls.

d. Exceedance Flow Management

i) Exceedance Flow Routes

- Install overflow pipes or use overland flow routing for rainfall events that exceed tree pit design capacity.

ii) Hydraulic Capacity Assessment

- Confirm overflow capacity using hydraulic assessment methods like weirs, orifices, and pipe flow analysis to manage exceedance flows effectively

B.4.3. Guidance on Tree Plantations

- Trees contribute to effective surface water management by reducing runoff volumes through transpiration and interception of rainfall.
- Trees enhance the urban landscape, improving community well-being, and increasing property values.
- Trees moderate the local climate, keeping areas cooler in summer and warmer in winter, which reduces building energy consumption.
- Trees filter harmful pollutants from the air and help reduce noise pollution.
- Trees create vital habitats for wildlife, supporting a diverse range of species within urban areas.
- Trees can be used to slow down vehicles and enhance road safety.
- Trees provide a food source and absorb atmospheric carbon dioxide, contributing to carbon sequestration.
- Trees draw water from the soil and release it through evaporation from their leaves, reducing runoff volumes.
- Tree surfaces intercept and absorb rainfall, delaying runoff onset and reducing its volume.
- Tree roots enhance soil infiltration capacity, reducing runoff.
- Trees can uptake and transform harmful chemicals from the soil, improving water quality.
- Tree Integration in SuDS Components
- Trees can be integrated into infiltration SuDS components like bio retention systems and swales to improve their effectiveness in managing surface water.
- Standalone Features:
- Trees can be used independently in soil-filled tree pits or planters to collect and attenuate runoff and filter pollutants.

a. Design Considerations

i) Tree Suitability for Managing Surface Water Runoff

- Trees are suitable for managing surface water runoff from small local areas, like those draining to a single road gully.
- Trees need adequate space, appropriate soil conditions, good gas exchange, drainage, and a reliable water supply.
- Soil properties and volume are critical for successful tree growth in urban areas and effective runoff management.

ii) Tree pit and Planter design considerations

- Tree pits or planters should provide sufficient soil volume for roots to grow without inhibiting tree development.
- Soil porosity, permeability, and infiltration rate are crucial factors for root health and water availability.
- It's essential to balance water availability for trees to prevent soil saturation and promote healthy root growth.
- Water storage should be below the root able soil volume most of the time, with occasional root inundation considered.
- Trees require significant water supply, especially large mature trees during dry periods.
- Designing the runoff area to provide adequate water for tree growth throughout the seasons is crucial.

iii) Designing for Mature Tree Growth

- Design tree planting zones to support the growth of mature, large species trees that can effectively manage runoff.
- Adequate soil volume and above-ground space are essential for large tree growth and longevity the time, with occasional root inundation considered.
- Trees require significant water supply, especially large mature trees during dry periods.

iv) Urban Environment Challenges and Solutions

- Consider tree rooting characteristics to ensure stability and viability in urban settings, where soil compaction and limited air/water access are common challenges.
- Use engineering structures to expand the rooting environment beneath paved surfaces, minimizing soil compaction and promoting root health.

v) Infiltration and Groundwater Considerations

- Determine the suitability of tree pit infiltration following specific guidelines to ensure stability and protect groundwater levels.
- Ensure that groundwater remains at least 1 meter below the lowest point of the tree pit to facilitate safe infiltration.

vi) Structural Growing Media

Structural growing media are soil-and-gravel mixes designed to support tree growth and serve as a sub-base for pavements. pH levels influenced by aggregate type in the mix; tree species should match the pH of the growing environment.

1. Sand-based Substrates (Tree Soils):

- Predominantly medium to coarse sand blended with green compost and clay for water and nutrient retention.
- Suitable for pedestrian areas and cycle tracks due to limited compaction requirements.

2. Medium-sized Aggregate Substrates:

- Mix of angular aggregate and soil to support vehicle loads without compacting tree soil.
- Used in lightly trafficked areas like car parks.

3. Stone Skeleton Substrates (Stockholm System):

- Utilizes larger aggregate particles compacted with soil to support heavier traffic loads like buses and HGV.

vii) Modular Structures

Cuboid structures (crate systems) that support pavement loads and prevent substrate compaction

1. Plastic, Concrete, or Steel Structures:

- Provide guaranteed soil volume for roots, additional water runoff storage, and prevent soil compaction.

2. Load-bearing Capacity:

- Depends on material; provides a greater root able volume compared to aggregate-based systems.

viii) Raft Systems

Planar structural layers distributing wheel and other loads to prevent soil damage and absorb compaction pressures.

1. Cellular Confinement Systems (Geocells):

- Honeycomb-shaped cells filled with coarse aggregate for air and water exchange

2. Geocellular Sub-base Replacement Systems:

- Units filled with soil to support traffic loads, used under highways subject to approval.

ix) Tree Planters

Bio retention systems with trees to enhance capacity, amenity, and biodiversity benefits; Impermeable geomembrane liners and drainage systems to prevent water logging in sensitive areas. Ensure sight lines are maintained; protective grilles should minimize damage from transient loadings.



Fig 26. Reference - Tree Planter, Western Harbour, Malmö, Sweden



Fig 27. Reference - The use of structural growing media in retrofitting



Fig 28. Reference - Geocellular systems for trees

b. Selection and siting of trees

i) Site specific selection

- Trees should be chosen based on site-specific constraints and opportunities to achieve hydraulic, water quality, amenity, and biodiversity objectives.
- Considerations include likely runoff characteristics, soil type, and location characteristics.
- Landscape architects can advise on suitable tree species based on these factors.

ii) Characteristics for Effective Runoff Reduction and Pollutant

Filtration:

- Trees with the following characteristics tend to be more effective:
- Wide spreading and dense canopies
- Long life expectancies
- Fast growth rates
- High tolerance to summer drought
- Tolerance of saturated soils
- Resistance to urban air and water pollutants
- Extensive root systems
- Rough bark
- To mentose or dull foliage surface
- Vertical branching structures

iii) Tree pit Placement

- Tree pits should be located at a safe distance from buried utility services (electric cables, water pipes) to avoid damage.
- Root barriers can be installed around the root-able soil volume to minimize damage to utilities.
- Underground utilities can be placed around tree pits, geocellular crate systems, and suspended pavement systems, but protection from water and root penetration is essential

c. Treatment Design

- Tree pits effectively filter pollutants from runoff and reduce overall pollutant loadings to receiving surface waters.
- Effective pollutant removal is required for all runoff events, including those occurring up to once a year (1:1 year event).
- Tree soils can be designed similarly to bio retention systems to achieve pollutant removal.
- Trees can remove a wide range of pollutants from soil, including metals, pesticides, organic compounds, nitrogen, and phosphorus.
- Trees with oxygen-rich rhizosphere can quickly take up excess nitrogen and phosphorus from soils.
- Hydrocarbons are trapped and degraded in the upper soil layers, particularly when exposed to sunlight.
- Engineered soil depths suitable for tree growth have demonstrated efficient removal (70-85%) of heavy metal loadings.
- The acceptability of allowing infiltration from tree pits depends on the extent of runoff contamination and the soil's capability to filter pollutants.
- Design considerations should align with bio retention system standards to ensure effective pollutant removal.

d. Amenity Design

- Tree planting should be planned and designed strategically to maximize amenity benefits, integrating with landscape and built environment delivery.
- Trees should be selected and planted to achieve surface water management objectives while enhancing the urban environment visually and seasonally.

- Implementing trees for surface water management should align with green street and green infrastructure strategies, transport strategies (walking, cycling, highways), and overall urban design.
- Canopy size and tree growth rate significantly influence cooling performance.
- Setting canopy cover targets and ensuring non-compacted rooting environments with sufficient size are key to achieving and sustaining desired canopy cover.
- Trees placed strategically to directly shade buildings (shade-effect trees) can reduce summertime energy demand for cooling.
- Careful placement is needed to avoid blocking warm radiation during winter while shading sun-exposed walls in summer, ideally along west-facing sides.
- Climate-effect trees influence local micro climates through evapotranspiration, leading to energy savings on air-conditioning in summer.
- Evergreen species can also reduce heat loss from buildings in winter by reducing wind speed and air infiltration.

e. Biodiversity Design

- Trees are essential for enhancing urban wildlife by providing food, shelter, and habitat for birds, invertebrates, and other species.
- Tree selection and species mix influence habitat diversity, but canopy volume is the key predictor of species use, as most animals require a minimum amount of canopy for survival.
- Optimizing tree location and planting patterns to increase habitat connectivity between vegetated areas.
- Creating several layers by incorporating shrubs, smaller trees, and ground cover within tree planting to enhance habitat diversity.
- Selecting nectar and fruit trees while considering issues like fruit dropping and species suitability for hard-surfaced areas.
- Native species are particularly effective in supporting urban wildlife.
- Building ecological resilience to diseases and climate change requires a diverse local tree population, incorporating both native and non-native species suitable for various urban settings.

f. Physical specifications

i) Specifications for tree structures

- Ensure effective water drainage to prevent water logging around tree roots.
- Prevent compaction of soils around tree roots.
- Specify suitable soil for healthy tree growth.
- Determine appropriate volume of tree pit/soil based on tree size and species.

ii) Soil volumes

- Trees require large soil volumes to grow and remain healthy.
- The recommended soil volume can be calculated based on tree canopy area.
- Research suggests minimum soil volumes based on tree trunk diameter.

iii) Pretreatment and Inlets

- Runoff can be introduced to tree pits or soil using various methods such as conveyance channels or sloped impermeable surfaces.

iv) Outlets

- Ensure tree pits are well drained.
- If infiltration is not possible, outlets to the surface water drainage system are required.
- Outlets should maintain the desired maximum water level and may use perforated pipes or Geo composites

v) Water mitigation considerations

- Prevent water from infiltrating adjacent sub-base construction below pavements to avoid risks.
- Use Geo membranes if necessary to prevent unwanted water migration.

g. Materials

i) Structural Growing Media Specifications

- Specifications should consider local climate and tree species.
- Seek guidance from arboriculturists or horticulturists when using proprietary products.
- Follow manufacturer recommendations for optimal results.

ii) Soil Requirements for Modular and Raft Systems

- Soil texture should be homogeneous throughout the profile.
- Well-graded soil with appropriate humus content (about 5%).
- Permeability should be suitable for effective drainage and water treatment (typically 100-300 mm/h)

iii) Tree soil characteristics

- Tree soils should not be overly compacted (75 to 80% of maximum dry density)

iv) Key Characteristics of Structural Growing Media

- Should maintain water-holding, drainage, structural, and load-bearing qualities.
- Capable of supporting plant growth even when compacted to 95% Proctor density.
- Performance should be demonstrated through field trials.

v) Influence of Stone Type on pH

- Stone type (limestone, granite, lava rock, etc.) Affects soil and soil water pH.
- Concrete products can raise pH over time due to deterioration

vi) Quality Assurance and Testing

- Soils used in tree pits and structural soils should undergo testing and approval as part of a quality assurance program

h. Landscape designing and planting

- Trees in surface water management should be fully integrated into the landscape and architectural design of new developments.
- Integration ensures that tree benefits are maximized and that trees enhance overall building and landscape performance.
- A landscape designer should guide decisions related to tree size, species, characteristics, and planting locations.
- Advice from an arboriculturist may be necessary to ensure proper tree selection and management based on site-specific needs and conditions.



Fig 29. Reference - Popular benches around trees



Fig 30. Reference - Popular benches around trees



Fig 31Reference - Inlets to allow surface water runoff to infiltrate into tree pits

The above information is sourced from "SUDS Manual"

B.4.4. Invasive species

Table.5. List of Invasive species for Removal

Trees	Shrubs	Herbs	Grass	Climber	Aquatic
Acacia mearnsii	Cestrum aurantiacum	Ageratina adenophor	Imperata cylindrica,	Antigonon leptopus	Eichhornia crassipes
Gliricidia Sepium	Chromolaena odorata	Ageratum conyzoides,	Parthenium hysterophorus	Basella alba,	Pistia stratiotes L.
Leucaena leucocephala	Cytisus scoparius	Ageratum houstonianum		Ipomoea asarifolia,	Pontederia crassipes Mart.
Muntingia calabura	Eupatorium adenophorum	Alternanthera philoxeroides		Ipomea carnea	
Senna spectabilis	Lantana Camara	Hyptis suaveolens,		Mikania micrantha,	
	Mimosa invisa	Tagetes minuta			
	Rubus ellipticus,				
	Rubus niveus				
	Solanum mauritianum				
	Ulex europaeus				



Alternanthera philoxeroides



Eichhornia crassipes



Ipomoea asarifolia



Lantana camara



Parthenium hysterophorus



Prosopis juliflora

B.4.5. Notes on Plant selection Criteria

These are the points to be considered while selecting plants

a. Regional Climate

- Local conditions can significantly differ, particularly in urban settings, with the climate of Chennai adding another layer of consideration.
- As the project progresses, it's essential to adapt to these site-specific factors, acknowledging that over time, the suitability of plant species may shift, with a potential inclination towards species better adapted to the southern climate of Chennai.

i) Natives

- When choosing plants, it's beneficial to opt for native species that naturally thrive in the local area, although they may not always be suitable for every urban situation due to specific site conditions or design strategies.
- However, they should be prioritized where suitable to foster favorable conditions for local wildlife. Consulting local nurseries can provide valuable assistance in challenging

scenarios by offering specialized knowledge of indigenous plant species.

ii) Locally Sourced

- Choosing plants that are sourced locally increases the likelihood of their successful adaptation to the regional conditions.
- Check **"Table 2: List of Plant Nurseries"** for a directory of nearby plant nurseries.

Table. 6. List of Nurseries

Sl.no	Name	Contact. No	Location	Address	Type of plants
1	13 Degree North	+91 9940450763	Chennai	Sparkling Sands Ave, Akkarai, Injambakkam, Chennai, Tamil Nadu 600119	Native plants
2	Azagu Nursery	+91 9498313159	Chennai	No. 2 Kovalam street VGP Layout Uthandi, Chennai - 600119	Native plants
3	Garden pro landscape	+91 9345930012	Chennai	7, Madanagopal St, Abiramapuram, Chennai, Tamil Nadu 600018	Native plants
4	Green shack aquascapes	+91 7760460770	Chennai	No.27 Sankalp nrusimha flat no003, ground floor 3rd cross, 7th Main Rd, Srirampura, Bengaluru, Karnataka 560021	Native plants
5	Auroville Botanical Gardens	+91 9626008428	Pondicherry	Auroville, Tamil nadu - 605101	Native plants
6	Arulagam Nursery	+91 9843211772	Coimbatore	Poonthalir Nursery Garden, Sathy Road, Ellappalayam P.O Coimbatore - 641697Tamil Nadu, India	Native plants
7	Chennai Plant Nursery	+91 73972 26937	Chennai	4/2, Anand Garden, 100Ft Road, Velachery, Chennai 600042 222/9, Medavakkam main Rd, Medavakkam, Chennai 600117.	Native plants
8	Green Madurai nursery	+91 93441 03364	Madurai	Alagar Kovil Main Rd, Kadachanendhal, Tamil Nadu 625301	Native plants
9	Star Bio Plants Nursery (Sri Satyanarayana nursery)	+91 93939 11188	Rajmundry	Near Dosalamma Temple, Kadiyapulanka, Mandalam, Kadiam, Andhra Pradesh 533126	Native plants
10	Kadiyam Nursery	+91 7397226937	Rajamahendravaram	Kadiyam, High School Rd, Rajamahendravaram, Andhra Pradesh 533126	Native plants

b. Tree Selection Criteria

- The criteria for selecting trees primarily focuses on site conditions and issues relevant to BGI, with consideration given to a tree's maximum height and width to determine its suitability for a given space.
- To enhance resilience against tree pests and diseases, the aim to diversify tree species within project areas, while maintaining visual consistency by grouping trees in blocks of 2-4 of the same species or alternating species with similar growth habits.
- Additionally, consideration of foliage and bloom textures and colors by month can enhance site aesthetics. Specific planting restrictions for certain species must be followed, with substitutes required for fall-dig hazard trees listed on design plans.
- Landscape-only trees are permissible for rain gardens and off-street projects but not in the right-of-way to preserve sightlines.
- Consideration should also be given to the type of system and the tree's location within it (e.g., entrance, lower, or upper zones, or as a street tree in a tree trench).

c. Shrub, Herb, Groundcover Selection Criteria

- The criteria for selecting shrubs, grasses, and flowering herbaceous species is primarily determined by site conditions and considerations relevant to BGI.
- Factors such as sunlight requirements, maximum plant size, and hydrologic needs are essential in assessing the suitability of a species for a particular area, with additional criteria possibly becoming relevant depending on the site.
- Generally, shrubs can be used alongside trees to provide year-round structure, particularly along edges for delineating maintenance borders or step-downs from sidewalks.
- Grasses and flowering herbaceous species are typically employed to offer robust coverage and stabilization within a system.
- Other secondary design considerations may include seasonal interest through colors, textures, heights, or enhancing wildlife habitat.

Table. 7. Plant selection Legend

Sl.no	Symbol	Elaboration
1	N	Native Plants
2	D	Drought Tolerant
3	F	Flood Resistance
4	SOR	Schedule of Rates
5	I	Irrigation
		Low
		Medium
		High
6	E	Exposure
		Shade
		Partial Sun
		Sun
7	M	Maintainence
		Low
		Medium
		High

B.4.6. Plant list based on Plant mixes



Buffer Mix

Habit	Botanical Name	Common Name	Height	Spread	N	D	F	SOR	I	E	M
TREE	<i>Pongamia pinnata</i>	Pungam Tree	25	15	✓	✓	✓	✓			
	<i>Polyalthia longifolia</i>	False Asoka	10-25	2.4	✓	✓					
SHRUB	<i>Lawsonia inermis</i>	Henna	2-6	2-6	✓	✓					
	<i>Murraya paniculata</i>	Orange Jasmine	2-7	3	✓	✓		✓			
GROUND COVER	<i>Cuphea hyssopifolia</i>	Mexican heather	0.6	0.9		✓					
CLIMBER	<i>Passiflora edulis</i>	Passion Flower	8	-		✓	✓	✓			

Notes

The mix consist of trees, layers of shrubs & climber along the compound wall.

Soil - The top soil needs to be ploughed well and the cleared soil shall be treated suitably with farmyard manure or vermicompost.

Legend

N - Native
D - Drought Tolerant
F - Flood Resistance
SOR - Schedule of Rates
I - Irrigation
E - Exposure
M - Maintenance

Low Medium High
 Shade Partial Sun Sun
 Low Medium High



Pongamia pinnata



Polyalthia longifolia



Lawsonia inermis



Murraya paniculata



Cuphea hyssopifolia



Passiflora edulis



Pathway Mix

Habit	Botanical Name	Common Name	Height	Spread	N	D	F	SOR	I	E	M
TREE	<i>Azadirachta indica</i>	Neem Tree	30	20	✓	✓		✓	Low	Partial Sun	Low
SHRUB	<i>Alpinia purpurata</i>	Red Ginger	2-4	1			✓		Medium	Partial Sun	Medium
HERB	<i>Mimosa pudica</i>	Shame Plant	0.15-1	0.5-0.5		✓	✓	✓	Low	Partial Sun	Low

Notes

The mix consist of shaded giving avenue trees with aesthtically pleasing shrubs and ground cover.

Soil - The top soil needs to be ploughed well and the cleared soil shall be treated suitably with farmyard manure or vermicompost.

Legend

N - Native
D - Drought Tolerant
F - Flood Resistance
SOR - Schedule of Rates
I - Irrigation
E - Exposure
M - Maintenance



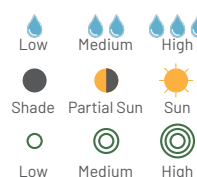
Azadirachta indica



Alpinia purpurata



Tradescantia spathacea



Lawn Mix

Habit	Botanical Name	Common Name	Height	SPREAD	N	D	F	SOR	I	E	M
TREE	<i>Butea monosperma</i>	Palash	5-15	9-12	✓	✓		✓	Low	Partial Sun	Low
GRASS	<i>Bouteloua dactyloides</i>	Buffalo grass	0.15-0.3	0.15-0.45		✓	✓		Medium	Partial Sun	Low
GROUND COVER	<i>Cynodon dactylon</i>	Durva	0.15	0.05-0.15	✓	✓	✓	✓	Medium	Partial Sun	High

Notes

The mix consist of grasses & herbs that are smaller than 300mm alongwith a deciduous tree that provides shade within the vast open space creating a habitat for perching birds.

Soil - The top soil needs to be ploughed well and the cleared soil shall be treated suitably with farmyard manure or vermicompost.

Legend

N - Native
D - Drought Tolerant
F - Flood Resistance
SOR - Schedule of Rates
I - Irrigation
E - Exposure
M - Maintenance



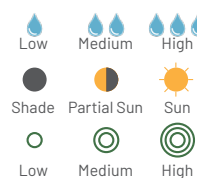
Butea monosperma



Bouteloua dactyloides



Cynodon dactylon





Grove Mix

Habit	Botanical Name	Common Name	Height	Spread	N	D	F	SOR	I	E	M
TREE	<i>Ficus hispida</i>	Peyatti, Gobla	15	12	✓	✓	✓				
	<i>Lannea coramandelica</i>	Indian Ash Tree	8-20	8-10	✓	✓	✓				
	<i>Neolamatkia cadamba</i>	Kadamba Tree	45	20-25	✓	✓	✓				
SHRUB	<i>Dodonea viscosa</i>	Hopbush	1-3	1.5-4.5		✓	✓				
	<i>Tabernaemontana s.</i>	Jasmine	1.5-1.8	1-1.8	✓	✓	✓	✓			
	<i>Senna auriculata</i>	Tanner's Cassia	1-1.5	0.5	✓	✓	✓				
HERB	<i>Ocimum sanctum</i>	Holy Basil	0.3-0.6	0.3-0.6	✓	✓	✓	✓			
	<i>Tradescantia spathacea</i>	Rhoeo	0.3	0.3	✓	✓	✓				

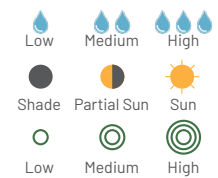
Notes

The mix consist of different layers of vegetation planted in ecocline to create hierarchy & diversity. It would create an ecosystem that will support the biodiversity & the landscape systems.

Soil - Soil mix should contain red soil, manure and sand. Top Soil needs to be added with manure. For tree planting, root ball needs to be treated with Azospirillum, a biofertilizer for growth enhancement, before planting. Cocopeat or any other dry manures can be mixed with loose soil to fill the pits; fresh manures have to be avoided. The topsoil layer need not be levelled evenly, the uneven terrain shall facilitate forest growth.

Legend

N - Native
D - Drought Tolerant
F - Flood Resistance
SOR - Schedule of Rates
I - Irrigation
E - Exposure
M - Maintenance



Ficus hispida



Neolamatkia cadamba



Lannea coramandelica



Dodonea viscosa



Tabernaemontana s.



Ocimum sanctum



Senna auriculata



Mimosa pudica



Pollinator Mix

HABIT	BOTANICAL NAME	COMMON NAME	HEIGHT	SPREAD	N	D	F	SOR	I	E	M
TREE	<i>Bahunia purpurea</i>	Butterfly Tree	4-7	5-7	✓	✓	✓	✓			
SHRUBS	<i>Hibiscus tiliaceus</i>	Hibiscus	4-10	3-5	✓	✓	✓	✓			
	<i>Barleria cristata</i>	Philippine violet	1-3	1-2	✓	✓					
	<i>Jasminum sambac</i>	Arabian jasmine	0.6-3	0.3	✓		✓				
	<i>Vitex negundo</i>	Chinese chaste Tree	2	2	✓	✓					
GROUNDCOVER	<i>Vinca rosea</i>	Periwinkle	0.15-0.6	0.2		✓					

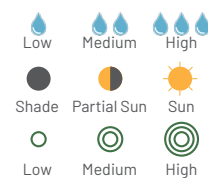
Notes

The mix consist of flowering colourful & fragrant species that will attract pollinators like butterflies, bees & birds.

Soil - It needs well drained sandy loamy soil. The top soil needs to be ploughed well and the cleared soil shall be treated suitably with farmyard manure or vermicompost. Otherwise, the soil shall be treated with Gypsum (Calcium Sulphate) to enhance the fertility.

Legend

N - Native
D - Drought Tolerant
F - Flood Resistance
SOR - Schedule of Rates
I - Irrigation
E - Exposure
M - Maintenance



Bahunia purpurea



Hibiscus tiliaceus



Barleria cristata



Jasminum sambac



Vitex negundo



Vinca rosea



Bioswales Mix

ZONE	HABIT	BOTANICAL NAME	COMMON NAME	HEIGHT	SPREAD	N	D	F	SOR	I	E	M
ZONE A	GRASS	<i>Vetiver zezaniodes</i>	Khus	1-2	0.5-1	✓	✓	✓	✓			
		<i>Acorus calamus</i>	Sweet Flag	0.6-0.9	0.4-0.6	✓		✓				
	HERB	<i>Ocimum sanctum</i>	Holy Basil	0.3-0.6	0.3-0.6	✓	✓	✓				
ZONE C	GROUND COVER	<i>Cynodon dactylon</i>	Durva	0.15	0.05-0.15	✓	✓	✓				
		<i>Eclipta prostrata</i>	False Daisy	0.1	-	✓		✓				

Notes

The mix consist of plants that can take in immediate water inudation & immediate period of dryness.

