STRUCTURAL SOIL TREE PITS FOR ENHANCED STORMWATER MANAGEMENT: DRAFT DESIGN GUIDE

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ABSTRACT

Structural tree pits are an innovative approach in urban landscaping and stormwater management, designed to support healthy tree growth in urban environments while managing stormwater runoff with reduced operation and maintenance costs. At source stormwater management in new developments in Auckland has been dominated by raingardens over the last decade. Small raingardens have proven to be very costly to operate and maintain.[1] The structural tree pit offers an efficient alternative that also delivers added benefits for our urban ngahere. These systems help address the challenges faced by trees in urban areas, such as limited space for root growth and the prevalence of impervious surfaces that restrict water and air reaching the tree roots.[2] As the system can be loadbearing and trafficable, space under footpaths, driveways and roads can be utilised.[3]

Structural tree pits are starting to be used in Auckland, but no formal guidance exists and there are conflicts between overseas guidelines and in the requirements and objectives between local agencies. A design solution that works for Auckland is required. Auckland Council Community Facilities and Stormwater (Healthy Waters) departments are working collaboratively with Auckland Transport, Maanaki Whenua Landcare Research, NIWA, Tektus, The Urbanist and additional experts in the field to develop design guidance for the use of Structural Tree Pits in the Auckland region.

Trees are a vital component of the sustainability and health of the city and should be considered as critical infrastructure with space to grow and thrive. There is competition for space in our densifying urban environments resulting in fewer street trees. Competing objectives and design constraints can result in existing trees being removed and new trees being left out, as they are not considered as critical infrastructure through the design and consenting process. It is noted that there is evidence of low survival rates amongst street trees planted over the last 20 years. Alongside these constraints, there is limited succession planting of mature street trees (refer figure 1).

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[1] S. Ira and R. Simcock, (2019). Understanding Costs and Maintenance of WSUD in New Zealand: Activating WSUD for Healthy Resilient Communities. Funded by the Building Better Homes, Towns and Cities National Science Challenge.

[2] L.F. Ow and E. Chan, (2021). Deferring waterlogging through stormwater control and channelling of runoff. Revised September 2021. Urban Forestry & Urban Greening Journal 65 (2021) 127351.

[3] B. Embrén and B. Alvem, (2017). Planting beds in the City of Stockholm – a handbook. Revised 2022 and translated. City of Stockholm.

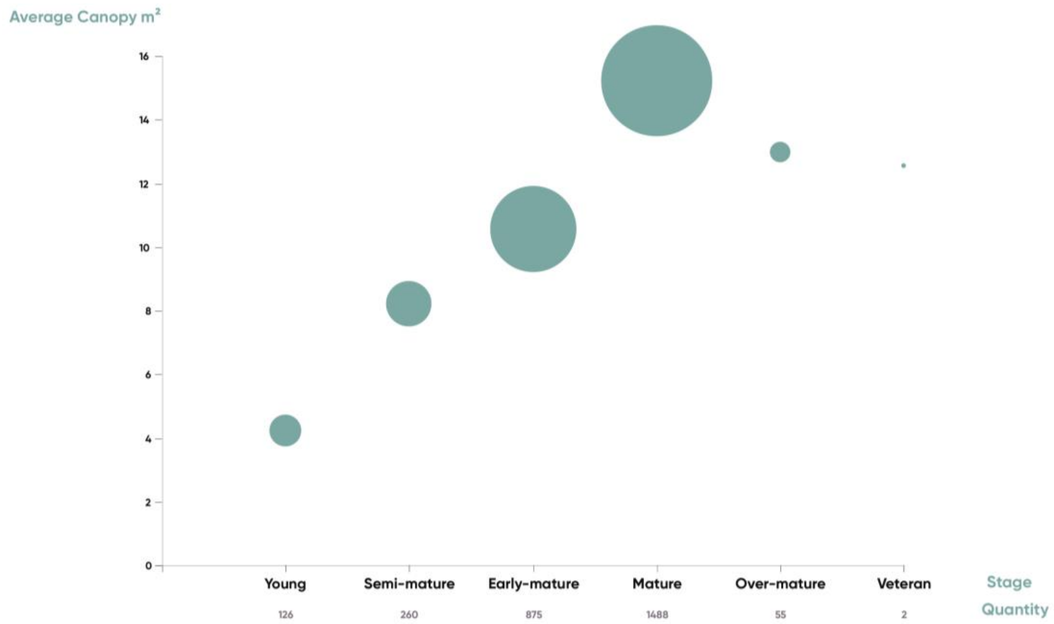

Figure 1: Maangere Tree Survey (~2800 trees) showing lack of succession planting of mature street trees
Source: Zoë Avery, The Urbanist

To ensure that trees can grow to maturity requires consideration to both above and below ground conditions. Some of the significant challenges street trees encounter include the lack of space, oxygen, water, and organic matter; damage from pruning and breakage; and conflict with services. These conflicts have resulted in poor tree survival across Tāmaki Makaurau. More space for tree roots and canopies is required to allow for large trees to mature.

Auckland Council's Urban Ngahere Strategy (2019) sets targets of 15% minimum canopy cover per local board and an average of 30% across the region. Average canopy cover is as low as 8% in several Local Boards with an overall average of 18%[4]. Street trees play a vital role in achieving these targets along with having significant benefits for our city and its people.