Soil -

Zone A - Sand, loam and clay at 50%:35%:15%

Zone B - Sand, loam and clay at 50%:30%:10% with vermicompost 10%

Legend

N - Native
D - Drought Tolerant
F - Flood Resistance
SOR - Schedule of Rates
I - Irrigation
E - Exposure
M - Maintenance

Low
 Medium
 High
 Shade
 Partial Sun
 Sun
 Low
 Medium
 High



Vetiver zezaniodes



Acorus calamus



Ocimum sanctum



Cynodon dactylon



Eclipta prostrata



Wetland Mix

ZONE	HABIT	BOTANICAL NAME	COMMON NAME	HEIGHT	SPREAD	N	D	F	SOR	I	E	M
ZONE A	GRASS	<i>Vetiver zezanioides</i>	Khus	1-2	0.5-1	✓		✓	✓			
ZONE B	SHRUB	<i>Pandanus amarylifolius</i>	Pandanus	1.5	1	✓	✓	✓				
		<i>Hygrophila auriculata</i>	Neermuli	0.6	0.4	✓		✓				
ZONE C	SHRUB	<i>Canna indica</i>	Indian Shot	1-3	1	✓	✓	✓				
	GRASS	<i>Calamagrostis</i>	Reed Grass	0.6-0.9	0.6	✓		✓				
ZONE D	AQUATIC PLANTS	<i>Ottelia alismoides</i>	Duck lettuce	0.2	0.15	✓		✓				
		<i>Centella asiatica</i>	Indian pennywort	0.1	0.15	✓		✓				
		<i>Nymphoides ssp</i>	Lily	0.15	0.25	✓		✓				

Notes

The mix consist of aquatic, submergent & emergent plants that can sustain in different levels of water inudation & moisure regimes.

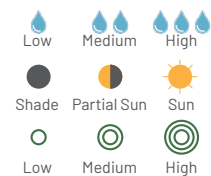
Soil -

Zone A - Sand, loam and clay at 50%:20%:20%

Zone B - Sand, loam and clay at 50%:30%:10% with compost 10%

Legend

N - Native
D - Drought Tolerant
F - Flood Resistance
SOR - Schedule of Rates
I - Irrigation
E - Exposure
M - Maintenance



Vetiver zezanioides



Pandanus amarylifolius



Hygrophila auriculata



Canna indica



Calamagrostis



Ottelia alismoides



Centella asiatica



Nymphoides ssp

B.5. Detailed Notes on Social Amenities

B.5.1. Notes on Playgrounds

1. Play equipments by age

a. 6 to 23 months

- Play areas for our toddlers, such as playhouses, crawl tunnels, and sensory panels, support their strength, stability, motor skills, and emotional development while also promoting their physical and cognitive development.

b. 2 to 5 years

- Analyze commercial playgrounds for young children, emphasising social interaction and motor skills development through slides, spinners, and climbers while maintaining safety throughout the design process.

c. 5 to 12 Years

- Check the commercial playground equipment designed for elementary-aged kids.
- It includes exciting play towers and puzzle-solving net climbers to meet the needs of kids with varying interests and skill levels.

d. 13 and above years

- Teens and adults alike can benefit from the workout challenges and other recreational activities that our outdoor fitness equipment offers, all contributing to a lifetime of health



Fig 32. Reference - Play equipments for 2 to 5 years



Fig 33 Reference - Play equipments for +13 years

2. Types of Play Equipments

a. Bridges and ramps

Commercial playground ramps and bridges let kids move more easily and improve their balance and coordination as they move between play structures.

b. Climbers

Due to children innate curiosity about climbing, commercial playground equipment such as ladders, climbing walls, and cable rope netting have become standard playground fixtures.

c. Decks

Commercial playground decks serve as the foundation upon which all playgrounds are constructed, offering a landing area in between play elements and a place to take a break.

d. Enclosures and panels

Commercial playground panels enhance safety and provide unique play activities inspired by science, art, nature, and other elements, making playground stand out from others.

e. Learning walls

Commercial playgrounds foster children imagination and creativity through universally designed, age-appropriate, and sensory-stimulating activities.

f. Mainstructures

Make sure the foundation of the commercial playground is sufficient to offer all the developmental advantages of play.

g. Spinners and motion play

Commercial playground equipment, such as seesaws, spinners, spring riders, zip lines, and merry-go-rounds, aids children in improving balance, depth perception, spatial awareness, and cause-and-effect comprehension.

h. Overhead events

Overhead play structures, such as monkey bars horizontally hung ladders that kids can grab, swing from, and move side to side are a common feature of commercial playgrounds.

i. Shade and roofs

Commercial playground shade structures offer sun protection for children, enhancing outdoor playtime enjoyment for both adults and children.

j. Sensory play

Commercial playgrounds that are rich in sensory experiences help kids of all ages and skill levels to develop and integrate their senses, which improves their ability to interact with, alter, and impact the world.

k. Signs

Customised playground signs are a great way to welcome guests, guide them, and complete a theme in a park.

l. Slides and gliders

Popular playground accessories, slides help youngsters develop a variety of abilities and senses while also providing entertainment.

j. Fitness equipment

Adding commercial playground fitness equipment to parks or playgrounds can enhance usage, promote physical activity among children and adults, and improve community health.

k. Swings

Commercial playground swings and swing sets help children develop body movement, speed, and motor planning skills for resisting or increasing active movement.

l. Tunnels

To suit the requirements, we provide a variety of tunnel alternatives for commercial playground, such as curved tunnels, straight crawl tunnels, and themes inspired by nature.

m. Nature Play

Permanent play structures can be built from natural materials such as logs and rocks with possible cost savings.

The above information is sourced from
<https://www.playlsi.com/en/commercial-playground-equipment/>



Fig 34. Reference - Sensory Play



Fig 35. Reference - Nature Play

3. Standards of Playfields

- The dimensions of playfields are crucial for providing adequate space for recreational activities.
- These dimensions often vary depending on the specific sport or activity being played.
- Considerations such as field length, width, and clearances around the perimeter are essential for ensuring safety and fair play.
- Properly designed dimensions contribute to the enjoyment and effectiveness of the playfield for participants of all ages

Table. 8. Standard Dimensions of playfields

Sl.no	Name	Dimensions
1	Badminton	13.5m length x 5.2m width for singles, and 13.5m x 6m feet for doubles
2	Basketball (including 3x3 basketball)	25m Width X 40m Length
3	Cycling	1.8m

The above information is sourced from
<https://www.playlsi.com/en/commercial-playground-equipment/>

4. Playground Surfacing

a. Factors to consider while choosing playground surface

- Initial purchasing cost
- Installation requirements and costs
- Ongoing maintenance needs and cost
- Long-term durability
- Lifespan of surface
- Visual appearance
- Degree of safety
- ADA compliance

b. Types of Playground surfacing

i. Loose-Fill

- To create a level playground surface, loose-fill materials like playground sand, rubber mulch, and engineered wood fiber are manually laid.
- Regular maintenance is necessary to keep it safe and compliant with ADA regulations.
- It should be 0.3m for beneath and around equipment because it compresses by at least 25% over time.

ii. Unitary Materials:

- Unitary surfaces, made from rubber mats and tiles, absorb energy and are bound together by a binder.
- These surfaces, including bonded in situ rubber, interlocking resilient tiles, and artificial turf, are durable, low maintenance, and safe for wheelchair users.
- They come in various colours and forms, making them cost-effective over time.

iii. Resilient Tiles:

- Unitary surfaces, made from rubber mats and tiles, absorb energy and are bound together by a binder.
- These surfaces, including bonded in situ rubber, interlocking resilient tiles, and artificial turf, are durable, low maintenance,

and safe for wheelchair users.

- They come in various colours and forms, making them cost-effective over time.

iv. Synthetic Turf:

- Synthetic turf offers cooler surfaces, various colors, and densities.
- It requires less maintenance than loose-fill materials and is budget-friendly for mid-range projects.

v. Poured-In-Place Rubber:

- This surfacing option is available in various colors, shapes, and customizable designs.
- Although it may have higher initial costs, it demands considerably less maintenance compared to alternative playground surfaces.

vi. Bond-In-Place Rubber:

- This surface is made of chemically bonded engineered pebbles with a recycled rubber cushioned layer, offering easy maintenance, UV resistance, and resilience to weather changes.
- It meets safety and accessibility standards while allowing for customizable designs or patterns.

Table. 9. Comparing Playground Surfacing chart

Surfacing type		Advantages	Disadvantages
Unitary Surfacing	Bond-in-Place Rubber	• Extremely durable • High longevity • UV resistance • Many design options • Low maintenance requirements • Meets accessibility and safety standards • Made from 100% post-consumer recycled material; pebbles are made of 20% post-industrial recycled material, and are all recyclable	• Requires certified installers • Weather-dependent installation • Higher initial investment • More challenging to repair or add/change playground elements
	Poured-In-Place Rubber	• Attractive and aesthetically pleasing • Many design options • Low maintenance requirements • High longevity • Low lifetime costs • Meets accessibility and safety standards • Environmentally friendly using recycled rubber tires	• Require certified installers • Weather-dependent installation • Site preparation requirements • More challenging to repair or add/change playground elements • Higher initial investment • Must be regularly swept of debris or vacuum-cleaned to prevent compaction
	Synthetic Turf	• Looks natural and clean • Cooler surface temperatures • Available in a wide variety of colors and densities • Meets accessibility and safety standards • Moderate maintenance requirements • Moderate longevity • Low lifetime costs • Durable and able to withstand heavy traffic	• Require certified installers • Higher initial investment • Site preparation requirements
	Resilient Tiles	• Low lifetime costs • Meets accessibility and safety standards • Moderate maintenance requirements • High longevity • Easy to clean • Stays in place • Easy to repair • Very durable • Many color and design options	• Require certified installers • Higher initial investment • Site preparation requirements • Corners and edges may curl over time

Surfacing type		Advantages	Disadvantages
Loose Fill	Loose Rubber	• Meets accessibility and safety standards • Great impact absorption qualities	• Limiting access for those in wheelchairs • More maintenance required • Potential fire hazard
	Sand	• Less upfront cost • Low site preparation required • Natural • Great impact absorption qualities	• Very limiting access for those in wheelchairs • More maintenance required to meet CPSC guidelines • Can hide sharp objects, insects and animal excrements. • Impacted by high humidity and freezing temperatures
	Pea Gravel	• Less upfront cost • Low site preparation required • Easy to install • Natural and non-toxic	• Limiting access for those in wheelchairs and difficult to walk on • More maintenance required • Potential choking hazard for young playground visitors • Can be thrown, scattered and tracked • Can hide sharp objects
	Wood Chip	• Low lifetime costs • Less upfront cost • Easy to install • Natural aesthetically pleasing look • Low site preparation required • Good shock absorbency	• More maintenance required • Bio-degrades, compacts and decomposes over time • Can hide sharp objects, insects and animal waste
	Engineered Wood Fiber (EWF) or rubber mulch	• Eco-friendly • Economical with low initial costs • Meets accessibility and safety standards • Low site preparation required • Stays in place better than other loose-fill material • Fairly durable	• High level of regular maintenance • High lifetime costs • Microbial growth when wet • Proper drainage system needed to prevent decay rate and keep the surface more resilient during colder weather • Design limiting

B.6. Detailed Notes on Maintenance

Table.10. Recommended Equipment for Surface General Maintenance

Equipment	Trash, Sediment, & Organic Debris Removal 4.3.1	Erosion Control/ Repair 4.3.2	Concrete Pavement, Masonry Repair & Modification 4.3.3	Settling Repair 4.3.4	Hardware Care 4.3.5
Angle grinder with cutting wheels and grinding wheels			●		
Axe		●			●
Backflow preventer(s) and associated appurtenances	●		●		
Backhoe		●			
Bolt cutters	●				
Buckets or tub		●			●
Chainsaw	●	●	●		
Chipper trailer type, either disc or drum. Minimum 12 knives	●		●		
Chisel	●				
Club hammer					
Concrete cut-off saw		●	●		●
Concrete mixing tray			●		
Cordless drills and batteries		●	●		
Crowbar		●	●		
Digging bar				●	
Drill bits (assorted concrete)		●	●	●	●
Dust pan and brush	●				
Electric jackhammer			●	●	
Extension cord(s)	●			●	
Fire hydrant center compression lock					
Fire hydrant wrench					
Float					
Generator			●	●	●
Screwdrivers, phillips and standard		●	●		
Hammer		●	●	●	
High-pressure sprayer/ hose					
Hoe					

Equipment	Trash, Sediment, & Organic Debris Removal 4.3.1	Erosion Control/ Repair 4.3.2	Concrete Pavement, Masonry Repair & Modification 4.3.3	Settling Repair 4.3.4	Hardware Care 4.3.5
Hose spray nozzles and appurtenances					
Laser level, standard level(s) (Torpedo, 2 foot, 4 foot)		•			
Leaf blower	•	•	•	•	
Line level		•			
Mallet		•	•		
Manhole hooks				•	
Mason line	•	•			
Masonry chisel set and stone hammer		•	•		
Masonry tools for mixing and finishing concrete and mortar		•			
Masonry trowel	•				
Scrub brush with fine bristles			•		•
Mini excavator		•	•		
Shovels (assorted)		•	•		
Pick mattock			•		
Pliers, adjustable wrenches, vicegrips, and pipe wrenches	•				
Pump (handheld)	•				
Push broom with firm bristles	•				
Rakes (assorted)	•	•			
Rotary/hammer drill (high speed)	•				
Saw to cut lumber for forms					•
Screwdrivers, phillips and standard					
Wheelbarrow or push cart	•	•	•	•	
Spade	•	•		•	
Stakes		•	•		
Tap and die set with clamp					•
Tarp or other receptacle	•	•	•	•	
Utility blade		•	•	•	•

C. Interviews

C.1. Questionnaire

Strategic Planning

1. Are you familiar with the Sponge City concept and GCC's initiative to build Sponge Parks?

- a. Flood Zones
- b. Groundwater Scarcity
- c. Hydrological Modeling
- d. Aquifer Recharge Potential
- e. Existing Greenery
- f. Existing Land Uses
- g. Pollutant Sources
- h. Access to Parks
- i. Community Need for Amenities

2. Can you tell us why the GCC is building Sponge Parks?

- a. Yes:
If so, please explain:
- b. No / Unsure

3. What factors did the GCC consider when planning for Sponge Parks?

- a. Flood Zones
- b. Groundwater Scarcity
- c. Hydrological Modeling
- d. Aquifer Recharge Potential
- e. Existing Greenery
- f. Existing Land Uses
- g. Pollutant Sources
- h. Access to Parks
- i. Community Need for Amenities

If yes, how was it factored in the sponge parks, Explain.

4. In your view, why were these factors not considered?

Document open-ended response:

5. What are the main reasons for the lack of strategic planning for Sponge Parks? (Pick Multiple)

- a. No Issues
- b. Lack of understanding in dept
- c. Lack of data / information
- d. Lack of staff technical capacity
- e. Lack of time
- f. Lack of budget
- g. Other:

Prioritization

6. Do you know on what basis the location for 57 Sponge Parks were determined by the GCC?

- a. Yes: (If so, provide reasons)
- b. No

7. Does your department use GIS or geospatial data to make prioritization decisions?

- a. Yes: (If so, provide reasons)
- b. No

8. In your view, what factors should determine which open spaces are prioritized for upgrading into Sponge Parks?

Document open-ended response:

9. In your view, what factors should determine which open spaces are prioritized for upgrading into Sponge Parks?

- a. No Issues
- b. Lack of understanding in dept

- c. Lack of data / information
- d. Lack of staff technical capacity
- e. Lack of time
- f. Lack of budget
- g. Other:

Project Planning

10. Did the GCC conduct any tests or studies on the site to determine the storage or recharge requirements of Sponge Parks?

- a. Yes:
If so, please explain:
- b. No / Unsure

11. Did the GCC conduct any stakeholder engagements or social and environmental impact to determine the programming or amenities within Sponge Parks?

- a. Yes:
If so, please explain:
- b. No / Unsure

12. In your view, what factors should be considered when sizing infrastructure components or recreational amenities within Sponge Parks?

Document open-ended response:

13. Did the GCC conduct any stakeholder engagements or social and environmental impact to determine the programming or amenities within Sponge Parks?

- a. No Issues
- b. Lack of understanding in dept
- c. Lack of data / information
- d. Lack of staff technical capacity
- e. Lack of time
- f. Lack of budget
- g. Other:

Concept Design

14. Can you explain the concept design of the Sponge Park? What are the components and how they designed?

- a. Yes:
If so, please explain:
- b. No / Unsure

15. Does the GCC follow any open space design guidelines, landscape standards, or best management practices to design Sponge Parks?

- a. Yes:
If so, what guidelines and standards:
- b. No / Unsure

16. How satisfied are you with the current design of the Sponge Parks implemented by GCC so far

- a. Highly satisfied
 - b. Somewhat satisfied
 - c. Somewhat dissatisfied
 - d. Highly dissatisfied
- Please explain your response:

17. In your view, what factors should inform the design of each component and how they come together in a Sponge Park?

Document open-ended response:

18. What are the main reasons that the implemented Sponge Parks have limited blue-green infrastructure with impacting social activities?

- a. No Issues
- b. Lack of understanding in dept
- c. Lack of data / information
- d. Lack of staff technical capacity
- e. Lack of time
- f. Lack of budget
- g. Other:

19. Do you have any recommendations to improve the current design of the Sponge Park?

Document open-ended response:

Detailed Design

20. Does the GCC follow design guidelines and standard specifications to size and detail blue-green infrastructure in Sponge Parks?

- a. Yes:
- If so, what guidelines and standards:
- b. No / Unsure
- If so, who can provide this information within the GCC:

21. How did the GCC produce the design documentation for costing and tendering for contractors?

- a. Sheet set with CAD drawings at scale
- b. CAD drawings not to scale
- c. Hand drawings / Sketches
- d. No standard documentation
- e. Other:

22. In your view, what aspects of detail designing and construction documentation practices within GCC can be improved?

Document open-ended response:

23. What are the main reasons that the detail designs and drawings for the Sponge Parks implemented so far lack consistency and clarity?

- a. No Issues
- b. Lack of understanding in dept
- c. Lack of data / information
- d. Lack of staff technical capacity
- e. Lack of time
- f. Lack of budget
- g. Other:

Finance

24. How does GCC determine the cost of Sponge Parks in terms of initial capital investment and recurrent operation and maintenance expenditure?

- a. Cost benefit analysis
- b. BOQ from Detailed Design
- c. Park department references
- d. Other:

25. What source of funding has been utilised by the GCC in the planning, design, and implementation of Sponge Park so far?

- a. Sectoral budget (SWD)
- b. Sectoral budget (Water)
- c. Sectoral (DRM)
- d. GCC Scheme (Singara)
- e. State Scheme
- f. Central Scheme
- g. Multilateral (ADB, TNUIFSL)
- h. PPP
- i. CSR
- j. Other:

List Scheme if selected

26. How would you evaluate the ease and scale of financing that is available to implement additional Sponge Parks?

- a. High availability
- b. Some availability
- c. Insufficient availability
- d. No availability

27. What source of funding would you to explore to access more financing to scale up implementation of Sponge Parks?

- a. Sectoral budgets
- b. Central / State / Local Schemes
- c. Intergovernmental grants
- d. Multilateral loans
- e. Climate or green financing
- f. PPP
- g. CSR
- h. Other:

Procurement

28. At what stage of the Sponge Park infrastructure lifecycle does GCC procure external technical services

- a. Strategic Planning (Planners/LA)
- b. Project Planning (Surveys/Tests)
- c. Concept Design (AEC/LA)
- d. Detailed Design (LA/Engg)
- e. Construction (Contractors)
- f. Operation and Maintenance
- g. Other:

29. How does GCC select technical service providers or consulting firms for Sponge Parks

- a. Quality and Cost Basis (Open Bid)
- b. QCBS (Empaneled Firms)
- c. Lowest Cost (Open Bid)
- d. Lowest Cost (Empaneled)
- e. Sole Source / Invited
- f. None
- g. Other:

30. How does GCC select contractors to implement Sponge Parks

- a. Quality and Cost Basis (Open Bid)
- b. QCBS (Empaneled Firms)
- c. Lowest Cost (Open Bid)
- d. Lowest Cost (Empaneled)
- e. Sole Source / Invited
- f. None
- g. Other:

31. How satisfied are you with the current procurement practices and whether GCC uses procurement effectively

- a. Highly satisfied
 - b. Somewhat satisfied
 - c. Somewhat dissatisfied
 - d. Highly dissatisfied
- Please explain your response:

32. In your view, what aspects of detail designing and construction documentation practices within GCC can be improved?

Document open-ended response:

Construction

33. How long did it take to construct the Sponge Park - from the first equipment arriving on site to park opening?

- a. Less than 1 month
- b. 1-3 months
- c. 3-6 months

34. How satisfied are you with the consistency of Sponge Park implementation to drawings issued and the quality of construction?

- a. Highly satisfied
- b. Somewhat satisfied
- c. Somewhat dissatisfied
- d. Highly dissatisfied

Please explain your response:

35. What stage of the Sponge Park infrastructure life cycle should be the focus to improve construction quality and outcomes?

- a. Project Planning (Better testing)
- b. Concept Design (Better design)
- c. Detailed Design (Better drawings)
- d. Procurement (Better practices)
- e. Construction (Better oversight)
- f. Other:

Select one or more and explain your response:

36. Was a project manager or site supervisor externally procured or assigned by the GCC to oversee contractor implementation of Sponge Park?

- a. Yes with proper QA/QC protocols
- b. Yes without protocols
- c. No
- d. Other:

37. Do you have any recommendations on improvements in construction practices that you observed?

Response:

Operation and Maintenance

38. How would you evaluate the maintenance requirements and O&M costs of the implemented Sponge Parks?

- a. Very high maintenance requirements and O&M costs
- b. Somewhat satisfied
- c. Somewhat dissatisfied
- d. Highly dissatisfied

Please explain your response:

39. Did the operation and maintenance practices of the parks change after the construction of the Sponge Park?

- a. Yes:

If so, describe how:

- b. No / Unsure

40. How many staff are in charge of maintaining the Sponge Park and what are their day to day roles?

- a. Gardeners: Role:
- b. Custodians: Role:
- c. Horticulturist: Role:
- d. Cleaners: Role:

Others:

41. Do you have any suggestions in the positioning, design or detailing of Sponge Park components that would reduce maintenance requirements?

Response: (Suggestions location of trees, sedimentation ponds, leaf litter catchers)

42. Do you have any recommendations on improvements in the operation and maintenance of the Sponge Park?

Response:

Decommissioning and Repurposing

43. Is the performance of the Sponge Park being monitored in the following ways:

- a. Water table depth: (documenting how much the water table rises after each rainfall and how much it falls in dry season compared to baseline)
- b. Runoff volume: (measuring volume of rainfall captured within Sponge Park or temporarily detailed in each storm event)
- c. Aquifer pollution: (testing water quality of groundwater around recharge well to ensure no pollutants from runoff)

44. Are the implemented Sponge Parks designed to handle storms of increased intensity due to climate change?

- a. Yes

If so, what return period storms for which climate scenarios:

- b. No

If so, is there financing allocated to upgrade or repurpose Sponge Parks

- c. Unsure

45. Are the implemented Sponge Parks designed to capture and filter runoff from roads?

- a. Yes

If so, can the Sponge Park be decommissioned if the aquifer is getting polluted

- b. No

If so, is there financing allocated and design capacity to upgrade Sponge Parks

- c. Unsure

46. What are the main gaps in GCC's ability to decommission, repurpose or upgrade Sponge Parks when they don't fulfill hydrological or social functions?

- a. No Issues
- b. Lack of understanding in dept
- c. Lack of data / information
- d. Lack of staff technical capacity
- e. Lack of time
- f. Lack of budget
- g. Other:

47. What are the main gaps in GCC's ability to decommission, repurpose or upgrade Sponge Parks when they don't fulfill hydrological or social functions?

- a. No Issues
- b. Lack of understanding in dept
- c. Lack of data / information
- d. Lack of staff technical capacity
- e. Lack of time
- f. Lack of budget
- g. Other:

Concluding thoughts

47. What are your views on scaling up Sponge Parks considering GCC's current capacity and experience from the implemented Sponge Parks?

Document open-ended response:

48. For the training exercise with GCC Department Heads and Engineers, which infrastructure lifecycle of the Sponge Park has the highest need for capacity building?

C.2. Responses to the Questionnaire

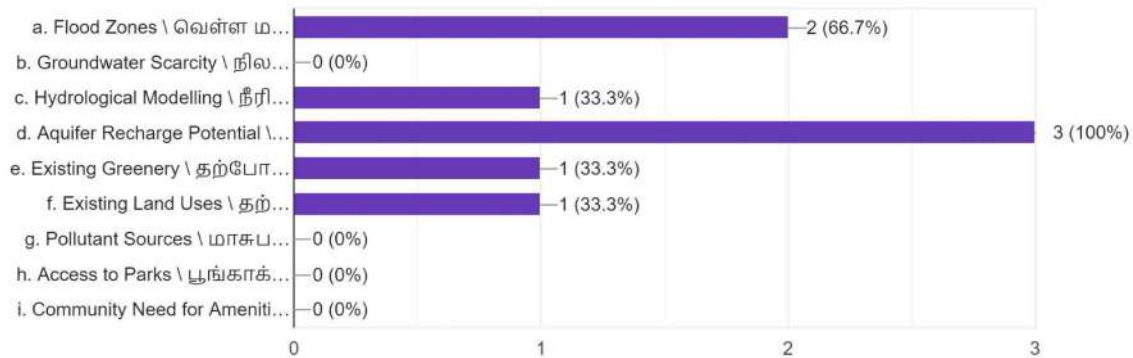
Table. 11. List of People Responded to Questionnaire

Sl.no	Name	Designation
1	S Baskaran	Superintending Engineer (SWD)
2	Vijayalakhmi	Superintending Enginee (Parks)
3	Rajendren	Cheif Engineer (General)
4	V.Eswaran	Asst Executive Engineer
5	Niresh kumar	Asst Executive Engineer (Parks)

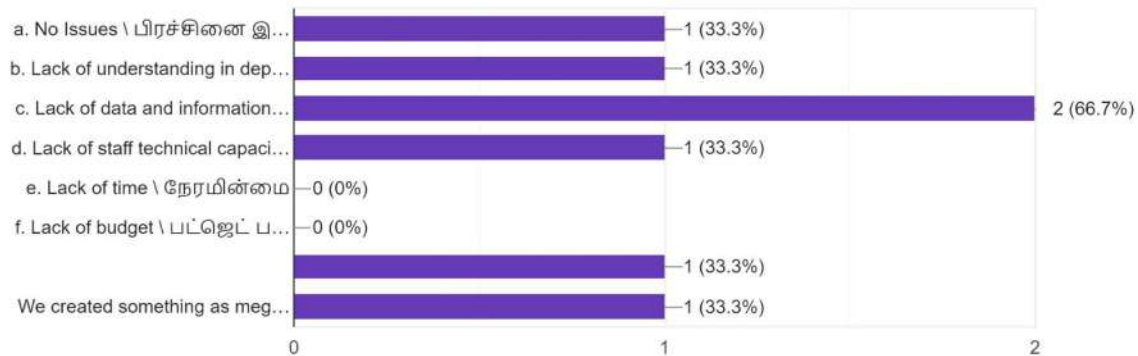
Sl.no	Name	Designation
6	P.V. Srinivasan	Zonal officer (Zone13)
7	Murugesan	Asst Executive Engineer

Strategic Planning

What factors did the GCC consider when planning for Sponge Parks?



What are the main reasons for the lack of strategic planning for Sponge Parks? (Pick Multiple)



Prioritization

Do you know on what basis the location for 57 Sponge Parks were determined by the GCC?



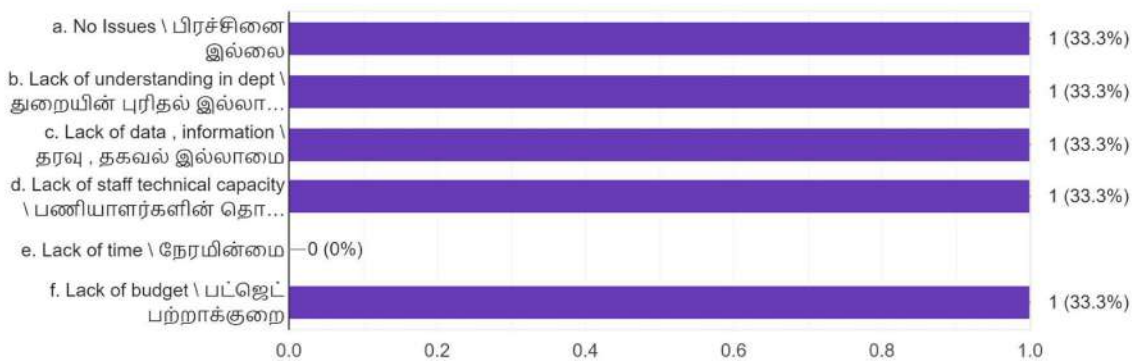
Does your department use GIS or geospatial data to make prioritization decisions?



In your view, what factors should determine which open spaces are prioritized for upgrading into Sponge Parks?

- Parks and playgrounds, open spaces
- Flood prone areas
- Based on population and park location

What are the main reasons for the lack of prioritization in the sponge parks?

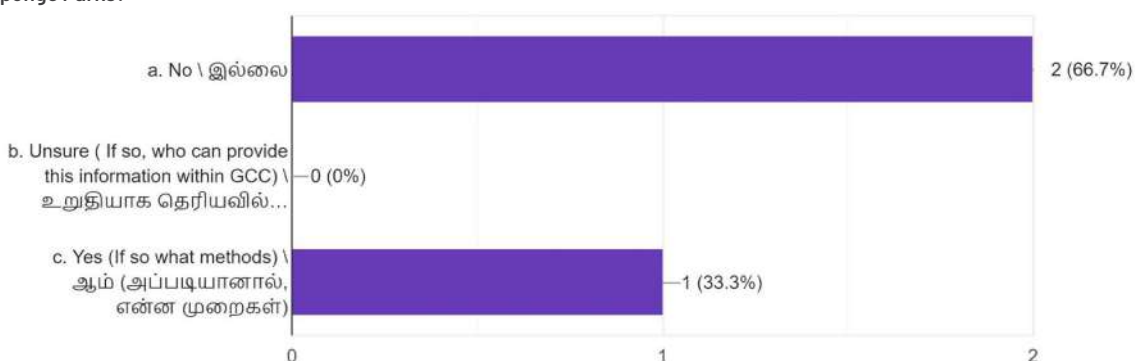


Project Planning

Did the GCC conduct any tests or studies on the site to determine the storage or recharge requirements of Sponge Parks?



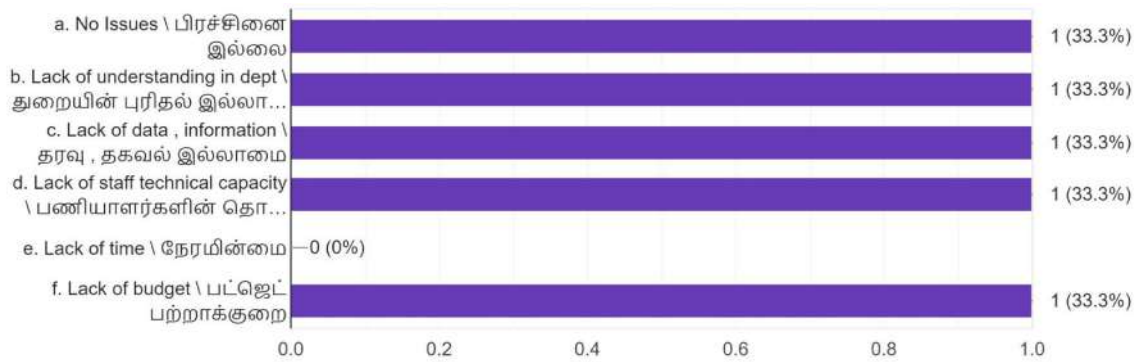
Did the GCC conduct any stakeholder engagements or social and environmental impact to determine the programming or amenities within Sponge Parks?



In your view, what factors should be considered when sizing infrastructure components or recreational amenities within Sponge Parks?

- 25% of space
- Soil Condition & Quantity of water inflow
- We should consider the requirements of the people

What are the main reasons for the lack of planning to determine sizing and programming Sponge Parks?



Concept Design

Can you explain the concept design of the Sponge Park? What are the components and how they designed?



Does the GCC follow any open space design guidelines, landscape standards, or best management practices to design Sponge Parks?



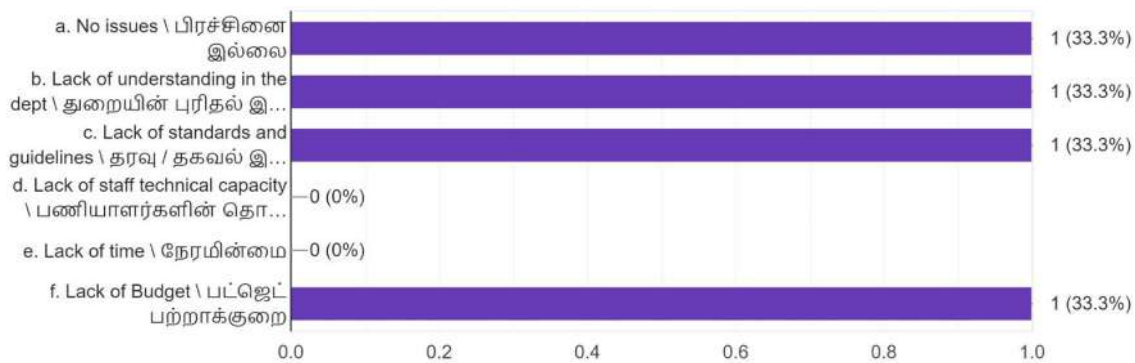
Does the GCC follow any open space design guidelines, landscape standards, or best management practices to design Sponge Parks?



In your view, what factors should inform the design of each component and how they come together in a Sponge Park?

- Urban area
- Landscape

What are the main reasons that the implemented Sponge Parks have limited blue-green infrastructure with impacting social activities?

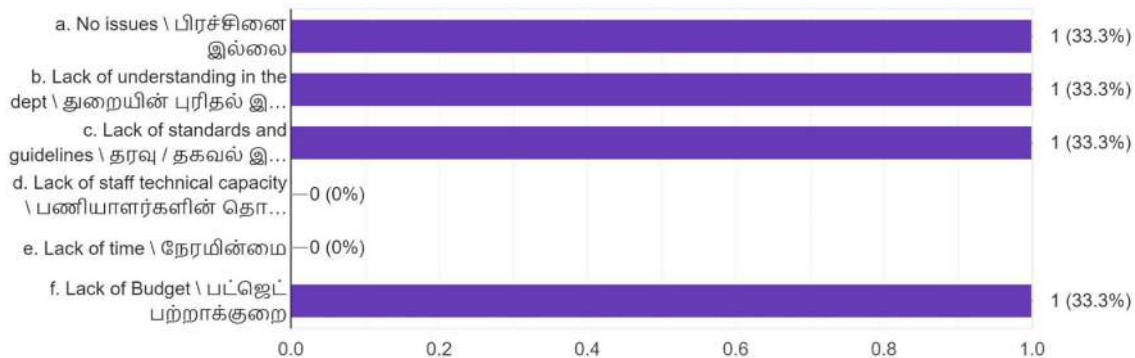


Do you have any recommendations to improve the current design of the Sponge Park?

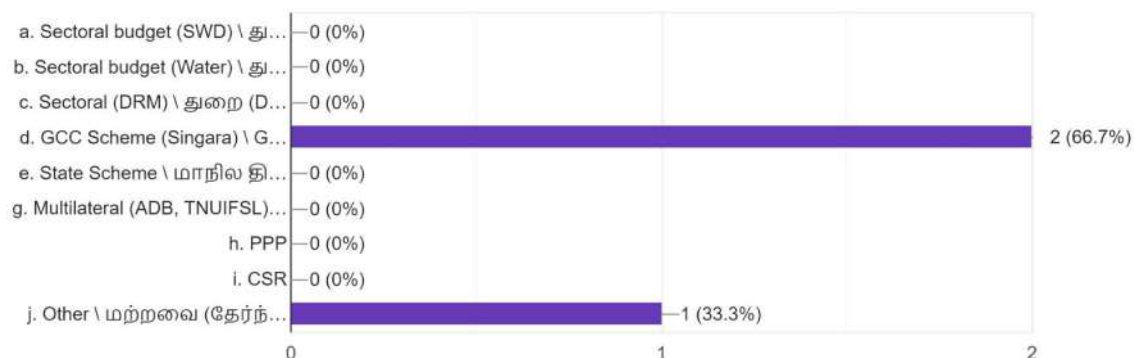
- Will be updated after observing the pilot project
- We can plant many trees around constructed sponge park

Finance

How does GCC determine the cost of Sponge Parks in terms of initial capital investment and recurrent operation and maintenance expenditure?



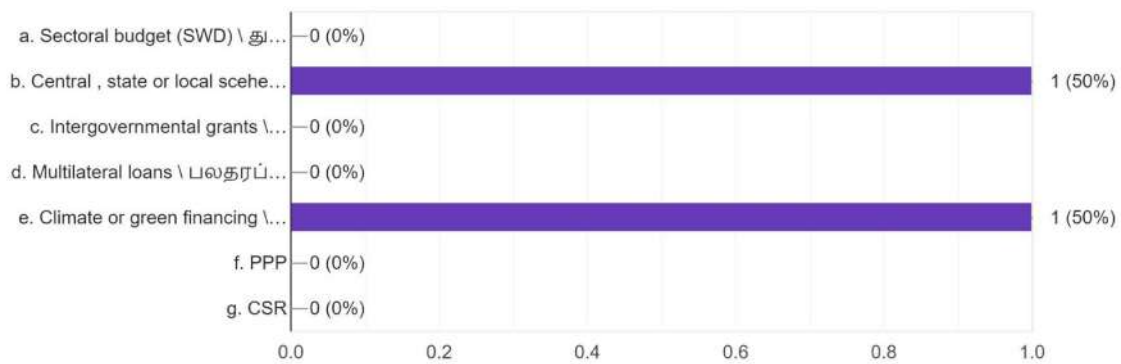
How does GCC determine the cost of Sponge Parks in terms of initial capital investment and recurrent operation and maintenance expenditure?



How would you evaluate the ease and scale of financing that is available to implement additional Sponge Parks?

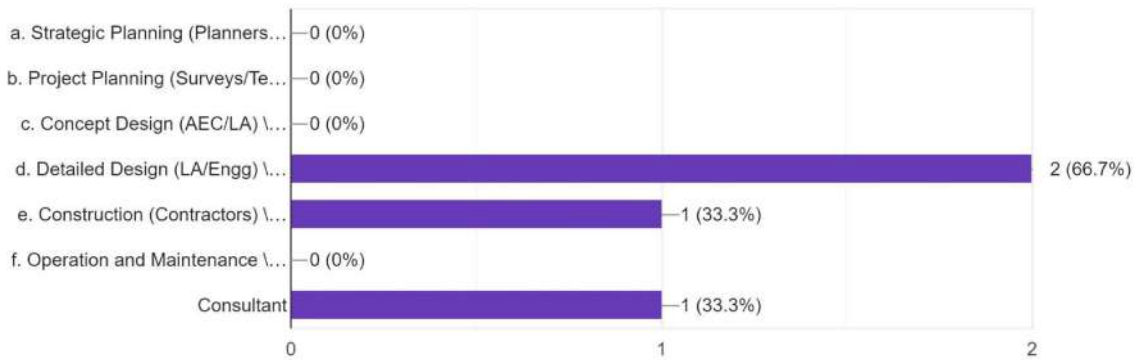


What source of funding would you to explore to access more financing to scale up implementation of Sponge Parks?



Procurement

At what stage of the Sponge Park infrastructure lifecycle does GCC procure external technical services



How would you evaluate the ease and scale of financing that is available to implement additional Sponge Parks?



How does GCC select contractors to implement Sponge Parks



How satisfied are you with the current procurement practices and whether GCC uses procurement effectively. Please explain your response.



Decommissioning and Repurposing

Do you have any recommendations on improvements in the operation and maintenance of the Sponge Park?

a. Water table depth:

(documenting how much the water table rises after each rainfall and how much it falls in dry season compared to baseline)

b. Runoff volume:

(measuring volume of rainfall captured within Sponge Park or temporarily detailed in each storm event)

c. Aquifer pollution:

(testing water quality of groundwater around recharge well to ensure no pollutants from runoff)

- measuring volume of rainfall captured within Sponge Park or temporarily detailed in each storm event

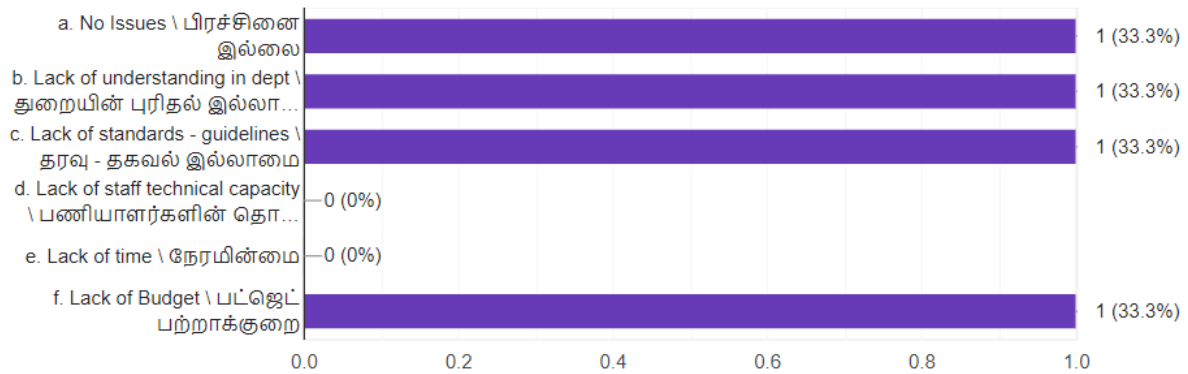
Are the implemented Sponge Parks designed to handle storms of increased intensity due to climate change?



Are the implemented Sponge Parks designed to capture and filter runoff from roads?

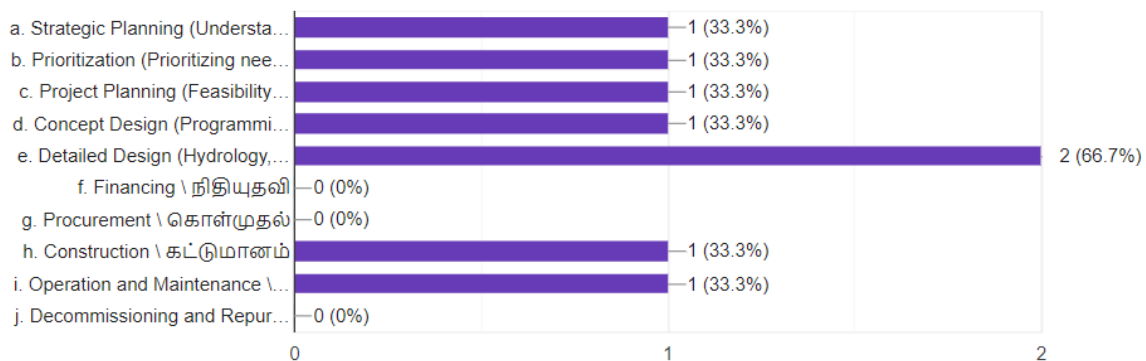


What are the main gaps in GCC's ability to decommission, repurpose or upgrade Sponge Parks when they don't fulfill hydrological or social functions?



Concluding Thoughts

What are the main gaps in GCC's ability to decommission, repurpose or upgrade Sponge Parks when they don't fulfill hydrological or social functions?



D. Workshop Proceedings

D.1. Validation Workshop

Date and Time : 23/02/2023, 12 pm – 2.30 pm

Purpose of the Workshop:

Validation workshop to engage with the GCC Staffs

Agenda of the workshop

- Introduction: From GCC and GiZ (10 minutes)
- Presentation: By Sponge Collaborative (40 minutes)
- Break: 10 minutes
- Discussion: Q&A Session (30 minutes)
- Questionnaire: With GCC Administrative Heads and Engineers

Summary

- The meeting commenced with an introduction to the Sponge park framework, aimed at bolstering the resilience of open spaces. Chief Engineer (General) Rajendren chaired the session, overseeing various agenda items.
- An update on the progress of the guidebook related to the Sponge park framework was provided during the meeting.
- Chief Engineer Rajendren offered valuable insights and recommendations on sponge park design, leveraging his expertise and experience.
- Zonal officers participated in an interactive discussion, contributing input and suggestions tailored to their areas of expertise and jurisdiction, fostering a collaborative exchange to enrich the effectiveness of the Sponge park framework.
- Additionally, an engaging interview session was conducted using Slido, an interactive platform, to gather real-time feedback and promote inclusivity during the meeting.



Fig 36. Photograph from Validation workshop 1



Fig 37. Photograph from Validation workshop 2



Fig 38. Photograph from Validation workshop 3

Table 12. List of Attendees participated in Validation Workshop

Sl.no	Name	Designation
1	S.Rajendiran	Chief Engineer (General)
2	V. Bhuvaneshwaran	Chief Engineer (Electrical)
3	R. NehruKumar	Chief Engineer (Park)
4	S.Baskaran	Superintending Engineer (SWD)
5	R.Vijayalakshmi	Superintending Engineer (Parks)
6	B.V.Babu	SE (Smart projects)
7	Katta Ravi Teja, I.A.S.	RDC (North)
8	K.J. Praveen Kumar, I.A.S	RDC (Central)
9	M.P. Amith, I.A.S.	RDC (South)
10	G.Tamilselvan	Zonal Officer 5
11	A.S.Murugan	Zonal Officer 6
12	K. Umapathy	Zonal Officer 11
13	P.S. Srinivasan	Zonal Officer 12
14	C. Lawrence	Zonal Officer 14
15	Executive Engineers	Zone 1
16	Executive Engineers	Zone 2
17	Executive Engineers	Zone 3
18	Executive Engineers	Zone 4
19	Executive Engineers	Zone 5
20	Executive Engineers	Zone 6
21	Executive Engineers	Zone 7
22	Executive Engineers	Zone 8
23	Executive Engineers	Zone 9
24	Executive Engineers	Zone 10
25	Executive Engineers	Zone 11
26	Executive Engineers	Zone 12
27	Executive Engineers	Zone 13
28	Executive Engineers	Zone 14
29	B.Sivakumar	Executive Engineer (SWD)
30	Karuppusamy	Executive Engineer (Bridges)
32	Suresh	JE - Dn.16 (Zone 2)
31	Thirumaran	AE - Dn.17 (Zone 2)
32	Sivasakthi	AE - Dn.21 (Zone 2)
33	Kavipriya	AE - Dn.18 (Zone 2)
34	Jayalakshmi	AEE (Zone 3)
35	Usha	AE - Dn.28 (Zone 3)
36	Premachandiran	JE - 34 (Zone 4)
37	Parthiban	AE - 35 (Zone 4)
38	Ahamed Astak	AE - 38 (Zone 4)
39	Siddharth	AE - 45 (Zone 4)

Sl.no	Name	Designation
41	Babu	JE - 46 (Zone 4)
42	Menaka	AE- Dn.50 (Zone 5)
43	Haribabu	AEE (Zone 6)
44	G.K.Babu	AEE (Zone 6)
45	K. Satish Kumar	AEE (Zone 7)
46	Victor	AE - Dn.86 (Zone 7)
47	K.Suresh Babu	AEE (Zone 7)
48	B.Dhanasekar	AEE (Zone 7)
49	Muthiah	AEE (Zone 9)
50	Venkatesa Shivanathan	AEE (Zone 9)
51	Raju	AEE (Zone 10)
52	Veera Raghavan	AEE (Zone 10)
53	Ganesh	AE - Dn.153 (Zone 11)
54	Kothandam	AE - Dn.151 (Zone 11)
55	Eswaran	AEE (Zone 12)
56	Rathinvel	AE 172 (Zone 13)
57	Hartin Rozario	AEE 40 A (Zone 13)
58	Ravichandran	AE (Zone 14)
59	Senthil	AE - 181 (Zone 14)
60	Saroja	AEE (Zone 14)
61	Rajasekar	JE (Buildings)
62	Chirsty Latha	JE (Buildings)
63	Hemalatha	AEE (SWD)
64	Banupriya	AE (RDC Central)
65	Ramamurthy	AEE (RDC Central)
66	Manjula	AEE (RDC Central)
67	Nisha	Consultant (Kadapakkam Basin)
68	Sriram	Consultant (NDMA)
69	Arun	Consultant (Kovalam Basin)
70	Pradeep	Consultant (Kovalam Basin)
71	Sourav Kumar Biswas	Sponge Collaborative
72	Praveen Raj	Sponge Collaborative
73	Saloni Nathan	Sponge Collaborative
74	Prakriti.S	Sponge Collaborative
75	Nivedha GG	Sponge Collaborative
76	Niveda Ramesh	Sponge Collaborative
77	Abdul Kalam	Sponge Collaborative
78	Shalini	Sponge Collaborative
79	Anuja Patil	Sponge Collaborative
80	Jevanand	Sponge Collaborative

D.2. Final Workshop

Date and Time : 26/04/2023, 2.30 pm – 5.30pm

Purpose of the Workshop:

Traning workshop with the SEs, EEs, AEEs, Zonal engineers

Agenda of the workshop

- Introduction: From GCC and GiZ (10 minutes)
- Presentation: By Sponge Collaborative (40 minutes)
- Break: 10 minutes
- Discussion: Q&A Session (30 minutes)
- Questionnaire: With GCC Administrative Heads and Engineers

Summary

- The session was initiated with the introduction of the Sponge park framework, a detailed strategy aimed at enhancing the resilience of open spaces through the use of a Guidebook.
- Dr. G.S. Sameeran, I.A.S. (Joint Commissioner- Works), led the meeting, overseeing various agenda items.
- Throughout the session, there was a concise yet informative update on the progress of the guidebook related to the Sponge park framework.
- Both Chief Engineer Rajendren and Dr. G.S. Sameeran provided valuable insights and recommendations regarding the design of sponge parks, drawing from their expertise and experience.
- Subsequently, Chief Engineer Rajendren facilitated a discussion involving zonal officers, who contributed input and suggestions based on their respective areas of expertise and jurisdiction.



Fig 39. Photograph from Training workshop 1



Fig 40. Photograph from Training workshop 2



Fig 41. Photograph from Training workshop 3

Table 13. List of Attendees participated in Final Workshop

Sl.no	Name	Designation
1	Dr. G.S. Sameeran, I.A.S.	Joint Commissioner (Works)
2	V. Bhuvaneshwaran	Chief Engineer (Electricals)
3	S.Rajendiran	Chief Engineer (General)
4	B. Shivakumar	Executive Engineer (SWD)
5	R. Selvakumar	AEE (SWD)
6	N. Ananadaraj	AEE (SWD)
7	K.Karthikeyan	Executive Engineer (Zone 3)
8	K. Devendren	Executive Engineer (Zone 2)
9	K. Thirumaran	AEE (Zone 2)
10	B.Suresh Babu	AEE 40 A (Zone 13)
11	M. Ulagarasan	JE - Dn.16 (Zone 4)
12	K.Premachander	JE - Dn.34 (Zone 4)
13	A.Sundaesan	JE - Dn.34 (Zone 6)
14	K.Senthil	AE-64 (Zone 6)
15	K.Sivapriya	AEE (SWD)
16	C. Tharini	AEE (SWD)
17	V. Hemalatha	AEE (SWD)
18	M. Rajamani	AE-169
19	A.V.K. Kamalraj	JE - Dn.171
20	A. Sathyanarayanan	JE - Dn.185
21	S. Krishnamoorthy	JE - Dn.182
22	S.Vijay	AE-16
23	G. Kannan	AEE (Zone 4)
24	M. Rajamohan	AEE (Zone 7)
25	K. Indra	AEE (Parks)
26	S. Anuradha	AEE (PG)
27	M. Geetha	AEE 24 (Zone 9)
28	A. Sugumar	JE - Dn.119
29	B. Muthulakshami	JE - Dn.141
30	K. Veeraraghavan	AE-127
31	P. Ravichandran	AE-184 (Zone 14)
32	S.K. Kalavathy	AE-196
33	R. Deenadayalan	JE - Dn.3
34	P. Karthick	AE-149
35	C. Dinesh	AE-86
36	B. Dhanasekar	AE-101 (Zone 8)
37	P. Venkatachalam Thirupathi	AE-156 (Zone 12)
38	G. Rajesh kuamr	AE-167 (Zone 12)
39	B. Sathish Kuamr	JE -SWD
40	K. Dinesh	JE -SWD

Sl.no	Name	Designation
41	D. Manoharan	JE - SWD
42	S. Balaji	JE - SWD
43	S. Jagadaesan	JE - Parks
44	V. Vinod	JE - Parks
45	G. Suresh	AE-37
46	R. Jayakumar	AE 01 (Zone 1)
47	K. Balasubramaniyam	AE 181 (Zone 14)
48	S. Kalaiarasan	AE 65 (Zone 6)
49	T. Saraswathi	AE 74 (Zone 6)
50	S. Vivekanandhan	AE 192 (Zone 15)
51	K.A. Mohammed Hussain	AE 177 (Zone 13)
52	S. Manimaran	AE 176 (Zone 13)
53	E. Arulselvam	AE 44 (Zone 15)
54	M. Sethu raj	AE 181 (Zone 14)
55	R. Palani	AEE- SWD (Zone 14)
56	J. Mohanraj	PMC/ADP
57	V. Murthy	AE 45 (Zone 15)
58	N. Saroja	AEE (Zone 15)
59	M. Muthiah	AEE (Zone 9)
60	V. Senthil	AE 191
61	M. P. Thanighavelan	EE 126 (Zone 9)
62	S. Gopinath	AE 181 (Zone 14)
63	Menaka	AE 50
64	S. Sudhakar	EE (Bridges)
65	G. Sudharsan	JE (SWD)
66	Sampath Kumar	Asst (SWD)
67	S.R. Balasubramaniam	EE (Zone 15)
68	K. S. Sudhakar	Technical Advisor GIZ
69	Manushi jain	Sponge Collaborative
70	Divya Thakkar	Sponge Collaborative
71	Sourav Kumar Biswas	Sponge Collaborative
72	Praveen Raj	Sponge Collaborative
73	Saloni Nathan	Sponge Collaborative
74	Abdul Kalam	Sponge Collaborative
75	Shalini	Sponge Collaborative
76	Anuja Patil	Sponge Collaborative
77	Jevanand	Sponge Collaborative

E. Sample Terms of References (TORs)

E.1. Sample ToR for Strategic Planning to Prioritisation

Project: Integrating Blue Green Infrastructure in Urban Planning and Climate Change Adaptation and Mitigation in Chennai Metropolitan Area (CMA)

Seeking: Multidisciplinary Consulting firm with Planning, Hydrology, Engineering, and Environment expertise

E.2. Sample ToR for Strategic Planning to Project Planning

Project: Providing Integrated Storm Water Drains (ISWD) for Hosur City Municipal Corporation

Seeking: Interdisciplinary Engineering firm with Stormwater Drainage, Hydrology, Engineering, and Design expertise

E.3. Sample ToR for Project Planning to Detailed Design (with Construction Supervision)

Project: Sponge City Park Development Project, Rajkot, Gujarat

Seeking: Architecture / Landscape Architecture firm with Landscape Architect, Horticulturist, Hydrology, Engineering, and Design expertise to provide good for tender documents and supervisory scope during construction

E.4. Sample ToR for Construction to Maintenance

Project: Development of Open Space Reservation Area as a Park and Playground at Porur, Chennai

Seeking: Contractor with Construction, Project Management, and Engineering expertise with two years maintenance responsibilities based on Tender Drawings and Specifics developed by Architecture / Landscape Architecture firm in prior procurement

Draft - Terms of Reference (TOR)**Preparation of Detailed Project Report for “Integrating Blue Green Infrastructure in Urban Planning for Climate Change Adaptation and Mitigation in Chennai Metropolitan Area (CMA)”.****1. Background****1.1 Chennai Metropolitan Area**

Chennai stands as the fourth largest metropolitan city in India. Chennai has been recognized for its world-class medical facilities, manufacturing hub, automobile industries, and software services, worldwide. The Chennai Metropolitan Area (CMA) falls in four districts of Tamil Nadu state viz. Chennai, parts of Thiruvallur, Kancheepuram, and Chengalpattu Districts covering an extent of 1189 sq.km. The Chennai Metropolitan Development Authority (CMDA) was constituted in 1974 as a statutory body under the Tamil Nadu Town and Country Planning Act, 1971. As per the Act, one of the major function of CMDA is to prepare a Master Plan for the Chennai Metropolitan Area.



Map 1. Chennai Metropolitan Area (1189 sq.km) expanded (5904 sq.km).
Source: CMDA

The First Master Plan for CMA was approved by the Government in G.O. Ms.No.2395, RD & LA Department, dated 04.12.1976. The Second Master Plan for CMA is in force since 02.09.2008 and will be effective till 2026. Currently, CMDA has initiated the preparation of the Third Master Plan (TMP) for 2026-2046 under World Bank-assisted Tamil Nadu Housing and Habitat Development Project (TNHHDP) for an extent of 1189 sq.km. Recently, the Government of Tamil Nadu in the Housing and Urban Development Department in G.O.Ms. No. 184, dated 21.10.2022 accorded approval for the expansion of the CMA from 1189 sq.km. to 5904 sq.km. annexing 1225 more villages spread in parts of Thiruvallur, Kancheepuram, Chengalpattu Districts and part of Arakonam Taluk in Ranipet District. The jurisdiction of CMA before and after expansion is shown in Map 1.

Chennai is a shore city along Bay of Bengal. Three rivers viz. Kosathalaiyar, Coovum and Adyar meander through the Chennai city before they drain into the Bay of Bengal. Chennai city is vested with several water bodies, forests and green fields which form the basis for the eco system in CMA.

1.2 Water Bodies in CMA

Chennai River basin comprises four sub-basins namely, Kosasthalaiyar, Cooum, Adayar, and Kovalam which are seasonal in nature and function as primary drainage channels for excess storm water runoff during rainy seasons. Another major channel is the Buckingham canal running north to south of the city artificially constructed by the British by connecting all the coastal wetlands conceived as an inland waterway system by the British. There are three major reservoirs namely Chembarambakkam, Poondi, and Sholavaram Red Hills and are the basic source of drinking water supply to CMA. Apart from the above mentioned rivers & reservoirs several channels, lakes of various dimensions are present across the entire CMA which are maintained by the PWD and some of them by the Local Bodies themselves. On the one hand, securing clean and adequate water for all the people in a metropolitan city is a major challenge whereas on the other hand managing the challenge of disasters caused by flooding as well poses burden on the government. Planning for a balance between these two extremities is the need of the hour in CMA which requires thorough understanding of not only the characteristics of the existing water bodies, permeability of the soil surface, contour of the area, rainfall, ground water, storm water runoff etc., but also the information like rate of population growth in the area, projected population for the area for

about 20 years, future water demand for the projected population and additional sources of water and infrastructure.

1.3 Green spaces in CMA

Forest cover in Chennai has a dubious distinction of having the lowest green cover among all the metropolitan cities in the country and research reports assert that the gap seems to be only widening. Forest Survey of India (2009) reports the green cover of Chennai city is 6.25% including 5 sq.km of moderately dense forest and 4 sq.km of open forest. In the 426 sq. km of Greater Chennai Corporation (GCC) area, only 64.06 sq km (15 percent) accounts for green cover as against the target of 33 percent stipulated in the National Forest Policy. Research reports from the Institute of Remote Sensing, Anna University, Chennai reveal that the green cover of CMA has reduced from 167.46 sq.km in 2005 to 153.03 sq.km in 2012. Pallikaranai marsh is one of the Ramsar sites in Chennai with an overall expanse estimated to be 5500 sq.km in 1972 and has currently been reduced to one-tenth of its original extent as evident from the state planning commissions report on Green Chennai City. One of the biodiversity-rich wetlands is currently threatened due to anthropogenic impacts and urbanization. Effective restoration of marshland would be wise and economically sensible for the natural flood control system in Chennai city. Currently, Chennai city is having about 525 public parks and about 128 traffic islands serving as lung spaces around the city.

2. Major resilience challenges and climate risks in Chennai

Like all other rapidly expanding metropolitan cities, Chennai also has its own share of resilience challenges: the city frequently endures natural calamities such as cyclones, floods, and heat waves, while coping with slow disasters such as droughts, poor waste management, encroachment, traffic congestion, and pollution. According to the Climate Change Vulnerability Index of 2021, Chennai ranks highest among the large Indian cities in terms of exposure to climate change-related threats. Flood risk in Chennai is also expected to worsen as per the climate models projecting a 11% increase in heavy rainfall under the RCP 4.5 and 16% under RCP 8.5 in 2050 which likely will cause more frequent and heavy floods if the drainage infrastructure is not improved. The State Action Plan on Climate Change and the City Climate Action Plan highlight the issues of flooding, sea level rise, water scarcity, and frequent droughts in the city.

Chennai's urban growth has sometimes taken place at the expense of the region's blue-green systems and open spaces. The loss of farmlands, floodplains, forests, streams, and

wetlands to urban development increases runoff, reduces aquifer recharge and increases the land surface temperature. The built-up area of the CMA has rapidly expanded in the past decades, stretching its infrastructure and service delivery capacity, and particularly creating a backlog in stormwater drainage, wastewater treatment, and disaster risk reduction services. The overall water storage capacity of the region's landscape has diminished due to the complete disappearance/encroachment or silting of water bodies. These changes to the landscape have left Chennai's residents more exposed to the risk of flooding, drought, and heat waves.

Climate change projections indicate that Chennai will face greater threats from extreme storm events, pluvial flooding, sea level rise, water scarcity, heat waves, urban heat islands, and poor air quality. Besides, it is to be noted that Chennai's water risks will aggravate over time unless the natural hydrological flows that sustain the water bodies and aquifers are restored. Delineating the basins is an effective method to identify the landscape units where the surface hydrological flows are self-contained and sustained. It will also provide the base for any river restoration/management planning in the region. The loss of green cover and increase in concretization has led to an increase in land temperatures in the urban landscape. The large waterbodies which are the major resource for water supply such as Red Hills, Sholavaram, Chembarambakkam and wetlands like Pallikaranai and grazing lands (Kazhuveli) are vulnerable for encroachment.

According to the Observed Rainfall Variability and Changes over Tamil Nadu state (2020) report prepared by IMD, Pune, based on the daily rainfall data from 1989 to 2018, the number of heavy rainfall days in the entire year is 3 to 4 days in Chennai while compared to other districts (0.1-3.2 days) in Tamil Nadu. The Chennai Metropolitan Area receives an annual rainfall ranging from 800 to 1400 mm and experiences a tropical wet and dry climate with high humidity. The majority of this rainfall mainly occurs during the monsoon season only for a period of three months between October and December. In the past decade, the city has endured more frequent and intense flood and drought extremes. The hydrology of Chennai is composed of a system of cascading wetlands along with the three rivers. The floods that occurred in the past were severe along the stretches of Adyar, Cooum and Kosasthalayar rivers, Buckingham Canal, and also along the neighboring areas of Pallikaranai wetland.

In the past 50 years, catastrophic floods have occurred in Chennai during the years of 1976, 1985, 1996, 2005, 2015, and 2021. These floods have caused devastating damages to the infrastructure of the city and numerous losses of lives. In 2015, Chennai recorded a rainfall depth of 348 millimeters (mm) over a 24-hour period following multiple torrential rainfall events in the course of a month claiming more than 400 lives. The floods destroyed property and livelihoods due to inundation, particularly of the poor and other vulnerable groups residing next to water bodies.

3. Nature-based Solutions (NbS) and Blue-Green Infrastructure (BGI) for climate resilience and its challenges

The term green infrastructure includes vegetated design elements such as parks, green roofs, greenbelts, alleys, vertical and horizontal gardens and planters whereas blue infrastructure relates to the hydrological functions viz., flow control, detention, retention, filtration, infiltration, reuse and recycling of water, for different sources of water like rainwater, urban storm water systems and groundwater aquifers with resilient provision for water supply and water security. Blue Green Infrastructure (BGI) refers to the systematic integration of blue elements like rivers, canals, ponds, wetlands, flood plains water treatment facilities and green elements such as trees, green fields, forests and parks with built environment in urban ecosystem. The potential benefits of BGI include increase in capacity of flow in rivers and channels, increased recharge of ground water, reduction in discharge of stormwater runoff, prevention of soil erosion and other ecological disturbances. Blue Green Infrastructure offers wide range of support in managing the challenges of climate change in urban areas in terms of economic viability and flexibility to adopt under different scenarios. Though the effects of BGI are not completely tangible immediately, it will enhance the resilience to climate change and capacity of mitigation in the long run. In this phase of rapid urbanisation and climate change risks, BGI is an efficient nature - based alternative to Grey infrastructure made of concrete and metal to mitigate flood and drainage. BGI creates connection with nature increasing urban biodiversity and provides opportunities for social interaction, well being and recreation. It plays a vital role in making a city more liveable, sustainable and resilient.

As the CMDA is set to prepare the Third Master Plan for the CMA (2027-2046) and the Regional Plan for the expanded CMA region to guide urban and regional development, the integration of blue-green infrastructure (BGI) into planning and implementation processes will greatly help build resilience of the region to flooding, water scarcity, and climate change.

Hence, CMDA envisages to conduct a study on Blue-Green Infrastructure (BGI) mapping to develop an integrated and sustainable approach for climate disaster reduction-oriented spatial planning and management for the Third Master Plan through a detailed assessment, policy recommendation, and applied design guideline, by hiring a consultancy firm. The BGI study will help identify strategies for improving green cover, protecting water bodies, sponge development, urban flood risk control, water quality and storage capacity, open space design, sea level protection, shelterbelts, and heat island effect mitigation, among other co-benefits.

2. Objectives of the Study

The primary objective of this consultancy study is to capture the existing characteristics of the blue green elements in CMA, analyze and identify the problems related to the blue green elements including climate change threats, identify the gaps and weaknesses, and develop suitable contextual BGI and recommendations on implementation strategy for climate-resilient urban and regional development in CMA. The study is also expected to highlight the constraints in implementation of the BGI as well as specify implementation strategy on short term and long term basis, indicating enabling conditions including institutional requirements in CMA.

The study should also include the assessment of climate change impacts and risks in Chennai and make recommendations on suitable BGI-oriented infrastructure design and policies for adaptation and mitigation. The design shall include a combination of structural and non-structural (ecological-engineering) techniques to soften the edges of the waterways, lakes, tanks, and ponds to give them a natural appearance (green corridors) and to alter the constructed urban barriers (streets, sidewalks, buildings, or train tracks) to improve the green cover and increase the resilience of the city from climate change impacts.

3. Scope of the study

The study has five components viz.,

- (i) Mapping of all blue green elements in the study area
- (ii) Assessment of climate change impacts and risks in CMA
- (iii) Assessment of current plans and regulations for BGI adaptability and assessment of demographic trend and institutional capacity for BGI in CMA

- (iv) Nature-based solutions for protection of existing blue green elements and development of contextual BGI with investment plan and implementation strategy and conceptual land use plan for CMA.
- (v) Delivery of final report, summarizing all findings and recommendations out of the study.

The detailed scope of the study is given below:

Component 1: Mapping of all Blue Green elements in the study area.

This component aims to cover the following tasks:

Task 1.1: Preparation of broad contour map for CMA in GIS

Task 1.2: Mapping of all the existing blue green infrastructure including micro drains and small green spaces such as road side parks, parks, traffic junctions, OSR, vertical garden, terrace garden in CMA in GIS using recent satellite images.

Task 1.3: The road network and storm water drain network in urban areas to be included from the database of Greater Chennai Corporation (GCC), Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) and concerned Local Bodies. Mapping the boundaries of the water courses / water bodies and all the missing links as per Public Works Department (PWD) revenue classification and historic satellite images.

Task 1.4: Mapping the cross sections of all water courses at crucial points with levels.

Component 2: Assessment of climate change impacts in Chennai Metropolitan Area (CMA) for planning of Blue Green Infrastructure

Task 2.1: The scope includes collection of primary and secondary data, a review of all available secondary information/reports/bulletins/related journal articles, etc. and benchmark the best practices to protect and develop Blue Green Infrastructure in urban areas more specifically in coastal cities and conducting necessary field surveys as required. Detailed tasks include the following:

Task 2.2: Conduct a preliminary assessment of the historic trend of climate risks and the climate change impacts on the urban environment in the study area, including the weather data, extreme climatic events, climate hazards, as well as vulnerability and risk assessment of

the study area, with special focus on spatial planning for flood, coastal erosion, water scarcity/droughts, and heat waves.

Task 2.3: Investigate the roadways, metrorail network, railway lines, bridges, culverts, causeways, surplus channels of waterways and other urban infrastructure, public works, and/or built facilities that influence the landscape of the BGI system and identify critical points and areas of risk in the study area.

Task 2.4: Conduct a landscape assessment from the mapping in component-1. To estimate the urban green cover and existing natural infrastructure (land use modeling) infrastructure potential map by overlaying the digitized.

Task 2.5: Identifying all the possible impacts of climate change that Chennai Metropolitan Area would be exposed to and the role of Blue Green Infrastructure in mitigating such climate changes.

Task 2.6 Summary of basin-level BGI strategies including wetland protection, riparian conservation, water body restoration, canal rejuvenation, flood plain enhancement, and green corridors as ecosystem-based adaptation pathways. A regional development plan at the basin level with a proactive conservation agenda (including greening along the river corridor) has to be prepared in consideration of sponge basins in Chennai to protect the upstream riverways and waterbodies in the study area.

Component 3: Assessment of current plans and regulations for BGI adaptability and assessment of demographic trend and institutional capacity for BGI in CMA

Task 3.1: Review the existing city development plans, land use regulations, Building regulations and sectoral plans, infrastructure investment plans that are related to the management of the BGI system, including the community green spaces, green cover, open spaces, green networks, and water resources viz., water supply, water quality, stormwater drains, rainwater harvesting structures and preservation of natural ecosystems. Using best practices around the world as a benchmark, identify the gaps and weaknesses in these current plans concerning climate resilience and BGI system strengthening.

Task 3.2: Review the current national and international land use planning/management policies and guidelines w.r.to waterways/waterbodies and develop suitable land use planning policies integrating nature based solutions for the waterways/waterbodies in CMA.

Task 3.3: Analyze the demographic growth trend and socioeconomic development prospects of the study area to assess the urban development trajectory and gaps in the current plans in terms of BGI system. Using urban settlement upgradation plans/redevelopment schemes (including PMAY schemes) within the study area to identify and assess the impacts/scale of informal housing encroachment on natural drains/ BGI in the city. Where necessary, the consultant may need to carry out modeling of spatial urban growth and land-use change scenarios, with an assessment of how different growth scenarios may impact/threaten the existing blue-green systems as well as identification of priority areas with high BGI potential for ecosystem-based adaptation. Areas of high ecological/environmental significance/value that are critical for BGI system enhancement should also be identified as conservation areas to inform the preparation of the TMP.

Task 3.4: Assess the current institutional framework, policies, plans and operational arrangement, and manuals/rules for decision-making in the maintenance of green infrastructure, waterbodies/ waterways, and management of floods. Also consider projects/programs in the pipeline, including institutional strengthening activities and technical assistance needed.

Component 4: Explore the potential for the application of nature-based landscape components and propose contextual BGI along with investment plan and implementation strategy and conceptual land use plan for CMA.

Task 4.1: Based on the urban green infrastructure and waterbodies/waterways in the study area, projected population and climate risk forecasts the Consultant shall generate scenarios of BGI application and its effect on climate mitigation in CMA

Task 4.2: The consultant shall develop suitable contextual BGI-oriented infrastructure design and policies for adaptation and mitigation. The design shall include a combination of structural and non-structural (ecological-engineering) techniques.

Task 4.3: The consultant shall give recommendations on implementation strategy for climate-resilient urban and regional development in CMA highlighting the constraints in implementation of the BGI, implementation strategy on short term and long term basis, indicating enabling conditions including institutional requirements in CMA and policies for adaptation of BGI.

Task 4.4: Validation of the strategy and proposal of its operationalization/implementation plan with phasing, in consultation with key stakeholders, including the citizen groups and developers/owners/management entities of the urban infrastructure in the study area, like, GCC, PWD, WRD, CMWSSB, Highways Department, Municipal Administration Department, Rural Development Department, CUMTA.

Component 5: Delivery of final report, summarizing all findings and recommendations out of the study.

The final report should include an Executive Summary, the main text that includes chapters that summarize findings from all the tasks conducted, and any necessary annexures for methodology notes, maps, tables, data, models, and references. Together with the final report, the consultant should also submit all the primary and secondary data collected, data analysis results, simulation models, drawings, and maps in digital editable formats to CMDA.

The final proposal shall be detailed in the form of GIS based maps for all contextual proposals.

The final report of the study should cover the existing characteristics of the blue green elements in CMA, problems identified in CMA relating to blue green elements including climate change threats, gaps and weaknesses in blue green system, suitable contextual BGI and recommendations on implementation strategy for climate-resilient urban and regional development in CMA. The final report of the study should highlight the constraints in implementation of the BGI and implementation strategy on short term and long term basis, indicating enabling conditions including institutional requirements in CMA and policies for adaptation of BGI.

Given the fragility of the Chennai ecosystem, an understanding of how the BGI system impacts vulnerable communities, and an analysis of how the proposed plan (even though conceptual) impacts/benefits these communities should also be included.

At least two stakeholder workshops need to be held to ensure that inputs from various stakeholders (including vulnerable groups and community organizations) are well incorporated. The consultant can propose the actual timing and schedule for holding the workshops as fit in their work plan, but tentatively one workshop should be held at the

inception stage for collecting inputs and concerns, while another being held before the delivery of the final report for validation of recommendations.

4. Data resources and collection

The CMDA will provide access to its available datasets and facilitate the consultant's access to other government-owned datasets. The consultant is expected to propose collection / procurement of datasets listed below but not limited to, during the Inception Report stage.

- a) Rainfall data for the stations within CMA and its immediate areas for available years (Max 100 years) from IMD / PWD so as to capture the hydrology of the four basins of CMA
- b) Reservoir inflow and outflow data of all the 4 major reservoirs (Puzhal, Poondi, Chembarambakkam, and Sholavaram)
- c) Tidal data for the Chennai basin from authorized agencies
- d) Survey of India maps for the project area and influencing area
- e) Aquifer-related data from State / Central Ground Water board/IRS-Anna university
- f) Topography (SRTM - 30m) from Survey of India and other records
- g) Topographic and thematic information generated for the Chennai area under the Urban Information Systems Program of the Ministry of Urban Development by the Department of Space.
- h) Land use/ land cover/cropped and irrigated areas/soils
- i) Water infrastructure details (Lakes and water spread area, barrages, diversions, irrigation systems, water supply intakes)
- j) Urban vegetation cover and wetlands including all designated parks, Open Space Reservation (OSR) areas, traffic islands & traffic medians used for greening,
- k) Natural barriers/retardants to flooding such as estuaries and information on their modeling already done by different agencies
- l) Flood-related information and existing flood control measures (historical flood extents, embankments)
- m) Water Resources (flows, groundwater levels)
- n) Pollution-related data from TNPCB [Air, Water (fresh and marine), Soil and Industries (effluents)]

5. Timelines and Deliverables:

The time of completion of the assignment is Nine months.

S. No	Stage	Deliverable	Timeline	Fee schedule
1.	Submission and approval of Inception Report	An overview of the project, along with technical approach & methodology and a plan of action on how the consultant is proposing to execute the project with clear timelines and milestones. Collection, and reviews based on secondary data from various stakeholders.	Within 4 weeks from the date of issue of Letter of Award and acceptance thereof (T+4 weeks)	15% of the contract
2.	Submission and approval of Interim Report	Conducting all Field Surveys with necessary outputs in the form of shapefiles/ GIS files etc., as required, and Validation. Preparation of blue-green infrastructure design for a pilot project which can act as a lever to change the collective culture in sustainable climate change mitigation in CMA.	Within 10 weeks from the approval of the Inception report (T+14 weeks)	25% of the contract amount
4	Submission and approval of Draft Final Report	Incorporation of field survey results identification of suitable BGI design with three options and selection of best option.	Within 16 weeks from the date of approval of the interim report. (T+30 weeks)	30% of the contract amount
5	Submission and approval of Final Report	Report covering all the field surveys, maps prepared, data collected, analysis of options available, selection of the best option, details of the selected proposal in the form of drawing, maps with dimensions, and incorporating the suggestions made by CMDA.	Within 6 weeks of approval of the draft final report. (T+36 weeks)	30% of the contract amount

The consultants have to make necessary presentations and shall be available for discussions with necessary key personnel, before the Department / Government during various stages of the study as and when required, apart from the review committee reviews.

The consultant has to submit 7 copies for each of the deliverables and submit the hard and soft copies of all reports, shape files of GIS analysis, and Auto CAD drawings. The hard copies shall be printed in duplex mode wherever possible. All the designs, data, and editable versions of the reports shall be submitted in soft copies. The final report (Approved version) shall be hard bound and submitted with 10 copies along with soft copy (both Editable & non-editable and all drawings, etc.,) in Pen Drive. The report layout and arrangement of chapters shall be shared with the client before submission of the reports.

The consultants shall make necessary presentation to GoI, GoTN, Departments, and Authorities as and when required with their key staff during the study.

6. Data, Service, and Facilities to be provided by the Client

The land details, sketches/maps, and data relating to this work available in the office of CMDA will be provided to the Consultant. The Consultants can access all basic information from the CMDA website www.cmdachennai.gov.in. The consultant can also access the study reports/documents in Second Master Plan, CCTS, and other related maps of CMDA.

7. List of Key Professionals:

Key Professional	Education	Experience requirements
Team Leader & overall coordinator (36 weeks)	Postgraduate degree in regional planning, environmental planning, urban ecology or urban planning.	- Minimum 15 years of professional experience in the fields of education mentioned. - Minimum 10 years of experience in the fields of land use, sustainable development, urban ecology, strategic planning, land scape planning, and urban planning in developing countries.
Hydrology Expert (36 weeks)	Postgraduate degree in Hydrology/ Urban Water	Minimum 10 years of relevant experience in working with national and local

Key Professional	Education	Experience requirements
	Resource Management	governments in developing countries. • Experience in facilitating similar exercises • Demonstrated experience in urban planning with a focus on water resource management, water supply and drainage and flood management.
Environment Expert (36 weeks)	Postgraduate degree in Civil Engineering / Environmental Engineering/ Environmental Sciences/Ecology/ Forestry/Agriculture /Horticulture	• Minimum 5 years of relevant experience in working with national and local governments in developing countries. • Demonstrated experience in environmental management planning, urban planning with a focus on green infrastructure, and nature-based solutions for flood management in similar assignments. • Experience in facilitating similar exercises
Landscape Architect/ Urban Designer (Mid-level) (36 weeks)	Postgraduate degree in Architecture, urban planning, regional planning, territorial or urban development.	• Minimum 5 years of relevant experience in working with national and local governments in developing countries. • Demonstrated experience in landscape designing in similar assignments in developing countries.
GIS Specialist (36 weeks)	Postgraduate in GIS and Remote Sensing/ Geography/ Post Graduate Diploma in GIS & Remote Sensing	• Minimum 5 years of relevant experience in working with national and local governments in developing countries. • Minimum 7 years of relevant experience in working with national and local governments in developing countries for PG Diploma in GIS & Remote Sensing candidates. • Demonstrated experience in spatial planning, mapping natural resource management, GIS and Remote Sensing based assessments, and overlay analysis, preferably in assignments of similar scope and geography.

8. Duration and Location

The services shall be delivered in Chennai, Tamil Nadu. The team is expected to stay in Chennai for at least **60%** of the time.

The consultants shall include the necessary support staff for fulfilling the requirements of this project.

- 1) Copy of the degree certificate / educational qualifications has to be enclosed with the C.V
- 2) The above team should be supported by adequate support staff like surveyors and other non-key-experts / specialists etc., with adequate experience to ensure that the objectives of the project are achieved within the timelines. The proposed team leader shall be assigned full-time for this project and shall not be associated with any other full-time ongoing assignment with any other client.

10. Review of Reports:

A technical committee constituted of representatives from the CMDA, UNEP, World Bank and other related stakeholder departments will evaluate the supplementary/complementary aspects of other sectoral studies such as Urban Heat Island effects, TNCDBR 2019 review, and T&CP Act review in the report for quality control. A separate review committee shall be constituted comprising official representatives from CMDA, and other stakeholder departments from GoTN (DoEF, WRD, TNGCC, CMWSSB, GCC) will review the progress of the work. The comments or views suggested by the technical committee on the various deliverables should be shared to the consultant within 15 business days of submission for incorporation/further action.

Section VII. Terms of Reference

Draft - Terms of Reference

TERMS OF REFERENCE FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR PROVIDING INTEGRATED STORM WATER DRAINS (ISWD) FOR HOSUR CITY MUNICIPAL CORPORATION

A. Background:

The Government of Tamil Nadu has been implementing urban investment projects with funds assistance from World Bank, JICA and KfW. The investments have made improvements in the living standards of the public, yet there is further scope and accordingly, Government of Tamil Nadu is presently implementing “Sustainable Municipal Infrastructure Financing Tamil Nadu (SMIF TN – Phase III)” assisted by KfW Bank (KfW).

KfW Bank has provided the Accompanying Measures (AM) Grants under SMIF TN III. The AM grant will be utilised for Updation & preparation of DPRs, other technical, feasibility studies/plan, enhancing the institutional capacities on climate resilience, enhancing the monitoring capacities, enhancing the financial capacity of the ULBs, and supporting activities to meet the objective of SMIF-TN-III.

Hosur is a growing town located in Krishnagiri District in the state of Tamil Nadu located at 880 above MSL. It also touches the border of Karnataka state and is 35 km away from the city of Bangalore. Hosur is considered as the oldest inhabited town in the state of Tamil Nadu as many Neolithic, Monolithic and Paleolithic sites have been found.

The city has a population of about 4 lakh, spread over 70 Km². The city is now known to be one of the fastest growing cities of South India with several large, medium and small industries setting their fabrication units in the city. The city has immense potential in terms of being a green and smart city, in the true sense of the words. Further, several dispersed residential layouts are coming up at great speed. Also, the current upmarket shopping centers, sandhais of the city are in dense commercial areas on the arterial roads (which are State of National Highway roads), which have grown rapidly in the recent past.

There are several risks that can pose a threat to the city's growth. A case in point is the unexpected flooding of the city due to heavy rains in October 2022. Currently, there are open drains to a span of 266 Km, 17.30 Km Raja Kalvais (main canals). Last year, these canals needed to be desilted during the heavy downpour to prevent houses from getting further submerged in storm water.

There is a need for an integrated plan for storm water drains in the city that can make the city resilient to face heavy downpours, which only seem like the norm with climate change. The city lacks a network of storm water drains that dispose rainwater/storm water into waterways in a scientific manner. The city has a network of 677.90 Km of roads which acts as a critical infrastructure for the state's development. But during the rainy season there is a constant threat of the highway roads and their service roads getting inundated because of inadequate networks of the storm water drains. Hence there is a need to plan for the construction of scientifically designed storm water drains for the city with focus on the lakes, their interconnecting network

and sponge parks of the city.

In this regard, the Director of Municipal Administration has requested TNUIFSL to appoint a consultant for preparing Detailed Project Report (DPR) for providing climate resilient plan through Integrated Storm Water Drains to Hosur City Municipal Corporation. Hence, in this connection it is proposed to appoint a consultant to study the present drainage system and to prepare a climate resilient Detailed Project Report (DPR) for providing climate resilient plan through Integrated Storm Water Drainage System to Hosur City Municipal Corporation, through the Project Development Grant Fund under SMIF TN - III managed by TNUIFSL.

B. Objective:

The objective of this assignment is

- To study, analyze and prepare a DPR for providing a climate resilient Storm Water Drainage System with all necessary integration of all existing water bodies/waterways/macro-drains for Hosur City Municipal Corporation by undertaking a detailed watershed / urban shed study on technical, financial, economical, environmental and social, preparation of prioritized capital investment plan, detailed engineering designs, working drawings including structural drawings, bar bending schedule, etc., cost estimates, preparation of standard operating procedures bidding documents for planning and implementation of such investments.
- To study, analyze and prepare a DPR for rejuvenation of Water Bodies including detailed engineering designs, working drawings, structural drawings, bar bending schedule, etc., cost estimates, preparation of standard operating procedures bidding documents for planning and implementation of such investments.
- To study, analyze and prepare a DPR for Sponge City / Parks concept by utilizing the identified vacant lands available in the Corporation area.

C. Scope Of Work:

The scope of work covers, but not limited to the following-

I. Surveys and Investigations

1. Assess the existing storm water drainage, its functionality, structural soundness, status of equipment (such as evacuation pumps) for handling of storm water, other structures for detention/retention of storm water, any other facilities for handling the storm water; and assess the levels of deficiencies such as problem areas, drain alignment changes, clogging / silting of drains, encroachments, unplanned developments, critical flooding areas/low lying areas and reasons there-of.
2. Carry out an inventory survey of existing storm water drainage systems including natural watercourses, ponds and roadside drains, bridges and culverts, their existing capacity for disposal of storm water, extent of mixing of storm water and sewage effluents, points of major interface between sewerage and storm water drains; the receiving water course for safe discharge and for possible back/reverse flow, if any. Develop a due designation / indexation system to refer to the drainage system and its components. Prepare field

- investigation reports with photo documentation and GPS referencing (Geo Tagged Photos).
3. Conduct primary field surveys and map all water bodies, temple ponds and flood water holding ponds/zones, structures – showing therein probable size duly dimensioned should be shown on plan along with various arrangements / devices (existing) to dispose the accumulated water to nearest outfall/logical disposal or conserve the water so as to reduce the shortage of water supply. GIS files of the above features with their associated attributes shall be submitted in .shp and .dwg format.
 4. Carry out detailed topographic survey. Prepare longitudinal sections of the system and cross sections of important rivers, major nallahs and drains covering a width of 10 m on either bank (to agree the selected sections with the client) generally at intervals of 30 m along with L-sections (unless restricted by any physical features), 5m on cross section on either side of drains and detailing all the temporary and permanent structures met within that width. All the structures and encroachments, if any will also be marked with enough details. Take existing levels for preparation of an arterial drain network leading to the river / canal. GIS files of the above features with their associated attributes shall be submitted in .shp and .dwg format.
 5. All the field surveys and investigations are to be conducted on par with the other studies presently being conducted in the Project Area.
 6. Consultant to identify the available Survey of India GTS BM in and around the project area and the levels transferred from it to the PBMs needs to be cross checked for closing errors.
 7. The consultants to prepare the base map of the project area and the existing SWD network are to be marked in the base map.
 8. The consultant shall ascertain the holding capacity of the discharge tanks and propose any suitable hydraulic interventions needed to seamlessly discharge the Storm water into it avoiding backflow. Also suggest improvement proposal limited to Flood retention such as deepening / improvement of inlet and surplus weirs and to suggest the proposals to eliminate the entry of sewage if any into the lakes.
 9. The consultant shall have to establish Permanent Benchmark (PBM) of 15 Nos within the project area with respect to the known Survey of India GTS (Great Trigonometrical Survey) benchmark or a GTS benchmark by a closed traverse survey transferred from departments like PWD, Highways, Railways etc. The PBM of dimension 0.6 x 0.6 x 0.9 m (as per the details in Annexure II) preferably in Urban Local Body office premises or in discussion with Urban Local Body officials. TBMs shall be established at least one in every 500m or at least one in every street/road.
 10. Geotechnical Surveys: Geotechnical Investigations tests as per relevant I.S / IRC Standards have to be done by consultants to arrive at design parameter for the formation and safe bearing capacity to determine the SPT-N values at depth specified in the relevant IS codes, soil samples taken from bore holes should be usually classified, index properties should be determined and presented in along with the final report. These boreholes should be normally taken to a depth of 3m below the depth where the 'N' value of soil is greater than 100 (to account for any drastic fall in 'N' value below this stratum). Geotechnical investigation has to be carried out for Culverts. Major Road Crossings, Trenchless Technology stretches, major proposed infrastructure at Canal, Channels, at disposal arrangements, RWH structures, Storm Water Pumping Stations if any etc.,. Locations of the Geotechnical Investigations shall be finalized with corporation. The subsurface water at each borehole be sampled and a chemical analysis carried out, to recommend appropriate cement / admixture for use in foundations. Recommendations

of a geo-technical expert should be furnished in the soil report and should cover aspects like appropriate soil stabilization measures if required, bearing capacity of the founding strata etc. After completion of soil investigation tests, based on the nature of soil, suitable foundations for the proposed structures should be discussed and suggested. The necessary certification shall be obtained from the ULB.

11. Soil investigations (trial pits / borehole) shall be conducted based on the design requirement for at least at a grid of 1 km x 1 km in the entire project area to determine the soil classification, depth of water table etc. The necessary certification shall be obtained from the ULB.
12. Topography survey to be conducted for all the parks (20 Nos) demarcating the overall boundary, existing components, vacant space, details of compound wall, RWH structures etc.
13. Soil investigation shall be conducted in the identified parks and complete analysis shall be disclosed and categorize the sub-surface soil in terms of its % of Sand, Silt and Clay and suggest its suitability for infiltration/sponge characteristics.
14. Boundary survey of the water bodies (22 Nos) demarcating the overall water body boundary, outside the water body bunds and also the water spread area as on the date of survey.
 - a. Total area of each water body falling within the FTL/MWL.
 - b. The LS of each water body bund showing the top width, bottom width all along the length of main tank bund, ring bunds around the water bodies. Cross sections at every 50 m intervals of the LS and levels at 1 m interval along the slopes of bund up to 15 m from the bottom edge of the slope.
 - c. Bed levels of the water bodies at gridlines along north-south and east-west at 25 m spacing to cover the entire bed of each water body and also to a distance of 50 m around the water bodies outside the bund of each water body giving ground levels at every 15 m interval along the gridlines.
 - d. Surveying and mapping all existing water inlet and outlet drains of the each water body indicating the width of channels as existing to a distance of 500 m from the water bodies along the upstream and downstream of the inlet and outlet channels. Cross sections of these channels (both inlet and outlet channels) have to be surveyed at every 25 m interval indicating levels at every 1 m up to the total width of the channel extending up to 5 m on either side of the channel. Cross section drawings bringing out details shall be prepared and submitted.
 - e. The full storage capacity of each water body shall be computed taking into consideration the survey data.
 - f. Existing surplus weir and its cross-section details such as top width, bottom width, top level, bottom level, length, condition and cross section at every 5 m distance with levels at 0.5 m intervals up to 10 m on either side along the alignment of the weir has to be shown in a drawing.
 - g. Contour survey of the bed, for baseline data - The contour map of each water body has to be prepared showing the depth of water bodies at different points by means of contour lines drawn for every 1 m difference in elevation. The map must be prepared based on bed levels taken at several points of each water body and not extrapolated from a few spot levels. The spot levels at intersections of 15 m grids have to be factually read and marked on the plan of the lake.
 - h. Bathymetry survey - The bathymetric map of the lake has to be prepared showing the depth of the lake at different points by means of contour lines drawn for every 1 m difference in elevation. The map must be prepared based on bed levels taken at several points of the lake and not extrapolated from a few spot levels. The spot

levels at intersections of 15 m grids have to be factually read and marked on the plan of the lake.

- i. Bio-diversity assessment-The consultants shall assess the pristine ecological status of the area based on the past / historical data, and then establish the current ecological status. The consultants shall define the mitigative measures to minimize impact of anthropogenic activities.
- j. The consultant shall collect representative water and soil samples for each water body and analyze for pollutants impairing its quality. Indicator parameters, sample collection and its procedures for analyzing shall be followed according to the norms stipulated by CPCB.
- k. The consultant shall analyze the water samples for eutrophication and represent it by an index indicating the status of the water body.
- l. Environmental baseline surveys such as air, noise, water, soil etc. to be conducted for the project area based on the requirements of the KfW Environmental Framework.
- m. The consultant shall identify the encroachment in each water body after finalizing its boundary. If any encroachment identified inside the water body, the consultant shall propose necessary resettlement and rehabilitation plan for the same as per updated Environmental Climate Change and Social Management Framework (ECSMF) and KfW Bank's Sustainability Guidelines (SG) including Environmental and Social Standards (ESS) of the World Bank.

II. Storm Water Drain

1. The project area is about 70 Km², (Detail in Annexure I)
2. The consultant shall study, analyze and consider from the upstream catchments contributing to the corporation till its final and logical disposal locations downstream.
3. DPR shall be prepared based on latest CPHEEO Manual on Urban Storm Water Management and adopt a catchment / watershed / urban shed approach using a professional/globally accepted, standard storm water drainage model for designing.
4. Conduct reconnaissance survey and preliminary assessment of the project area, get a broader understanding of the status and issues of the existing storm water drainage, its catchment patterns, the existing and proposed land use planning, and existing condition of water bodies with hydraulic details within the Urban Local Bodies apart from the final disposal locations.
5. 30 years rainfall data shall be obtained from the recognized Government departments and available secondary information (with due validation). In case of non-availability of rainfall data, the nearest rainfall station data shall be obtained representing its catchment.
6. Upon Collection of rainfall records for 30 years from IMD, provide a range of potential of changes in Intensity – Duration – Frequency (IDF) value based on appropriate global climate scenarios, and evaluate impact of potential mitigation measures for an agreed planning scenario, for Storm event records including the return frequency of the storms (e.g. Storm event record for 1 in 2, 5, 10, 20 and 50 years Storm). Design rainfall should be based on annual exceedance (AE) series for return periods equal or less than 5 years.
7. The consultants to carry out the hydraulic designs compatible to import in other modelling software such as StormCAD, SewerGems, SWMM, Mike etc.
8. More attention to be provided in the catchment delineation in such a way that inundation / flooding / ponding in the streets to be avoided.

9. Upstream and downstream impact of the project area to be considered while designing the SWD.
10. Collect and update information regarding flood levels in the Project area during rainfalls of different intensity. Identify the major drainage and minor drainage of the existing storm water drainage network. Also collect historical data on extreme flood events and associated impacts.
11. The consultants shall analyze the ongoing storm water drainage / Lake projects in and around the project area and take into account the proposal of these projects.
12. Prepare the contour maps for the study area to show the topography of the area. Also capture details of major drains and their catchment areas, major outfalls, flow patterns, their preliminary longitudinal sections, drain reaches etc. GIS files of the above features with their associated attributes shall be submitted in .shp and .dwg format.
13. Indicate the details of other underground services, mainly sewers and water mains, electrical cables etc., which are in the vicinity of the storm water drainage system and show their distance from storm water drains with a view to know about the possibility of providing by-pass storm water drain/rider sewers for the sewer line, as required and for deciding their location. The surveys shall be done along with the Engineers of the Corporation. 5% of the survey works has to be cross checked in the field and certified by the Corporation Engineers.
14. Assess the flooding records including extent of flooding, area of inundation and depth; existing drainage system records including the size, invert levels and ground levels of the drains; Hydrographical and Topographical data of the main channels. Sewerage network, pumping stations, overflow locations / connections if any. Industrial type, locations, waste discharge characteristics and out fall locations.
15. Based on the field surveys conducted prepare legible maps and also detailed survey to identify the catchment and sub-catchment areas of the network and contributory areas from outside the project area, and the major outfalls and assess their capacity to receive the storm waters from the project area; assess the soil characteristics and area development patterns.
16. The consultant shall study the future urbanization of the project area with consideration of the different impacts for the drainage system, especially the lakes, odai, and Rivers and the same should be applied in the design of storm water drain system. Any existing pattern / system of sequential filling and management of waterbodies or traditional water harvesting structures for RWH or flood control shall be duly considered and integrated into the proposed system with possible upgradation.
17. The excavated muck/grit/ soil / solid waste / hazardous waste to be disposed of from the SWD shall be analyzed for various parameters as per required norms. Also, the consultants shall study and suggest measures for avoiding dumping of solid waste into drains. No of samples shall be decided based on the land use pattern and availability of other infrastructure like Sewerage, SWM etc (minimum of 10 locations).
18. The consultant shall conduct soil and groundwater investigations and propose RWH inside (pipe shafts) and outside (recharge wells, recharge pits) the drains based on the hydraulic calculations.
19. Temporary flooding of selected areas may be allowed, on economic considerations. Based on the analysis of the level of intensity / frequency of rain beyond which such flooding is likely to happen, and the areas where it is likely to be done, based on various scenarios and costs, which shall be agreed by the client.
20. In case the capacity of existing major drains/rivers connecting the river / canals are not sufficient to take care of the maximum run off, then remodeling of the existing major

drains or new additional drains may be proposed to avoid any inundation of rainwater in the project area. The adequacy of the outlet of the existing major rivers / canals and boundary conditions of the receiving water bodies may also be checked for the total maximum run off in the project area and propose suitable measures to address the issues.

21. A comprehensive and state of the art drainage design must also consider the water bodies and the natural buffer functions of the water bodies.
22. This water balance shall be compared with the existing and future storage volumes of the lakes and the flow capacity of the connecting channels.
23. Where there is interface(Domestic/Commercial/Industrial sewage) between sewerage system and storm water drainage, propose appropriate plans to remove / reduce the interface (disconnect and divert entry of sewage into the lakes); and/or reduce the impact.
24. The existing SWD system and the proposed system shall seamlessly merge to function without bottlenecks.
25. Using preliminary longitudinal sections of the existing drains and water courses, and their tentative slopes fixed early on, undertake trial designs, to compare alternative drain reaches, based on which select the most suitable alternative for the final design, which are technically and economically justifiable.
26. Drains should be planned to take into consideration the ground levels, slope of the ground, valley and ridges and approved land use plan for development of Urban Local Bodies. For each length of Storm drain, the drainage area should be indicated clearly on the map and measured. The boundaries of each tributary are dependent on topography, land use, nature of development and shape of the drainage basins. The incremental area may be indicated separately on the compilation sheet and the total area computed.
27. While formulating designs, the existing side drains, canals, and other major storm water canals / rivers maintained by the PWD Department., Highways Department should be analyzed based on the maximum rainfall and storm water runoff for the project area on a scientific basis.
28. Catchment based approach shall be adopted also to ensure there is full network – without ‘missing’ the required ‘links’. Missing links shall be identified and integrated.
29. The consultant shall include both adaptation and resilience aspects for solutions. Nature Based Solutions for resilience shall be given due consideration while planning the presence of multiple tanks, lakes, outfalls and rivers in these proposed towns.
30. Consultant shall bring in novel concepts like ‘sponge city’ or any other similar concepts.
31. Consultant shall also look at proposed developments which might hinder/support drainage, development plan etc.
32. Traditional water harvesting, water reuse, spill over and retention mechanisms if any shall also be duly considered in design and rejuvenated, with required upgradations.
33. The designs shall be prepared taking into consideration of all potential risks from the works and site constraints to ensure safety during implementation, operation and maintenance. The access difficulties in frequented places like schools, religious places, offices, etc, public utilities that cross the drain needs to be specifically considered for design of drains in such points. Vulnerabilities of the existing conditions shall be assessed considering various scenarios & gaps to be identified and based on this analysis, adaptive strategies shall be suggested.

34. Based on this analysis, identify the most appropriate alternatives that may include drain improvements, augmentation/extension, flood detention measures, improvements in flood handling equipment/structures, including provision of storm water pumping stations where necessary, strengthening of existing structures etc. The proposed alternative (which consists of various sub-alternatives on major drains / decisions on flood water retention / pumping etc) shall be the economic one amongst the selected alternatives, looking from capital / O&M costs angle; in addition to meeting the planning and design requirements mentioned above. Mechanized cleaning for Maintenance of RWH structures shall be ensured through design.
35. Consultant to Prepare Environmental, Climate Change and Social Impact Assessment Report as per the Annexure -V to ToR
36. Based on the above, the concept (drains) of SWD drains shall be submitted by the consultants for this stage.
37. SWD drains shall be prioritized as primary drains, secondary drains and tertiary drains. SWD drains shall be proposed only where there is sufficient runoff, sufficient width of street, no natural barriers, etc., in other areas kerb and gutter arrangement shall be studied and proposed.
38. Open source Satellite Imagery/ Data of the study area shall be referred to map the existing details in GIS format. The baseline data gathering, and analysis will consider the ongoing hydrology and hydraulics work in the water shed. GIS base maps for the existing base plans and future master plans and all the maps related to Eco-sensitive zones, cultural heritage sites, Slum encroachments in the canal boundaries etc.,.
 - (i) Roads
 - (ii) Drains/ River/ Canals including drainage catchment areas/ boundaries.
 - (iii) Sewerage network, pumping locations, overflow locations connection including sewer shed if any.
 - (iv) Land use map
 - (v) Administrative Boundaries
 - (vi) Climate change adaptation scenario as per RCP 4.5 scenario upto 2055.
 - (vii) GIS files of the above features with their associated attributes shall be submitted in .shp and .dwg format.
39. GIS Map shall have layers clearly defined. It should be designed such a way that with a tick mark each layer should be added for easy use by officials of Corporation. All attributes captured in the survey should be brought in as layers. It should have the utility drawings as a layer apart from Contour map, Satellite imagery, flow diagram, sub basins etc. GIS/other maps may also be provided to ULBs in easily workable Google Earth platform so that they can understand the topography & layout and use it for their long term planning.
40. Project Designs: For the given purpose and functional use of the respective projects, proper design has to be developed. The system shall be designed following CPHEEO / MoUD guidelines and IRC: SP42 “guidelines on road drainage”. In built-up areas and junctions, a network of subsurface drains with interception chambers may be considered to intercept the surface flow. The consultants can have freedom to choose the type of substructure and superstructure, provided code specification / CPHEEO stipulations are met. The drawings and designs shall include a general arrangement

drawing and a detailed longitudinal section drawing of all components in size A1 or A2. The level of detailing shall be such so as to enable check of conformance with code provisions, including detailed construction drawings and bar bending schedules.

41. Divide the project area into various drainage zones (preferably based on sub catchment boundaries) considering the natural topography and contributory areas with a view to adopt decentralized approach as far as possible and economize the cost of overall system and also to avoid pumping stations. Zoning should be done after detailed field survey and investigation. Consultants shall also study the impact of the project on the adjoining areas.
42. If pumping station warranted based on the topography or site conditions in the project area, the consultant shall carry out the detailed design of pumping station and pumping main including structural, electro-mechanical with all necessary ancillary works. The pumping system shall be designed based on MoUD guidelines.
43. Identify appropriate planning and design parameters based on the project area situation; mainly, the appropriate design frequencies of the storms (based on degree of protection needed vs. permitted flooding, based on type of area – residential, commercial, business districts etc), the run-off coefficients, proposed method of computation, proposed channel shapes etc., and design shall be based on CPHEEO and MoUD guidelines, with appropriate justified modifications if needed.
44. Utilizing proven and readily available computer dynamic modeling software (that allows for visually depicting the design changes, and their impact), carry out analysis of existing situations of storm water drains to identify deficiencies and develop alternative strategies for and options for expansion / augmentation of the existing system to address system deficiencies. While planning the system, give considerations to the principles and functional requirements listed below:

Principles: The proposed solutions should

- a) Collect and safely convey storm water to receiving waters.
- b) To flood proof important buildings/areas (major drainage design)
- c) To cater for frequent or nuisance storm water flows (minor drainage design)
- d) To retain within each catchment as much incident rain as possible by maximizing use of existing natural water courses and providing floodway reservations / minor detention measures within the catchment area
- e) Follow the general alignment of the existing water way.
- f) Provide minimum interference with manmade / natural obstructions (particularly on the drain alignments);
- g) Reduce land acquisition and R&R; Possible alternatives to minimize land acquisition and social impacts.
- h) Meet the existing and proposed developmental needs and ongoing / proposed projects in and around the project area.
- i) Study the project alternatives and minimize the impact on the surrounding areas such as trees and other Sensitive Environmental Components (SEC) and suggest mitigation measures for design, construction and O&M phases.

Meet the functional requirements:

- (i) Sustainability (maximizing use of natural drainage, storage's);

- (ii) Functionality (ease of maintenance, reliability of suggested measures)
 - (iii) Levels of service (alleviation from flooding, community expectations through consultations with various stakeholders, obtaining and incorporating the feedbacks received as appropriate, damage consequences); and
 - (iv) Cost effectiveness (maintenance, environmental benefits, balance between allowed damages vs. safety)
45. The consultant shall make necessary hydrodynamic modeling of the proposed drains and existing drains, lakes, rivers, odai, upstream area (inflow) and downstream area (outflow) of the project area for different storm events. The flooding areas and mitigation measures for the same shall be provided.
 46. The modeling shall be done using standard dynamic software and simulations for various concepts. Necessary training has to be given to the client.
 47. The Inundation map for various climate change scenarios and the mitigation measures for the proposed network shall be prepared. Indicate the existing inundation areas clearly, showing probable depth of water accumulation in case of heavy rainfall intensities. Assess the reasons for such inundation based on the information collected and carryout economic analysis to estimate the resultant costs such as reduction of damage of roads, reduction in fuel costs of pumping (for bailing the flood water), damage to the residential and other structures, etc.,
 48. Identify the prioritized investments and phasing. For the flood prone areas identified in the Background, indicate appropriate measures that need to be taken up on priority.
 - 49.
 50. Prepare maps with latest existing and proposed measures, along with their phasing and current land use.
 - a. Overall Master Plan map, showing major and secondary drains, salient facilities, catchment areas, outfalls, receiving water bodies etc.
 - b. Schematic diagram showing flow directions, flows, facility sizing nomenclature etc
 - c. For the drains, L-section and cross-section drawing showing minimum 10 meters on either side of the drain, @ every 30m interval or as required with details of underground facilities, salient structures/obstructions; of all the existing drains to be remodeled and the proposed drains indicating the details of drains.
 - d. Permanent Benchmarks (PBM) shall be established using the existing GTS benchmark. The number of TBM's and PBM's mentioned above shall be established on all salient locations, the details shall be submitted along with geo tagged photographs and .shp file as part of the output.
 51. Feasibility study for using pre-cast structures shall be studied as part of this project. Structural designs shall be based on soil investigation report for channel improvements and all SWD sections; Design of new channel bed profile that includes low flow channel to improve sediment transport to limit deposition. Strategies to assess feasibility of increasing existing tank storage and provision of rainwater harvesting structure at designated locations along storm water drain. Structural and non-structural measures to regulate and curb dumping of solid waste in the channel. Feasibility of providing storm water quality management devices along the storm water system e.g., trash racks, float booms; Provision of silt trap pits and RWH along the channels to be

- assessed and included in the report with detailed cost estimation. Mean Sea Level (MSL) will be established at permanent structures (e.g Culverts, Bridges & Buildings) in all waterways/watersheds; if any other data is required according to the site conditions furnished with desirable rates.
52. The adequacy of load bearing capacity for SWDs, existing culverts and other road crossings in the alignment must be assessed for their structural adequacy.
 53. BoQ / Estimate Provisions / Bid Documents: Critical costs that need to be included in cost estimates, among others, are:
 - (i) Shifting of underground utilities; & tree cutting / transplantation
 - (ii) safe disposal of muck from the SWD during construction as well as diversion arrangements, dewatering arrangements etc
 - (iii) disconnection of house sewer connections from SWD
 - (iv) working in unsafe and unhygienic areas- narrow areas-highly populated and high traffic areas and high rock and high water table;
 - (v) rates for the material of construction;
 - (vi) Provision for Finance charges, insurance charges, labour cess, third party inspection charges, employer's office, transport, etc,;
 - (vii) statutory taxes and duties;
 - (viii) provisions for ESHS/safety planning including sidewall/ structure protection, safety of households and access to households where SWD works are taken up, Environmental and social Management Plan;
 - (ix) Environmental monitoring
 - (x) appropriate costs shall be provided in the estimate to cover the additional cost towards vehicles, staff, laboratory equipment and tests etc. for the employer;
 - (xi) Price contingencies linked to implementation time frame and expected escalation; and
 - (xii) Detailed BOQ including ESMP measures components, technical specifications, designs and drawings for all project components.
 54. Based on the preferred solutions, identify a prioritized capital investments plan, for which prepare detailed engineering designs, contract packages, implementation plans, including ESMP and Environmental Monitoring Plan (EMOP), costing and bid documents. The consultant shall prepare a Resettlement Plan and carry out consultations, FGDs and the outcome of consultation should be brought into the Final Report.
 55. Prepare a financial operating Plan for the corporation as appropriate. The financial operating plan shall consist of financial assessment of corporation for ascertaining financial sustainability of proposed investments, undertaking of financial analysis of existing financial situation and also the preparation of 10-15 year financial projections for corporation (the "Financial and Operating Plan") covering summary Income-Expenditure and Balance Sheet / Capital Account statements of the corporation after taking into account the capital and operating costs of the proposed SWD investments. This will be an important input into the phasing of SWD investments as well.

56. The consultant shall also prepare a financing plan, cost benefit analysis and ERR for the proposed investments. The Financial analysis shall be carried out based on the 1. Own Financing, 2. Financing by State & Central Government grants; & 3. External Assistance through multilateral agencies. The sensitivity analysis considering climate change aspects to be carried out.
57. Prepare structural designs of storm water handling structures, major drains, to withstand the hydraulic / other forces.
58. Consultant to suggest suitable materials for construction with cost benefit analysis for different materials and sections.
59. Study the extent of road crossings required for different types of roads maintained by different agencies. Consultant to suggest the most effective way in making the road crossings for traffic prone areas. The cost of road cuts shall be included in the cost estimates.
60. Prepare detailed cost estimates based on item rate basis using the latest schedule of rates / market rates as appropriate. Estimate necessary road restoration charges wherever needed. Assist the corporation in getting administrative / technical sanction for the scheme from competent authorities. There should not be any lump sum items in the bill of quantities. For items not covered under the schedule of rates, market rates to be assessed and three quotes have to be obtained.
61. Based on the surveys and designs and ESMPs evolved by the consultants, within the framework and the requirements of the project, the consultants have to prepare detailed item and quantity schedules and work out the cost estimates.
62. Prepare suitable procurement plan, tender documents based on priority, project implementation schedule for execution and contract packaging plans including phasing and priority.
63. All the designs, field investigations, surveys, other analyses and reports shall be as per MoUD Guidelines, Indian Standards (IS), Indian Roads Congress (IRC), and CPHEEO Manual on Storm Water Drainage Systems as applicable.
64. Review existing arrangements for maintenance of the storm water drains, the institutional arrangements and capacities and gaps, assess O&M costs – recurring and additional for the proposed investments; based on which prepare Maintenance Management Plan, including future renewal plans, strategies to meet O&M costs, institutional authority and scope of SWD zones falling under that authority, institutional strengthening measures including possible outsourcing activities. Possible steps to avoid encroachment/squatting (by developing footpaths, Walkways, parking lots, and so on) during O&M Stage. Prepare maintenance management plans using the mechanical devices will be proposed for desilting the storm water channels.
65. Consultant shall identify the locations for disposal of surplus earth in consultation with corporation officials and necessary conveyance charges to be included in the cost estimates and BoQ.
66. Involve the officials of the following departments / agencies at all stages of the work and shall liaise with the Nodal officer very often.
 - (i) National / State Highways Department/NHAI
 - (ii) Southern Railways
 - (iii) Public Works Department
 - (iv) TWAD

- (v) TNEB
 - (vi) Department of Telecommunication
 - (vii) Rural Development Department
 - (viii) Director of Municipal Administration
 - (ix) Others (Archaeology, Forest, as required)
67. All regulatory clearances, permissions, NOC including for land requirements, SH/NH/NHI road crossings, ASI, Forests has to be listed and discussed with concerned agencies at the time of DPR preparation itself by the Consultant and signed minutes to be attached as part of DPR.
 68. Land required: Similar exercise needs to be done for each land parcel that is required for the project and signed minutes attached as part of DPR after consultation with landowners.
 69. Technical alternatives associated with each such clearance / land parcel to be evaluated and the best option to be recommended based on the discussions with concerned agencies as noted above.
 70. The consultant must conduct all field surveys / field investigations, etc., for the entire Project area as required based on the MoUD guidelines. The quantities stated in the Annexure I are indicative only.
 71. Prepare an Executive summary with need, necessity and justification based on ERR, technical, ESIA, etc., in the absence of a dedicated or partial UGSS scheme. Tamil translation of the final executive summary to be provided.
 72. Finalized Report of Inception to Draft Final Report
 73. Prepare a maintenance management plan using the mechanical devices (e.g. robotic excavators) proposed for desilting the storm water channels and it shall be brought under Capital Expenditure. Estimated cost to this to be included in the cost estimates.
 74. The machinery and equipment to be purchased for O&M shall also be suggested.
 75. The checklist satisfying MoUD guidelines and ToR & Action Taken previous minutes of meeting compliance shall be provided by the consultants at each stage of the Report.
 76. Packaging of the Proposals based on the priority.
 77. Social, Environmental, Archaeological, Occupational Health and Safety aspects
 78. Prepare Resettlement Plan (RP) as per ESCMF requirements for the project and Identify any further resettlement requirements/including social impacts identified during project implementation and costs that may be required and provide all information required in relation to right-of-way access as well as the relocation of existing utilities, if required, and other obstructions at the proposed work sites, including vendor stalls, permanent as well as temporary economic impacts in the project sites.
 79. Prepare Community Participation and Gender Equality and Social Inclusion as part of (GESI) Action Plan as per ESCMF.
 80. List out all the necessary environmental permissions and statutory requirements required prior to construction, ASI/Department of Archaeology, Department of Forests, National Parks, and tree-cutting etc.
 81. Stakeholder Consultations and Disclosure: Conduct stakeholder consultations and prepare a dissemination report and disclosure report.

82. The costs for conducting stakeholder consultations have to be borne by the consultants.
83. Cost estimates and BOQ: Based on the ESMP, cost estimates shall be prepared which shall be included in the project cost and necessary BOQs shall be identified for inclusion in the bid document to ensure implementation of ESMP.
84. Quality Assurance Plan (QAP): The Consultant shall submit a quality assurance plan for the proposed DPR and QAP implementation plan and responsibility for each stage and overall responsibility.
85. Adopt an Integrated approach to SWD which shall include provision of sustainable urban services such as solid waste management, wastewater management and water supply infrastructure. The consultant shall also study and include the impacts and mitigation measures of the ongoing and proposed projects in and around the project area in the Detailed Project Report. The proposed SWD network shall seamlessly synergize with the existing network in the project area and in upstream and downstream catchment of project area with an integrated approach.

III. **Sponge City / Park Concept**

1. The consultant to carry out the reconnaissance survey for all the 503 OSR sites and identify the suitable location for developing sponge parks and public parks with public amenities (20 Nos) such as pathway, children play area, open gym, meditation centre, landscaping, toilets, security cabin, compound wall with elegant entrance etc. The locations for the developmental activity to be discussed and finalized with the ULB.
2. Study and find the suitable and feasible areas where sponge city concepts can be implemented preferably in public parks, open areas etc.
3. Study and find the suitable and feasible areas where parks can be developed with the provision of sponge park components like rainwater harvesting, infiltration trench with other amenities such as foot path, children play area, compound wall, entrance, toilets, landscaping, lighting, etc.
4. The sponge city concept shall encompass all the components which enhances the overall infiltration capacity of the catchment.
5. The sponge city concept shall cover components in various aspects such as rainwater harvesting, improve storm water management, drain naturalization, water recharging structures, recharging aquifer, and others etc.,
6. All the water bodies such as lakes, ponds, temple tanks, abandoned quarries etc. are to be linked suitably with SWD to improve the water storage and act as RWH structure.
7. Innovative RWH system to be proposed in the Project Area to strengthen the ground water table.
8. The consultant to study the water table and soil type in the proposed sponge city / sponge parks concepts.
9. The consultants to assess the existing flora and fauna in the parks and prepare the drawings duly earmarking the existing details.
10. Consultant to prepare the DPR including the detailed designs, estimates, architectural & structural drawings, bid documents etc.
11. A spatial map shows the overall catchment with the concept of sponge city and various components as proposed above.
12. The consultant shall study the successful case studies and implementation of such sponge parks/cities at national level and ensure the proposed design adheres the

guidelines/principles of sponge parks/cities.

13. Consultant to Prepare Environmental, Climate Change and Social Impact Assessment Report as per the Annexure -V to ToR

IV. Rejuvenation of Water Bodies

1. The consultant shall study all the water bodies (list of water bodies provided in Annexure IV) with reference to the topographical maps, satellite imagery, revenue records, Town Survey Registers, Tank memoir etc.,
2. The consultant shall study the past and present storage capacity of the water bodies.
3. The consultant shall collect and update information regarding flood levels in the project area during rainfall of different intensities.
4. The consultant shall identify the inlets and outlets, other structures of the water bodies and its existing condition. Explain the nature of inlet/outlet such as kutchra, pucca, lined etc., with engineering drawings.
5. Identify sources of pollution that discharges polluted water into the water bodies and the agencies/industries responsible for causing such pollution and suggest the mitigation measures for pollution abatement. The consultant shall study the water quality and soil quality in the project area.
6. Identify the parcels of vacant land available abutting on the water bodies and drawings with respect to alignment and extent of land that can be reclaimed.
7. The consultant to identify the interconnections/link between the water bodies.
8. Consultant to propose the measures to restore the interconnections/link between the water bodies and to the primary source.
9. The consultant shall highlight the issues relating to retention of water in the water bodies for replenishing water losses due to evaporation & seepage and suggest measures for retaining water in the water bodies. Suggest various technologies for the same.
10. The consultants shall study the impact of any invasive species such as water hyacinth, prosopis juliflora and plan for removal of the same.
11. Consultant to assess the stability of the bund for all the water bodies and propose various bund stabilization options.
12. Explore different approaches for efficient cleaning and protection of water bodies from future abuse.
13. Consultants to explore various options for restoration of the water bodies by using various technologies, materials, etc.,
14. Consultant to develop 4 Nos. of the water bodies with a) landscaping along or near the waterfront with a natural outlook that will provide the general public with an open space for leisure. The consultant shall identify the existing flora in the project area and suggest suitable plantation along the bund, vacant spaces surrounding the water bodies, avenue trees in adjacent roads/lanes. Native species shall be recommended to serve the lake ecosystem and also to serve as a habitat for birds and terrestrial organisms.
b) Explore leisure activities like walking, jogging and other activities with minimum human interference in the water bodies and along the linking channel.
15. Prepare an action plan for restoration, waterfront development and operation & maintenance of water bodies. The action plan shall suggest short term and long-term

- measures to protect and maintain the water bodies in an integrated manner.
16. Identify various funding options for the implementation of the project. (Central Govt Grants, State Government Grants, International Grants etc).
 17. The consultant shall prepare detailed designs for which working drawings shall be prepared (engineering, architectural, etc.,) along with Bill of Quantities and Cost Estimates.
 18. To study and suggest for overflow arrangement, interconnectivity with other lakes/water bodies, rainwater drains, bund strengthening, etc., with detailed designs and cost estimates.
 19. Consultants shall explore the possibilities like fishing, angling by the stakeholders.
 20. To provide green concepts and urban planning principles.
 21. The consultant shall suggest measures to protect the water bodies from future misuse such as disposal of wastewater, dumping of solid waste, encroaching, commercialization etc.
 22. Consultant to study the STP treated used water parameters to for the safe disposal into the water bodies and provide suitable technology for further treatment if required to dispose the treated used water into the waterbodies as per the relevant guidelines with detailed designs, drawings, estimates, BOQ and bid documents etc.
 23. The consultants shall provide 3 concepts with 2D and 3D views as part of Interim Report and walkthrough for the finalized concept as part of Final Report. Based on the finalized concept the consultants have to prepare detailed design and drawings, BoQ and cost estimates.
 24. Consultant to Prepare Environmental, Climate Change and Social Impact Assessment Report as per the Annexure -V to ToR

V. Climate Resilience Report

1. The consultant shall prepare climate resilience/climate action plan report considering the Representative Concentration Pathway (RCP) 4.5 and 8.5 scenario.
2. The consultant shall suggest the various possible measures to adapt the extreme climate events in future specific to the project area.
3. The consultants shall also study the sustainability, climate change impacts, climate resilience and incorporate Climate Change Adaptation strategies in the design of the storm water drainage as part of the Draft Final Report.
4. Climate change is increasingly straining water infrastructure with historic droughts amplifying water scarcity on the one hand and extreme storms causing urban flooding on the other.
5. Consultants shall provide the implementable solutions that will improve the performance of urban infrastructure and provide recommendations for climate resilience shall include provision of Green infrastructure encompasses a variety of water management practices, such as vegetated rooftops, roadside plantings, absorbent gardens, and other measures that capture, filter, and reduce storm water to reduce flooding and cut down on the amount of polluted runoff that reaches streams, rivers, lakes, and oceans..
6. Consultant may refer and best utilize a report put out by the Ministry of Earth Sciences (MOES), Government of India in June 2020, on 'Assessment of Climate Change over the Indian Region. This report provides a detailed overview and synthesis of the

published scientific literature on climate change over India and adjoining regions, for the subject assignment.

7. Undertake stakeholder consultations as per ECSMF requirements.

VI FINAL BID DOCUMENTS

1. Tender: Preparation of Bid documents as per the rules and regulations and in the prescribed format of ADB/KfW / GoTN.
2. The Tender documents will be submitted in adequate packages as instructed by the review committee consisting of the following:
 - (i) Main Volume
 - (ii) Drawings for each of the package along with bar bending schedule
 - (iii) Technical Specifications (incl. ESHS requirements) to that package
 - (iv) Cost Estimate relevant to that package.
 - (v) Costs for Implementation of Environmental And Social Management Plan and Environmental Monitoring Plan in BoQs.
3. The methodology for de-watering / temporary works / providing temporary approach platforms for residences during construction/ other measures during construction shall be given in detail by the consultant in the Tender Technical Specification volume.
4. The consultant shall make necessary presentations to funding agencies after completion of the assignment as required.

VII STANDARD OPERATING PROCEDURE FOR STORM WATER DRAIN

1. SOP for SWD shall be prepared based on the MoUD guidelines, CPHEEO O&M manual on SWD, National Disaster Management Authority (NDMA) Guidelines on Management of Urban Flooding and shall contain the following specific for Hosur Municipal Corporation.
2. Consultant shall study the existing reports available with corporation for SWD, flood management, disaster management.
3. Mention line agencies and departments involvement in the SOP.
4. Rainfall is occurring in catchment area of rivers / channels flowing through and impacting the inundation.
5. Details of the tanks (holding flood water) and the channels flowing through corporation maintained by PWD / any other department.
6. SOP shall contain flood management strategy for (i) Pre-Monsoon Phase -, Preparedness: Planning for Disaster Reduction, (ii) During Monsoon Phase: Early Warning, Effective Response and Management: Relief planning and execution, i) Post-Monsoon Phase: Restoration and Re-habilitation.
7. SOP shall describe the Establishment of Emergency Operations Centers (EOC) in corporation. Shall be prepared based on the present setup for emergency operations. Describe the Establishment of Crisis control center with Tasks to be performed by corporation co-ordination and with the support from all other line departments and involved agencies.

8. SOP shall contain the details of involvement and coordination of various key public agencies/ departments (including corporation) with their role at preparedness stage, Early warning stage, Rescue and Relief during flooding stage or at restoration and Rehabilitation stages.
9. Action plans by Key Agencies including corporation upto ward level.
10. Describe how real-time information on operation of the lakes could be integrated with Decision support system for corporation.

VIII Dissemination and Capacity Building Report – The consultant to conduct the one-day Capacity Building training on the dissemination of the project and submit the dissemination report.

D. DATA, SERVICES AND FACILITIES TO BE PROVIDED BY THE CLIENT

Data available with ULB, reports, plans shall be provided to the consultants.

E. OUTPUTS

1. Inception report: General discussion about macro level details, along with solution to the flood-prone areas indicated. Methodology for the study, Work Plan and time schedule and Quality Assurance Plan.
2. Survey Report: All field surveys and investigations along with drawings and data as per the ToR. Certificate from the ULB for 5% check for the survey works.
3. Interim report and Master Plan: Feasibility analysis and preliminary design including possible alternatives, broad costs of proposals, inference on the survey and field investigations, E&S initial screening reports, Social Assessment Report and Resettlement Action Plan, Environmental Assessment report, O&M plans, economic analysis and justification, details of confirmation to planning, design and O&M as per the ToR.
4. Stakeholders Consultation Plan : Stakeholder Engagement plan to be prepared in line with the ECSMF SEP outline.
5. Draft Final Report: Draft detailed design, Draft Resettlement Plan, draft ESIA and Environmental and Social Management Plan, cost estimate (including items identified in ESMP, procurement and implementation plans) BOQ., Financial Operating Plan, phasing and contract packaging, etc. Draft Bid Documents and Draft SoP.
6. Final Report and Bid documents: Final detailed design along with flow chart, drawings, final RP, ESIA and ESMP, cost estimates, financial operating plan, phasing and contract packaging, etc. The IEE, RP Reports and Final Bid document (Package wise) shall be in separate volumes and Final SoP.
7. Dissemination and Capacity Building Report: The consultant to conduct the one-day workshop and provide the training on the SoP.
8. Consultants shall attend periodical reviews to be conducted by the clients with various departments of the government. Consultants shall make presentations to clients and to various departments as required during various stages of the assignment.

9. The consultant shall be required to come for discussion as required before and after submission of each stage of deliverables.
10. The consultant shall be required to submit 9 copies of each of the reports besides providing a soft copy of all reports and Auto CAD drawings. Wherever possible, duplex mode shall be used for submission of reports. The report layout and arrangement of chapters shall be shared with the client prior to submission of the reports.

F. OUTPUTS AND RELATED PAYMENT SCHEDULE:

Sl. No	Deliverables	Cumulative Days from Lol	DPR I - ISWD	DPR II - Water Bodies	DPR III - Parks
			Payment Schedule in % of the contract agreement value		
1	Inception Report	30	5.0	2.0	1.5
2	Survey Report	90	10.0	4.0	2.5
3	Interim Report and Master Plan	150	10.0	4.0	2.5
4	Draft Final Report, Draft ESHS report and Draft Bid Document	240	17.5	7.0	3.5
5	Stakeholder Consultations and Dissemination Report	270	2.5	1.0	1.0
6	Final Report, Final ESHS report and Final bid documents - IV	345	10.0	5.0	2.0
7	SoP (Parallel Activity)	345	2.5	1.0	1.0
8	Dissemination and Capacity Building Report	360	2.5	1.0	1.0
Total			60.0	25.0	15.0

Note

1. The consultant should submit separate reports for SWD, Rejuvenation of Water Bodies, Sponge City / Parks concept and Climate resilient plan.
2. The consultant should submit seven copies of all the above reports along with soft copy (MS word, Excel, AutoCAD, GIS, PDF, others) of the report for review. All the pages in reports shall be printed in duplex mode except for A3 pages. Separate Reports has to be prepared for each package (if more than one package is finalized by the client).
3. The Consultant shall make necessary presentations to clients and to various departments as required during various stages of the assignment.
4. Consultants shall submit periodical monthly, quarterly reports in detail to the clients and

shall attend periodical reviews to be conducted by the clients with various departments of the government.

5. Consultants shall make presentations to clients and to various departments as required during various stages of the assignment.
6. The costs for conducting stakeholder consultations should be included in the financial proposal.

H. PROCEDURE FOR REVIEW OF PROGRESS REPORTS.

The review committee will review the progress of the work. The decision / suggestion carried out will be reviewed in the next meeting. The comments or views on the various reports shall be given to the consultant within 15 days of submission. The various reports submitted by consultants may be reviewed by the KfW, and the comments and suggestions have to be incorporated by the consultants accordingly.

I. Team Composition & Qualification Requirements for the Key Experts (and any other requirements which will be used for evaluating the Key Experts)

1. Team Composition with estimated Input: The Consultant team comprises of Key-experts with estimation of 45 person-months DPR, and national Non-key experts of 60 person-months, excluding those required for Consultant's administrative, clerical and support staff. The duration of the Consultancy is 12 months. The key experts' positions with their estimated inputs are provided in Tables below:

Table 1: Team Composition - Key Experts

S. No.	Key Professional	Man Months
1.	Team Leader cum Water Resources Expert	12
2.	Strom Water Drainage Expert	9
3	Hydraulic Modeler	9
4	Soil and Water Conservation Expert	3
5	Landscape Architect	3
6	Climate Change Expert	3
7	Environmental Expert	3
8	Social & Resettlement Safeguards Expert	3
	Total of Key Experts	45

Table 2: Team Composition – Non-Key Experts

S. No.	Position	Man Months
1	Structural Engineering Expert	4
2	Financial Expert	3
3	GIS Expert	3
4	Ecologist	3
5	Botanist	3
5	Quantity Surveyor (2 Nos)	8
6	Field Engineer (2 Nos)	12
7	CAD Engineer (2 Nos)	24
	Total of Non-Key Experts	60

2. Expected Qualification Requirements and Tasks assigned to the Key experts:

2.1. The Consultant is expected to propose experts adequately qualified and experienced to undertake efficiently the task/ responsibility assigned to them. The tasks/ responsibilities assigned and detailed educational qualification and experience requirement for the respective expert are as mentioned below.

2.2. **Team Leader cum Water Resource Expert:** Team leader will be responsible for overall project management, administration and ensure overall compliance of contract agreement, deliverable management, policy documentation, interaction with the policy makers for project budgetary, bid- process management etc. He / she will be responsible for watershed management, catchment delineation, flood modelling, identification of flood hotspots, hydrological activity of the project area etc. Team Leader shall be a graduate in Civil Engineering and Postgraduate in Hydrology / Hydraulics/ Water Resources / Environmental / Public Health Engineering with about 15 years' experience in designing and implementation of flood routing structures including Storm water drains for urban areas and rejuvenation of water bodies / waterways.

2.3. **Storm Water Drainage Expert:** Storm Water Drainage Expert will be responsible for planning, design and engineering services for the effective storm water drain network, identification of flood hotspots and mitigation measures to reduce the inundation in the project area etc. He / She shall be a graduate in Civil Engineering and Postgraduate in Hydrology / Hydraulics/ Water Resources / Environmental / Public Health Engineering with about 10 years experience in the design and implementation of SWD projects.

2.4. **Hydraulic Modeler:** Hydraulic Modeler will be responsible for carryout the hydro dynamic modelling of the storm water drains networks, flood routing structures etc. He / She shall be a graduate in Civil Engineering and Postgraduate in Hydrology / Hydraulics/

Water Resources / Environmental / Public Health Engineering with about 10 years' experience in storm water drainage network modeling.

- 2.5. Soil and Water Conservation Expert:** Soil and Water Conservation Expert will be responsible for exploring the measures to increase the water retention capacity of the catchment and nature-based-solution for flood mitigation. He / She shall be a graduate in Agricultural Engineering / Civil Engineering with Post graduation in Soil and Water Conservation Engineering / Water Resource Engineering / Hydrology about 10 years' experience in the area of Watershed management/Flood mitigation/nature based solution for flood mitigation/sponge park design/sponge city development/Storm Water Drain.
- 2.6. Landscape Architect:** Responsible for developing landscape designs for waterbodies. A postgraduate in Landscape Architecture with a minimum of 10 years experience in preparation of landscaping of designs for waterbodies, river front development works/design of sponge parks/sponge city development etc.
- 2.7. Climate Change Expert:** Responsible for climate change impact assessment study/planning the climate change adaption strategies and resilience specific to the project area. A postgraduate with a minimum of 10 year's experience in climate change impact assessment studies/city level climate action plan studies/climate change modeling/planning, managing and implementing climate change adaptation and resilience strategies.
- 2.8. Environmental Specialist:** Environmental Specialist work will include (i) Identifying regulatory clearance requirements and finalizing the documentary requirement in obtaining the same; (ii) Preparing EMP / site specific Environmental Plan (ii) Preparing IEE & EMP; ensure that IEE reflects the final design. (iii) Suggest mechanisms to redress the complaints such that the complaints/grievances are addressed in a timely manner and resolutions are properly documented when encountered during implementation; (iv) carrying out consultations (iv) Assistance in any other environmental safeguard related tasks as required. He/She shall be a postgraduate in Environmental Engineering / Environmental Science with about 10 years' experience in preparation of Environmental Assessment/ Initial Examination Reports for similar urban infrastructure projects under multilateral funding and well-versed with the latest E&S safeguards policies and frameworks of KfW bank, ADB, World Bank.
- 2.9. Social cum Resettlement Safeguard Specialist:** A Postgraduate in Development Studies/Economics/ Sociology / Social Works / with 10 years of experience preferably in preparing Social Impact Assessment reports/ Resettlement Plan and well versed with current E&S policies and frameworks of KfW bank, ADB, World Bank & TNUIFSL(SPS 2009, WB-ESF). Experience in preparation of RP/RAP for urban infrastructure projects of urban local bodies such as Storm Water Drains, UGSS, Water Supply Projects, Road

Projects. Experience in Social baseline alignment surveys, base line socio economic census surveys. The tasks are i) Based on final designs, carry out census and socio-economic surveys /verification surveys for the affected people and prepare resettlement plan (RP) in line with the TNUFIP resettlement framework (RF), ii) Identify requirement for any EUPs/NOCs for sub-project sites and assist in documentation / process in obtaining the same. Prepare any additional safeguard documentation, if required, such as due diligence reports, iii) conducting public consultation and disclosure activities, as part of preparation of RF.

3. Expected Qualification Requirements to the Non-Key Experts:

- 3.1 The Consultant is expected to deploy Non-key Experts having qualified and experienced as described hereunder to undertake efficiently their task/ responsibility as below.
- 3.2 **Structural Expert:** Postgraduate in Structural Engineering with 10 years of experience in structural design of urban infrastructure projects.
- 3.3 **Financial Expert:** Responsible for preparation cost benefit analysis, financial assessment and analysis, financial Plan for the implementation of the projects, Revenue generation possibility etc. Postgraduate in Economics / MBA Finance with 10 years experience and adequate exposure to municipal financial analysis.
- 3.4 **GIS Expert:** Responsible for preparation of watershed boundary maps, land use maps, thematic maps required for the project etc. Graduate in Civil Engineering / Remote Sensing/ Geo Informatics with 5 years of experience in building and maintaining GIS databases and use GIS software to analyse the spatial and non-spatial information in GIS projects and other similar urban infrastructure projects.
- 3.5 **Ecologist:** Ecologist will be responsible for study the flora and fauna present along the waterbodies and propose protection measures by way of restoration / conservation programme. A postgraduate in Ecology/Environment/Life Science with 10 years in experience assessment of riverine or wetland ecosystems.
- 3.6 **Botanist:** Responsible for selection of species, plantation methods, maintenance methods etc. Masters in Botany with 5 years experience in design and maintenance of parks and gardens.
- 3.7 **Quantity Surveyor:** Graduate in Civil Engineering with 10 years' experience in estimation of urban infrastructure projects.
- 3.8 **Field Engineers:** Graduate in Civil Engineering with 5 years of experience in water supply / sewerage systems / storm water drainage projects and other similar urban infrastructure projects.
- 3.9 **CAD Engineer:** Diploma in Engineering with 7 years of experience in preparation network drawings, structural drawings in Auto CAD for water supply / UGSS / SWD /SWM projects including data imports from GPS, Total Station, checking of vertical and horizontal profiles etc.

4. Note:

- 4.1. Adequate support staff like civil engineer, structural engineer, geo technical

engineer, surveyors, institutional, Financial, Climate Resilient, capacity building, soil experts, etc., may be brought in by the consultants from allied and associated fields with adequate experience to ensure that the objectives of the project are achieved within the stipulated timelines.

- 4.2. The Team Leader shall be full time professional for all the activities and to be stationed in Hosur / Chennai till the completion of Study.
- 4.3. The Consultant shall make necessary presentations to Authority and to various departments as required during various stages of the assignment with necessary key experts as required basis.
- 4.4. Any and all material shared during the course relating to the Projects are confidential including but not limited to the recommendations, information being shared, (the “Confidential Information”) shall not be made public or shared with any other party without the prior written consent of the other Parties to this agreement or the Party to whom such Confidential Information belongs.
- 4.5. In case of any specific meeting requirement required by the TNUIFSL / Hosur corporation for project related work, it shall be attended by the consultant and report shall be furnished within a reasonable time. No additional cost will be provided to the Consultant for attending multiple meetings.

I. REVIEW COMMITTEE:

The Reports submitted by the consultants are reviewed and approved by the review committee (either by review committee or letter of approval / acceptance from corporation), and the review committee comprises the following officials:

1. Representatives from Director of Municipal Administration
2. Representative from ULB
3. Representative from Highways Department
4. Representative from Water Resources Department
5. Representative from Local Planning Authority
6. Representative from NHAI
7. Representatives from TUFIDCO
8. Representatives from TNUIFSL
9. Experts will be nominated (if required)

E.3.

REQUEST FOR PROPOSALS

RFP NO: JSIPL/RFP/2024/007



Request for Proposal – Sponge City Park Development Project, Rajkot, Gujarat

This RFP document includes the following parts:

PART A	:	Cover Page
PART B	:	Instructions to Bidders
PART C	:	Terms of Reference
Attachment A	:	General Terms and Conditions
Attachment B	:	Funder Required Clauses
Attachment C	:	Design Brief
Attachment D	:	Financial Proposal Template (Please refer to excel file attached with the RFP document separately).

All proposals, inquiries, and correspondence pertaining to this solicitation are to be directed to the email ID: procurement@in.jsi.com

PART A: COVER PAGE

Issuance Date	:	14 May 2024
Questions Due Date/Time	:	20 May 2024
Response to Query	:	22 May 2024
Proposal Due Date/Time	:	27 May 2024

Background

John Snow India Private Limited (JSI India), a subsidiary of JSI Research and Training Institute, Inc., a 501(c)(3) not-for-profit corporation registered in the state of Massachusetts, USA, is a leading public health organization dedicated to improving the health of individuals and communities across the country. We develop and implement high-impact, sustainable, and locally-owned public health initiatives. A robust interface and relationships with the government, private sector, and civil society allow us to convene and collaborate, innovate, inform policy, and develop sustainable & scalable models of programs. Over the years, JSI India has become a recognized leader for its innovative approaches in reproductive, maternal, newborn, and child health (RMNCH), Immunization, urban health, Tuberculosis, nutrition, supply chain management, monitoring & evaluation, and health system



strengthening. We are implementing projects funded by USAID, the Bill & Melinda Gates Foundation, GAVI, and other leading funders.

2. ARC Project Overview

The Asia Resilient Cities (ARC) Project is a five-year cooperative agreement funded by the U.S. Agency for International Development (USAID) and implemented by JSI Research & Training Institute, Inc. (JSI), with partners DevTech Systems, Inc., BRAC, and ICF. Over the course of five years, ARC will address cross-cutting urban development challenges in select cities in Asia by promoting sustainable urban growth; supporting resilient, low-carbon urban infrastructure; and integrating climate change and environmentally conscious approaches.

ARC signed a letter of commitment with the Rajkot Municipal Corporation in May 2023, allowing ARC to co-create a work plan for 4 years in the city. JSIPL has signed the Memorandum of Understanding (MoU) with Rajkot Municipal Corporation in March 2024 to implement the workplan for climate resilience.

JSIPL is committed to the highest standards of ethics and integrity in procurement. JSIPL has zero tolerance for fraud and strictly prohibits bribes, kickbacks, gratuities, and any other gifts in-kind or in monetary form. JSIPL also strictly prohibits collusion (bid rigging) between vendors and between vendors and JSIPL staff. JSIPL selects vendors purely on merit and will only engage vendors who demonstrate strong business ethics. Vendors must not participate in bid-rigging or attempt to offer any fee, commission, gift, gratuity or any compensation in-kind or in monetary form to JSIPL employees. Vendors who do so will be disqualified from doing business with JSIPL. Additionally, JSIPL has a conflict-of-interest policy that requires staff to disclose when there is a potential conflict of interest due to the staff-member's relationship with a vendor, and if necessary, to refrain from participation in a procurement involving that vendor.



PART B: INSTRUCTIONS TO BIDDERS

1. DEFINITIONS

Bidder: The firm providing proposals for the services requested under this RFP.

Contractor/Vendor: The firm awarded the services requested under the RFP in the form of a PO/contract.

Buyer/Client: John Snow India Private Limited (JSIPL)

2. PROPOSAL SUBMISSION AND REQUIREMENTS

Bidders are encouraged to read the RFP document in its entirety and ensure that their quotation addresses all of the items cited in the proposal instructions. All proposals must be submitted by the deadline established in the RFP. Offers received after this due date and time will not be accepted for consideration.

Questions

All questions or clarifications regarding this RFP must be in writing and submitted to procurement@in.jsi.com, no later than *20 May 2024*. The subject line of the queries submission email should state, ***Pre-Bid Queries- RFP No JSIPL/RFP/2024/007– Sponge City Park Development Project Rajkot, Gujarat***

Questions and responses will be circulated to all RFP recipients who have indicated interest in this RFP. Only written answers from JSIPL's authorized representative will be considered official and any answers received outside the official channel, whether received verbally or in writing, from employees of JSIPL, or any other party, will not be considered official responses regarding this RFP.

Submission of Proposals:

The bidder's proposal must be accompanied by a cover letter typed on official organizational letterhead and signed by an individual who has signatory authority for the bidder. The bidder must submit a complete proposal package **on or before the due date of 27 May 2024**. All proposals, inquiries, and correspondence pertaining to this solicitation are to be directed to the email ID: procurement@in.jsi.com.

The proposals must be prepared in two separate volumes:

- i. Technical Proposal; and
- ii. Financial Proposal.



Technical Proposal should be submitted separately at the above-mentioned email address. The subject line of the email should state, **Technical Proposal- RFP No JSIPL/RFP/2024/007– Sponge City Park Development Project Rajkot, Gujarat**

Technical proposals must not make any reference to pricing data in order to ensure the evaluation of the technical proposal strictly on the basis of technical merit. File size for both files cannot exceed 10 MB in one email; if your file size exceeds this, send it in 2-3 parts marking each part clearly in the subject line

Financial Proposal should be submitted in a separate email at the above-mentioned email address and should mention the following in the subject line **Financial Proposal- RFP No JSIPL/RFP/2024/007– Sponge City Park Development Project Rajkot, Gujarat**

The written proposal must contain the following information and documentation:

Proposal Guidelines

Rajkot, a rapidly growing city in the state of Gujarat, faces significant challenges regarding water availability. As the city expands and the demands on its water resources increase, managing water supply sustainably has become a critical concern for local authorities and residents alike. Water reservoirs such as Nyari and Aji have provided water for decades, and the Narmada Canal project has also rejuvenated the city. However, because groundwater is only a partially replenishable resource, its availability varies by season and the amount of rainfall. Through a combination of innovative solutions and collaborative efforts, Rajkot can overcome its water challenges and build a resilient water management system that supports its growing population and economic development.

As part of the action plan for climate resilience in Rajkot, RMC has finalized several projects to enhance the city's capability in water management and conservation. **The Sponge City Park Development project** is a flagship initiative within the broader citywide water conservation strategy, formulated jointly by RMC and ARC. The project aims to serve as an exemplary public nature project, showcasing live water conservation strategies for public learning and enjoyment, while enhancing the Rajkot's resilience.

The Rajkot Municipal Corporation seeks to develop a 14-acre park within the city limits as a destination public space that adheres to the Sponge City concept. The site, currently a wetland, requires transformation into an accessible green space, aligning with Rajkot's dedication to water conservation, groundwater recharge, and community wellbeing.

Situated on the western outskirts, around 500 meters from the 150 ft ring road, the site features a water channel traversing its expanse. Divided into five land parcels, one recently developed as a neighbourhood-level park, the site offers significant potential for enhancement through strategic interventions. Community engagement and meaningful participation – particularly with residents of the high-rises which surround the site – will be crucial to the project's success.



The key objectives for the project include the treatment of the water channel, implementation of traditional groundwater recharge techniques, construction of recharge wells, and placemaking to enhance surface treatment and user experience.

The Sponge City Park should enhance water resilience and serve as an educational hub that is accessible and well-known to the community.

Required Qualifications and Experience:

- The design consultancy firms/ agency with the Council of Architects (COA), India registered architects will only be eligible to apply. In case of international firms, relevant architect/ urban design registration with the recognised organization/ institute in the base country of the firm.
- Minimum three completed projects in urban design/ landscape design domain specifically focusing on water conservation, sponge city concept, place-making, etc

Proposal Requirement:

Interested candidates are required to go through the above guidelines and the shared link for the site brief.

A. Prepare and submit a presentation of conceptual design for the project covering the following aspects:

Background of the Firm/Individual

- Details of completed projects with similar objectives.
- Key outcomes related to water conservation, community engagement, and social wellness.

Preliminary Site Study and Context Analysis

- Key inferences about the site, considering the larger Rajkot context and the immediate neighborhood.
- Analysis should include climate, watershed, green cover, infrastructure services, socio-cultural aspects, and potential stakeholder involvement.

Understanding of the Larger Context

- Analysis of Rajkot city and the site's neighborhood, focusing on climate resilience.
- Highlight opportunities for integrating water conservation, community learning, and wellness.

Conceptual Design and Supporting Materials

- Design proposal with layouts, sketches, drawings, and visuals.
- Incorporate resiliency principles such as encouraging learning and experimentation, encouraging diverse and meaningful participation, and promoting multilevel governance.
- Highlight features that will make the park accessible and inclusive.

Key Features and Strategies

- Water management and placemaking strategies.
- Technical knowledge and innovative ideas for water conservation, recharge, and social wellness.
- Educational components to teach the community about water conservation, resilience, and environmental stewardship.

Community Engagement and Participation

- Plan for engaging the local community, particularly residents of the surrounding high-rises.
- Encourage diverse and meaningful participation in the design, implementation, and use of the park.
- Outline strategies for public outreach, inclusive engagement, and making the park known and used.

Implementation Mechanism and Governance

- Plan for phased implementation.
- Promote multi-level governance by outlining roles for RMC, local communities, and other stakeholders.

Innovation and Additional Ideas

- Any other innovative ideas or approaches for enhancing resiliency, water conservation, public education, and community wellbeing.
(see the attached design brief for site details)

Proposed Plan and Approach

The Technical proposal shall describe how the bidder intends to carry out the Terms of Reference as stated in Part C. It should be concise, specific, complete, and demonstrate a clear understanding of the work to be undertaken and the responsibilities of all parties involved. It must demonstrate the bidder's eligibility, as well as their capabilities and expertise in conducting each step of the activity.

Bidders shall include only information necessary to provide a clear understanding of the proposed action and the justification for it. Greater detail than necessary, as well as insufficient detail, may detract from a proposal's clarity. Assume that the reader is not familiar with the particular context in which the project will be implemented. Minimize or avoid the use of jargon and acronyms as much as possible. If acronyms or abbreviations are used, include a separate page explaining the terms.

Capabilities and Past Performance

The bidder must submit a capabilities statement along with documentary evidence of three past performances including experience of work with Municipal Corporations, if any

The capabilities statement will be used to evaluate the bidder's organizational, financial, and technical capacity, in relation to the Terms of Reference in Part C. The Capabilities Statement must include, but is not limited to: size of the agency, financial resources available to complete this work, staffing



competencies and capabilities, past experience performing similar work with other donor organizations, and a company profile and/or brochure.

Other Requirements-Legal and compliance details

S. No	Particulars	Detail
1	Name and Address of the Agency	
2	Type of organization (Whether Proprietorship, partnership, private proprietor/partners)	
3	Telephone Number/Mobile Number	
4	Email Address (Procurement)	
5	Company Website info	
6	Name, Address, Contact No and Email Id of the Directors/Proprietor/Partners	
7	Name and contact details of Authorized Representative	
8	Year of formation of the agency/company	
9	GST Registration No (Pls attached Certificate)	
10	Agency Registration No (Pls attached Certificate)	
11	MSME Registration No (Pls attached Certificate)	
12	PAN No (Pls attached Pan Card)	
	Service Details	
1	Type of Service:	
2	Place of Service	
	Other details about company if any pls mention (Pls attached Cancel Cheque)	
1	Name (as per bank account)	
2	Account Number:	
3	IFSC Code:	
4	Bank Name:	

Financial Proposal Requirements

1. The bidder should submit their most competitive and complete cost proposal **document in the requested format. (Please refer to attachment C (excel file) shared with RFP document)**
2. All costs must be stated in Indian National Rupee (INR).

3. The price of the PO/ contract to be awarded will be an all-inclusive fixed price. No fee or additional costs can be included after the award negotiation. All items/ services must be clearly labelled and included in the total offered price.
4. All applicable taxes will be extra and should be presented separately.
5. Total price indicates all prices inclusive of all applicable taxes
6. All proposed costs must be directly applicable to performing the work under the award and budgeted amounts should not exceed the market cost/value of an item or service.

3. AWARD

JSIPL intends to issue a Purchase Order (PO) payable on the basis of receipt of all deliverables/ services within the timelines mentioned and agreed.

4. EVALUATION CRITERIA

Proposals will be evaluated first to ensure that they meet all mandatory requirements and are responsive. To be considered responsive, a proposal must include all documentation as listed above. Proposals that fail to meet these requirements will receive no further consideration. A non-responsive proposal to any element may be eliminated from consideration.

Responsive proposals will be evaluated and ranked by a committee on a technical basis according to the criteria below. Those proposals that are considered to be technically acceptable shall then be evaluated in terms of cost.

For the purpose of selection, the bidders will be evaluated based on a weighted point scale (totalling 100 points) against both the technical and financial criteria as indicated in the table below.

S.no	Parameters	Total Marks (100)
1	Firm's experience in water conservation and placemaking (per project 5 marks)	20
2	Understanding of the site and context	5
3	Approach to the project	10
3.1	Adherence to sponge city principles, Approach sensitive to ecology (Adoption of sustainable practices)	5
3.2	Approach based on improving people's experience	5
4	Design of the park (Functionality and Innovation)	30
4.1	Placemaking- Integration of the park pockets, Seamless flow of activities and experiences curated for people, Provision of linkages, edge conditions and diverse activities for the park as a neighbourhood level park and a city level public space etc	8
4.2	Water conservation strategies- Water retention, enhancement and treatment strategies for the rejuvenation of the natural waterway and micro watershed, and provision of other water conservation systems, etc	8

4.3	Integration of blue-green infrastructure- Percentage of softscape areas vs hardscape, provision of green infrastructure elements such as rain gardens, bioswales, permeable pavements, and vegetated buffers, etc	8
4.4	Accessibility and Inclusivity - Integration of street design with the park, Inclusive design (Design for all irrespective of age, gender and ability), enhancement of socio-economic wellbeing for the surrounding communities, etc	6
5	Implementation mechanism	5
6	Overall Innovative aspects	10
Total Technical		80
FINANCIAL PROPOSAL:		
Reasonableness of proposed budget (<i>See Financial proposal requirements</i>)		20
Total Financial		20
GRAND TOTAL:		100

Weightage criteria for Evaluation:

The proposals will be evaluated out of a total score of 100 in a ratio of 80:20, where 80% of the marks are allocated for the technical proposal and 20% for the financial proposal.

5. TERMS OF AWARD

This document is a request for proposals only, and in no way obligates JSIPL to make any award. Any expenses incurred in excess of the agreed upon amount in the Purchase Order(s) will be the responsibility of the consultant and not that of JSIPL. Therefore, the bidder is duly advised to provide its most competitive and realistic proposal to cover all foreseeable expenses related to provide requested services.

All deliverables produced under the future award/contract shall be considered the property of JSIPL. JSIPL may choose to award a contract for part of the activities in the RFP. JSIPL may choose to award a contract to more than one bidder for specific parts of the activities in the RFP.

6. PROPOSAL VALIDITY

The bidder's technical and cost proposals must remain valid for not less than 180 calendar days after the deadline specified above. Proposals must be signed by an official authorized to bind the bidder to its provisions.

7. PAYMENT TERMS

JSIPL payment cycle is net 15 days upon receipt of deliverables to the satisfaction of activity manager, goods/services, inspection and acceptance of services as in compliance with the terms of the award and receipt of vendor invoice. All payment shall be paid on a deliverable basis, no advance payment shall be made against the deliverable. Full cooperation with JSIPL in meeting the terms and conditions of payment will be given the highest consideration.



8. FINANCIAL RESPONSIBILITY

Bidders must include in the capabilities statement that they have the resources to complete the proposed activities within the period of performance and under the terms of payment outlined below. JSIPL reserves the right to request and review the latest financial statements and audit reports of the vendor as part of the basis of the award.

9. LANGUAGE

The proposal, as well as correspondence and related documents should be in English.

10. NEGOTIATIONS

The bidder's most competitive proposal is requested. It is anticipated that any award issued will be made solely on the basis of bidder's proposal. However, JSIPL reserves the right to request responses to additional technical, management and cost questions which would help in negotiating and awarding a contract. JSIPL also reserves the right to conduct negotiations on technical, management, or cost issues prior to the award of a PO. In the event that an agreement cannot be reached with bidder, JSIPL will enter into negotiations with alternate bidders for the purpose of awarding a PO without any obligation to previously considered bidder.

11. REJECTION OF PROPOSALS

JSIPL reserves the right to reject any and all proposals received, or to negotiate separately with any and all competing bidders, without explanation. JSIPL would communicate the result only with the selected bidder; separate communication to those rejected would not be sent and no queries in this respect would be entertained by JSIPL.

12. INCURRING COSTS

JSIPL is not liable for any cost incurred by bidders during preparation, submission, or negotiation of an award for this RFP. The costs are solely the responsibility of the bidder.

13. MODIFICATIONS

JSIPL reserves the right, in its sole discretion, to modify the request, to alter the selection process, to modify or amend the specifications and scope of work specified in this RFP.

14. CANCELLATION

JSIPL may cancel this RFP without any cost or obligation at any time until issuance of the award.



Part C: TERMS OF REFERENCE

Purpose	To engage a consultancy firm/agency for Sponge City Park Development Project Rajkot, Gujarat
Company/Division	John Snow India Pvt Ltd/ Asia Resilient Cities Project
Activity Manager	Project Lead-ARC Project
Location	Rajkot, Gujarat
Period of contract	Expected start date- 15 June 2024 Expected End Date- 2 years after onboarding the agency

SCOPE OF WORK:

The consulting firm is required to provide services for Urban/ Landscape Design services in respect of the following:

Part I - URBAN DESIGN

- Taking Authority's instructions and preparation of design brief.
- Site evaluation, analysis of architectural character, social issues and heritage.
- Feasibility study.
- Preliminary proposal for development/re-development and their impact on immediate environs.
- Area study and infrastructure services recommendations including pedestrian/ vehicular movement and parking, etc
- Comprehensive design services of:
 - Site development, services and their interconnectivity.
 - Landscape Architecture.
 - Conservation of any ecological features.
 - Graphic Design and Signage

Part II - SITE DEVELOPMENT

Comprehensive architectural services beyond Part I about external Engineering Services and related buildings/structures; water treatment facilities, water retention and harvesting structures, roads, pathways, culverts & bridges; boundary walls, gates.

PART III - LANDSCAPE DESIGN

Landscape design services beyond Part I about public spaces. The consulting firm is required to provide services in respect of following:

- Site appraisal and suitability
- Site planning
- Landform and grading
- Surface drainage design and water management.
- Irrigation design
- Open space design - hard and soft areas
- Planting design

- Landscape structures and features
- Civil work design and detailing
- Garden Furniture design
- Illumination design
- Graphic design and signage
- Co-ordination of external services
- Periodic inspection and evaluation of works at site

SCHEDULE OF SERVICES:

The Design consulting firm shall, after taking instructions from the Authority, render the following services in Table 1.

Table 1: Schedule of services for Urban and Landscape Design projects

#	STAGES	DETAILS OF SERVICES
1.	Programming and Site Evaluation [Stage 1]	• Ascertain Authority's requirements, examine site constraints & potential; and prepare a design brief for Authority's approval. • Study of existing land use in and around the project area. • Study of contextual issues, socio-cultural aspects, landscape features and built form etc. • Study of existing infrastructure, accessibility, circulation pattern and parking. • Prepare report on site evaluation, state of existing buildings, services, features if any; and analysis with basic approach to circulation, activity distribution, interconnectivity and external linkages including rough estimate of project cost based on discussed objectives. • Furnish report on measures required to be taken to mitigate the adverse impact, if any, of the existing and/or proposed development in and around the site.
2.	Concept Design [Stage 2]	• Carry out site analysis and furnish a site appraisal report with regard to the potential of the site vis-à-vis activities. • Prepare drawings and documents to enable the Authority to do the detailed survey including soil investigation at the site of the project, • Furnish preliminary scheme for site planning. • Preparation of design of the area showing circulation pattern, zoning of various uses and relevant details, water retention, treatment and harvesting strategies, conceptual landscape design according to brief and revised estimate of cost on area basis. • Submission of model and Conceptual design to the Authority/statutory authorities for approval & ensure compliance with codes, standards and legislation, as applicable and carry out necessary changes as may be required.
3.	Preliminary design and drawings [Stage 3]	• Modify the conceptual design incorporating required changes and prepare the preliminary drawings, sketches, etc. for the Authority's approval along with preliminary estimate of cost on area basis.

4.	Drawings for authority's/statutory approvals [Stage 4]	• Preparation of drawings showing the common facilities for circulation, parking, open spaces and external Architectural form. • Preparation of drawings showing landscape, street furniture graphic signage. • Preparation of drawings showing schematic network of services. • Furnish modified project cost. • Prepare detail designs of various architectural/ landscape elements and components. • Prepare drawings necessary for Authority's/statutory approvals and ensure compliance with codes, standards and legislation, as applicable and assist the Authority in obtaining the statutory approvals thereof, if required.
5.	Working drawings and tender documents [Stage 5]	• Prepare working drawings, specifications and schedule of quantities sufficient to prepare estimate of cost and tender documents including code of practice covering aspects like mode of measurement, method of payments, quality control procedures on materials & works and other conditions of contract
6.	Appointment of contractors [Stage 6]	• Invite, receive and analyses tenders; advise Authority on appointment of contractors.
7.	Construction [Stage 7]	• Prepare and issue working drawings and details for proper execution of works during construction. • Approve samples of various elements and components. • Visit the site of work, at intervals mutually agreed upon, to inspect and evaluate the construction works and where necessary clarify any decision, offer interpretation of the drawings/specifications, attend conferences and meetings to ensure that the project proceeds generally in accordance with the conditions of contract and keep the Authority informed and render advice on actions, if required. • In order to ensure that the work at site proceeds in accordance with the contract documents/drawings and to exercise time and quality controls, the day-to-day supervision will be carried out by a Construction Manager (Clerk of Works/Site Supervisor or Construction Management Agency in case of a large and complex project), who shall work under the guidance and direction of the Design consulting firm and shall be appointed and paid by the Authority. • Issue certificate of virtual completion of civil works and plantation.
8.	Completion [Stage 8]	• Prepare and submit completion reports and drawings for the project as required and assist the Authority in obtaining "Completion/Occupancy Certificate" from statutory authorities, wherever required. • Issue two sets of as built drawings including services, structures and plantation.

PAYMENT TERMS:

The payment milestone for each of the services in the scope of work will be in the following stages as mentioned in the table 2 below, consistent with the work done plus reimbursable expenses as mutually agreed upon.

Table 2 Milestones and payment terms for Urban and Landscape Design services-

Stages	Key Activities/Milestones	Payment %
1	On submitting conceptual designs and rough estimate of cost.	15%
2	On submitting the required preliminary scheme for the Authority's approval along with the preliminary estimate of cost	5%
3	On incorporating Authority's suggestions and submitting drawings for approval from the Authority/ statutory authorities, if required.	15%
4	Upon statutory approval, if required and preparation of working drawings, specifications and schedule of quantities sufficient to prepare estimate of cost and preparation of tender documents.	10%
5	On inviting, receiving and analysing tenders; advising Authority on appointment of Contractors.	10%
6	a. On submitting working drawings and details required for commencement of work at site. i. On completion of 20% of the work	10%
	ii. On completion of 40% of the work	5%
	iii. On completion of 60% of the work	5%
	iv. On completion of 80% of the work	5%
	v. On Virtual Completion	10%
7	On submitting Completion Report and drawings for issuance of completion/occupancy certificate by statutory authorities, wherever required and on issue of as built drawings	10%
	Total	100%

Payment will be made on completion of the deliverable subject to acceptance and certification by the JSIPL activity manager.

TRAVEL REQUIREMENT

The agency may have to travel to meetings and discussions in Delhi or any other locations subject to prior written approval to JSIPL. All travel and related arrangements will be made by the service provider directly. Travel expenses are to be reimbursed on actuals as per JSIPL policy. The agency will raise travel reimbursement invoices in the name of JSIPL. The invoice shall be submitted along with all original travel invoices for reimbursement.

Data Privacy & Protection:

- The information/data acquired by the agency during the performance of this scope shall remain confidential and cannot be disclosed to any third-party without the prior written consent of JSIPL, except where necessary for the execution of the contract. Data protection and privacy encompass the following:
- Protection of Client information.
- Protection of information assets belonging to JSIPL and Rajkot Municipal Corporation.



- To ensure confidence when sharing/storing information, prior written consent must be obtained, and the JSIPL activity manager must be kept informed.
- The agency shall adhere to JSIPL's data privacy policy.

Branding Guidelines:

The agency is expected to adhere to the standard style guide of the JSIPL Asia Resilient Cities Project. The style guide will be provided to the agency upon signing the contract.

JSIPL Responsibility

- JSIPL will be in charge of working with RMC to gather information and directions for selected consultancy firm/agency.
- JSIPL will monitor the agency's work to make sure everything follows the rules. Once RMC approves and everything is okay, JSIPL will process for payments. JSIPL also be allowed to use the information for various reports and papers.

Responsibility of selected consultancy firm/agency

- The selected agency will establish a robust collaboration with the Rajkot Municipal Corporation (RMC) and JSIPL, ensuring seamless coordination and adherence to all pertinent rules, protocols, and project guidelines. This entails fostering effective communication channels and aligning strategies to meet project objectives while upholding regulatory standards and ethical practices.
- The chosen agency pledges unwavering commitment to uphold Indian environmental compliances and adhere to the stringent regulations set forth by the ARC project. This includes robust compliance with environmental laws, sustainability principles, and project-specific directives to mitigate ecological impact and promote responsible development practices.

**CHENNAI METROPOLITAN
DEVELOPMENT AUTHORITY,
CHENNAI**

CONSTRUCTION WING

**First Floor, 'A' Block
CMDA office complex,
'E' Road, Koyambedu,
Chennai - 107**

COVER-I

e-BID DOCUMENT

E-TENDER FOR THE WORK OF

**DEVELOPMENT OF OPEN SPACE RESERVATION AREA AS A
PARK AND PLAYGROUND INCLUDING CIVIL, LANDSCAPE,
ELECTRICAL, IRRIGATION, PLUMBING, ETC. AT PORUR,
CHENNAI.**

PERIOD OF CONTRACT: 6 MONTHS

Contractor

CHENNAI METROPOLITAN DEVELOPMENT AUTHORITY,

**CONSTRUCTION WING, CIRCLE-I,
FIRST FLOOR, 'A' BLOCK
CMDA OFFICE COMPLEX,
'E' ROAD, KOYAMBEDU,
CHENNAI - 107**

COVER-I

**PRE-QUALIFICATION APPLICATION
AND PRICE TENDER DOCUMENT
(TWO COVER SYSTEM)**

**NAME OF WORK : DEVELOPMENT OF OPEN SPACE
RESERVATION AREA AS A PARK AND
PLAYGROUND INCLUDING CIVIL,
LANDSCAPE, ELECTRICAL, IRRIGATION,
PLUMBING, ETC. AT PORUR, CHENNAI.**

E.M.D AMOUNT : Rs.6,08,000/-

DATE OF TENDER : 12.05.2023

**Superintending Engineer
Circle-I, CW, CMDA, Ch-107**

Contractor

SALIENT FEATURES IN TENDER NOTICE

1.	Name of Work	“Development of Open Space Reservation area as a park and playground including Civil, Landscape, Electrical, Irrigation, Plumbing, etc. at Porur,
2.	Duration of downloading the tender form	From 27.04.2023 to 11.05.2023 upto 3.00PM
3.	Last Date and Time for Receipt of bid	on or before 11.05.2023 upto 3.00PM
4.	Office where the bids are to be deposited / where bids will be opened	Tenderers should be submitted their bids through online only.
5.	Time and Date of opening of e-bids	4.00 PM on 12.05.2023
6.	Earnest Money to be deposited with Tender	Rs.6,08,000/- (Rupees Six Lakhs Eight Thousand Only)
7.	Annual turnover of Rs.18.00 crores in any one of the preceding five years (From April 2017 to March 2022)	: Copies of balance sheet, profit and loss A/C for the relevant year duly certified by the Chartered Accountant.
8.	Eligibility criteria	1) The TENDERER should be a well-established, reputed/registered contractor in any of State/Central Govt. Departments/Govt. undertakings / Boards under Class-I with Monetary limit above Rs. 75.00 lakhs with up to date renewal and registered as a legal entity in India for a minimum period of ten years, and having experience of minimum ten years and capacity of “Providing Landscapes works with allied works such as Civil, Electrical, Plumbing, Irrigation, etc. 2) The tenderer should have satisfactorily completed works as mentioned below in any one of the preceding five years from Jan.2018 to Dec.2022.

Contractor

		(i) Bidder should have successfully executed for Landscaping works with allied works such as Civil Engineering, Electrical, Plumbing, Water supply etc., to a value not less than Rs.6.00 crores, including landscaping work for a value not less than Rs.1.11 crores in a single work in the preceding 5 years (from Jan.2018 to Dec.2022) in any of State/Central Government/Government undertaking/Boards as mentioned above with up to date renewal. (or) Two such projects, costing not less than, Rs 3.00 Crores, including landscaping work of Rs.60.00 lakhs, each project (from Jan.2018 to Dec.2022). (ii) The applicant should produce a Solvency certificate for a value of Rs.1.50 crores (Rupees One Crore fifty lakhs only) issued by Bank or Revenue department. Solvency certificate must have been obtained not earlier than first Dec 2022. (iii) The tenderer should furnish the latest Income Tax Return / Saral, GST registration Certificate, Registration as a contractor, Performance certificate and Annual Turnover and also to furnish all documentary evidence for Pre-qualification as per technical bid in order to be eligible to participate in this tender.
9.	Validity Period for Tender	90 days from the date of opening of the Bid.
10.	Contract Period	6 Months from the date of handing over the Site

Note:

1. Pre-qualification document without prescribed credentials will be rejected.

Superintending Engineer
Circle-I, CW, CMDA, Ch-107

Contractor

FOR THE SPECIAL ATTENTION OF THE APPLICANTS

1. Downloading of tender documents under two cover system i.e., Pre-Qualification document and price Tender document (Commercial Tender) to the Applicant will be available in e-tender website @ free of cost and can be downloaded from <http://tntenders.gov.in>
2. Approval or otherwise of the Qualification Tender will be strictly based on the detailed evaluation done on the basis of the Documents / Records / Evidences / Certificates produced by the Applicant in the Qualification Application in Cover-I
3. Qualification Tender (Cover 1) will be opened as per Notice Inviting Tender and after detailed evaluation, the date and time of opening of price Tender will be intimated to the qualified applicants.
4. The Tenderer should furnish the duly digitally signed Pre-qualification document and Price Tender document in all pages.
5. The Superintending Engineer, Circle-I, Construction Wing, CMDA, Chennai-600 107 may be contacted for further information in the matter.

Office Phone No.044-29585513

**Superintending Engineer
Circle-I, CW,CMDA, Ch-107**

Contractor

TWO COVER SYSTEM

QUALIFICATION TENDER & PRICE TENDER APPLICATION

From

To

Office of the Superintending Engineer,
Circle-I, Construction Wing,
Chennai Metropolitan Development
Authority, First floor, 'A' Block,
'E' Road, Koyambedu,
Chennai - 600 107.

Sir,

Sub: "Development of Open Space Reservation area
as a park and playground including Civil, Landscape,
Electrical, Irrigation, Plumbing, etc. at Porur, Chennai".

Ref: E-Tender Notice No.2/2023-2024 Dt.26.04.2023

1. Having examined the two cover system documents in respect of Pre-Qualification document & price Tender document including scope of work, Time Frame for construction and the criteria stipulated for Qualification, I/We hereby submit all necessary information and relevant documents for qualifying me/us, to offer my/our Tender for the above mentioned work.
2. The Application is made by me/us on behalf of (Partnership firm / Private limited company / Public Limited Company) in the capacity of -----
----- duly Authorized to submit the Tender.
3. Necessary evidence admissible in law in respect of authority assigned to me / us on behalf of the Partnership firm / Private Limited Company / Public Limited Company, for applying for qualification is attached herewith.
4. I / We present my / our documents herewith taking into consideration all the instructions in the Qualification schedule supplied to me / us including Contractor

special instructions to Applicants / Criteria for Qualification schedule / Information and Instructions in the detailed two cover Tender notice etc.,

5. The EMD amount is remitted through online payment, as notified in the Qualification Tender as detailed below

- I.

- II.

- III.

I / We understand that on behalf of CMDA, the Office of the Superintending Engineer, Circle-I, Construction Wing, Chennai Metropolitan Development Authority, Koyambedu, Chennai - 600 107 reserves the right to reject any or all the Tenders without assigning any reason thereof or to drop the proposal altogether.

Date:

**Signature of the Applicant including
Title Capacity in which Application is made**

**Name:
(IN BLOCK LETTERS)**

Encl: 1. Qualification schedule and price Tender schedule (Two cover system)

- 2.

- 3.

- 4.

- 5.

Contractor

QUALIFICATION & PRICE TENDER NOTICE

TWO COVER SYSTEM **FORM OF CONTRACT : LUMPSUM**

1. INVITATION:

E-tender under two cover Tender system i.e. Pre-Qualification document & Price Tender document (item rate Tenders) are invited for and on behalf of the CMDA, by the Superintending Engineer, Circle-I, Construction Wing, Chennai Metropolitan Development Authority, Tower-III, Koyambedu, Chennai - 600 107. One cover contains EMD, Pre-Qualification conditions and other details. The second cover contains Price Tender schedule.

2. ELIGIBILITY CRITERIA FOR QUALIFICATION (FOR LEAD MECHANICAL CONTRACTOR):

The TENDERER should be eligible for Qualification and fulfill the following qualification criteria:

- (i) The TENDERER should be a well-established, reputed/registered contractor in any of State/Central Govt. Departments/Govt. undertakings / Boards under Class-I with Monetary limit above Rs. 75.00 lakhs with up to date renewal and registered as a legal entity in India for a minimum period of ten years, and having experience of minimum ten years and capacity of "Development of Open Space Reservation area as a park and playground including Civil, Landscape, Electrical, Irrigation, Plumbing, etc. at Porur, Chennai".
- (ii) The tenderer should have satisfactorily completed similar nature of works as mentioned below in any one of the preceding five years ending 31st Dec 2022.
 - (a) Bidder should have successfully executed for Landscaping works with allied works such as Civil Engineering, Electrical, Plumbing, Water supply etc., to a value not less than Rs.6.00 crores, including landscaping work for a value not less than Rs.1.11 crores in a single work in the preceding 5 years (from Jan.2018 to Dec.2022) in any of State/Central Government/Government undertaking/Boards as mentioned above with up to date renewal.

(or)

Two such projects, costing not less than Rs. 3.00 Crores, including landscaping work of Rs.60.00 lakhs each project (from Jan.2018 to Dec.2022).

Contractor

- (b) The Bidder should be a well-established and reputed contracting company, registered as a legal entity for a minimum period of Ten years and having overall experience and capability in the field of “Development of Open Space Reservation area as a park and playground including Civil, Landscape, Electrical, Irrigation, Plumbing, etc. at Porur, Chennai”
- c) Any project submitted against this criteria has to be in any State/Central Govt. Departments/Govt. undertakings/Boards during last Five years ending 31st December, 2021
- d) **Joint venture is allowed to participate in the tender. The annual turnover of Rs.18.00 crores, experience for Rs.6.00 crores and Solvency for Rs.1.50 crores will be considered either in Single or jointly amongst the Lead and Co-applicant.**
- e) **Experience certificate should be deposited in the tender box at o/o The SE-I, Construction Wing, first floor, Chennai Metropolitan Development Authority office building, ‘A’ Block, ‘E’ Road, Koyambedu, Chennai – 600107 before the closing date of bid i.e. on 11.05.2023 upto 3.00pm**
- (iii) The applicant should produce a **Solvency certificate** for a value of **Rs.1.50 crores** (Rupees One Crore Fifty lakhs only) issued by Bank or Revenue department. Solvency certificate must have been obtained not earlier than first Dec 2022.
- (iv) The applicant should furnish the Annual turnover of **Rs.18.00** crores in any one of the preceding five years from April 2017 to March 2022.
- (v) The tenderer should furnish the latest Income Tax Return / Saral, GST registration Certificate, Registration as a contractor certificate, Performance certificate and Annual Turnover and also to furnish all documentary evidence for Pre-qualification as per technical bid in order to be eligible to participate in this tender.
- (vi) The tenderer must not have been debarred or black listed by any of the Central / State Government Departments / Government Undertakings
- (vii) **The Experience / Performance certificate submitted by the Tenderer under Sub-Contract will not be considered.**
- (viii) If the date of opening of tenders happens to be a public holiday, tenders will be opened on the next working day at the same venue and time.

Contractor

3) **PROJECT DESCRIPTION:**

The Government of Tamil Nadu made an announcement that to development of large public open space parks & playground at Porur at an extent of 21 acres. This proposed park is emphasizes that as a multi-functional infrastructure that will serve as a regional destination for recreation, Culture, urban ecological habitat, and community amenities. Overall green cover of the park will help absorb significant levels of Carbon di-oxide (CO₂) from the environment and thereby help in reducing carbon emissions from the surroundings. The proposed park greatly improves the health and well-being of residents in peri-urban communities, improves air and water quality and introduces new habitats or biomes that increase biodiversity, while also helping the community tackle climate related environmental risks.

4) **SCOPE AND STATUS OF THE WORK UNDER THIS TENDER :**

“Development of Open Space Reservation area as a park and playground including Civil, Landscape, Electrical, Irrigation, Plumbing, etc. at Porur, Chennai”.

5) **PERIOD OF COMPLETION**

The period of completion shall be 6 months (Calendar months) from the date of handing over of the Site to the successful Tenderer.

Pre-Qualification document not accompanied with online Earnest Money Deposit will be rejected as ‘Non-responsive’ Tender.

6) **EARNEST MONEY DEPOSIT**

Earnest money deposit of **Rs.6,08,000/-** (must accompany the qualification tender for this work) shall be paid only online through the

<http://tntenders.gov.in>. The EMD is exempted from payment for MSME / NSIC registered contractors, which bidders can upload their MSME and NSIC certificate as a PDF

Contractor

6.1 Pre-Qualification document not accompanied with Earnest Money Deposit will be rejected as 'Non-responsive' Tender.

6.2 If upon acceptance of Tender, the Tenderer withdraws his Tender after the acceptance of Tender or fails to pay the requisite security deposit amount within the specified period of time, the Earnest money deposit paid with the Tenderer will be forfeited.

6.3 EMD will be retained in the case of successful Tenderer and will not carry any interest. It will be dealt with as provided in the Tender.

6.4 The Earnest Money Deposit will be refunded automatically to the unsuccessful tenderers, after uploading the LOA in the website.

7. SECURITY DEPOSIT:

7.1 The successful tenderer shall furnish a Security Deposit for an amount equivalent to 2% of the Contract value, which includes the earnest money deposit already paid and 3% of the contract amount shall also be furnished towards performance guarantee within 15 days (Fifteen days) from the date of receipt of work order. If the successful Tenderer fails to execute the Contract (i.e. sign the agreement) within the aforesaid 15 days time, the Earnest Money Deposits amount remitted with the Pre-Qualification document will be forfeited.

7.2 The Security Deposit in the shape of irrevocable bank guarantee will also be accepted.

7.3 In addition to the aforesaid security deposit, the Executive Engineer shall deduct from the running account bills, a sum equivalent to 5% (five percent) of the total value of each bill as retention money, for due fulfillment of the Contract.

7.4 At the time of making final payment, 2½% of retention money shall be refunded and the balance 2½% shall be retained by the department. This amount will be refunded to the Contractor on expiry of one year reckoned from

Contractor

the date of completion of work provided that the Contractor execute an indemnity bond for a further period of three years indemnifying CMDA against any loss or expenditure incurred to rectify any defect noticed due to faulty workmanship by the Contractor or substandard materials used by the Contractor. The Executive Engineer concerned should certify that no liability is due from the Contractor for the release of this amount.

8. LANGUAGE OF TWO COVER TENDER SYSTEM:

Tenders shall be offered only in the prescribed forms in “**ENGLISH**” only.

9. VALIDITY OF PRICE TENDER:

The Tender shall be valid for a period of 90 days (Ninety days) from the date of opening of Tender.

10. SUBMISSION OF PRICE TENDER BY TWO COVER SYSTEM

10.1 Tenderers should quote their rates both in figures and in words for each item per unit and amount for each item of work for full quantity. Grand total of the whole Contract should be furnished without fail in the last page of schedule “A” of Price Tender document.

10.2 E-tenders will be received through online only (**as per web site digital clock**) and under any circumstances/reasons whatsoever, tenders will not be received beyond this scheduled time.

10.3 Submission of Tenders through by speed post, courier etc., will not be considered.

11. OPENING OF TENDERS:

The e-tenders will be received upto 3pm on **11.05.2023 (as per web site digital clock)** by the Superintending Engineer, Circle-I, CMDA and opened the same in Tower-3 building, first floor, Koyambedu, Chennai-107 @ 4.00 p.m (as per web site digital Clock) on **12.05.2023. The Pre-qualified bidders will be informed as the date & time of online price bid opening**

Contractor

(Cover-II). The lowest value quoted in the e-bid will be considered for acceptance

12. RATES AND PRICES:

This is a fixed price Contract. Price adjustment clause (To account for rise or fall in the money value during the Contract period) is not operable for this Contract and the Tendered amount should remain **“FIRM”** during the entire period of Contract.

- 13.** All the communication regarding to tender opening & finalization between tenderers and CMDA should be informed through online only. All the tenderers are requested to see the updates of the tender in the website then & there, CMDA is not responsible for tenderer's lapse in this regard.

14. WHOM TO CONTACT:

The Superintending Engineer, Circle-I, Construction Wing, Chennai Metropolitan Development Authority, Tower III, Koyambedu, Chennai - 600 107 may be contacted for further information in the matter through email:cmda-cw-sel@tn.gov.in.

Office Phone Number : **044-29585513**

**Date & signature of the Applicant
with seal**

**Superintending Engineer
Circle-I, C W, CMDA, Ch-107**

Contractor

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