Traditional urban development and redevelopment does not leave much space for stormwater management, despite increasing understanding and acceptance of the value of green infrastructure and water sensitive design. Existing stormwater mitigation solutions to achieve regulatory requirements for stormwater management of both water quality and water quantity have in the past frequently resulted in designs which included a proliferation of small devices such as raingardens within the road corridor. These are expensive to maintain, pose safety risks and can be difficult to fit into the streetscape, especially where the berm is busy with other underground services. Rain gardens can also take up space which would have been used for street trees.

4 Golubiewski, N., G. Lawrence, J. Zhao and C. Bishop (2021). Auckland's urban forest canopy cover: state and change (2013-2016/2018). Revised April 2021. Auckland Council technical report, TR2020/009-2

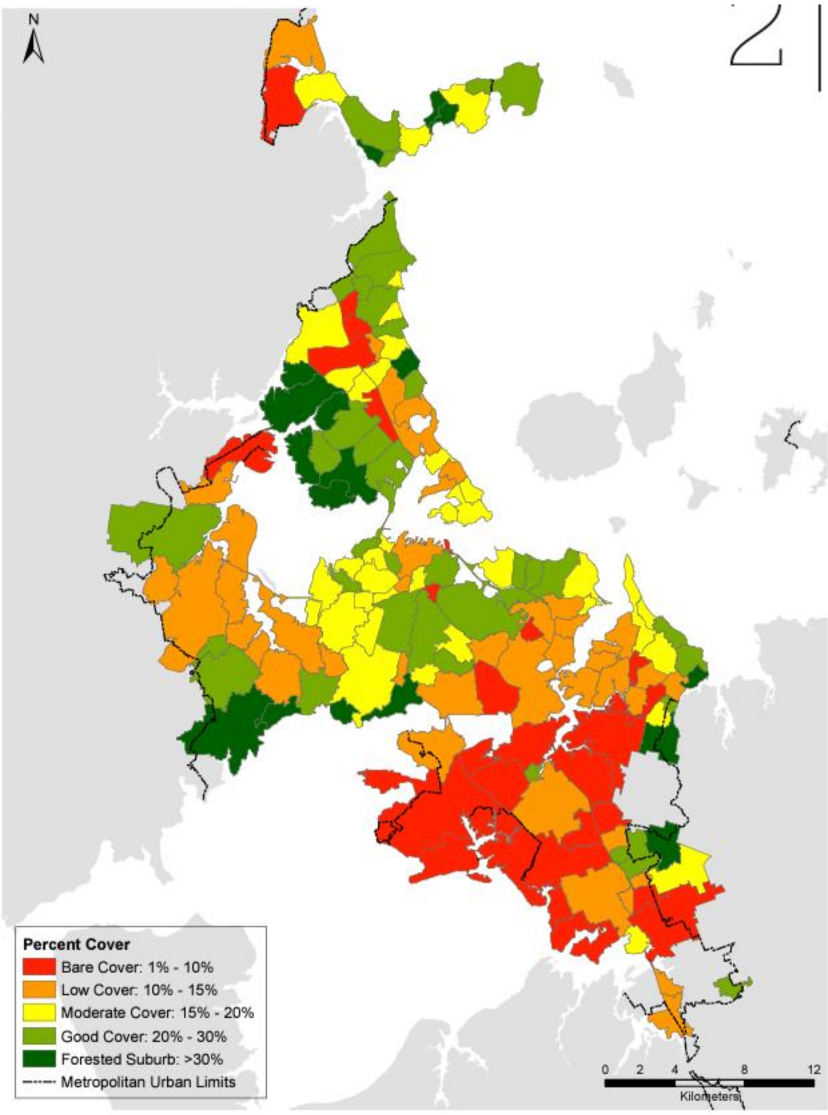

Figure 2: **Average percentage canopy cover of urban ngahere (3m+ height) in Auckland suburbs – based on analysis of the 2013 LiDAR survey**

Source: **Auckland's Urban Ngahere (Forest) Strategy (Auckland Council 2019)**

Structural tree pits offer part of the solution to this challenge. They have the potential to provide benefits for urban ngahere and stormwater management whilst also fitting with the competing demands of the transport corridor. Originating in Stockholm, Sweden, they use a specially engineered type of soil known as structural soil.

Structural tree pits are engineered to provide a supportive growing environment for trees using specially designed soil systems that can bear the load of the pavement, driveways, and other urban infrastructure, preventing soil compaction around the tree roots. They use a blend of soil and structural components, like rigid frameworks or stones, to create voids within the soil. These voids facilitate root growth and allow for better air and water infiltration, promoting healthier and more robust tree growth. These pits are designed to capture and infiltrate stormwater runoff. This water then percolates through the soil, where it can be accessed by the tree roots. By doing so, these pits help in reducing stormwater runoff, mitigating flood risks, and enhancing water quality and groundwater recharge.

Understanding the ecosystem services structural soil tree pits support is critical in helping achieve uptake of these systems and achieving the associated benefits. Often actors are siloed into their particular profession and do not necessarily consider the wider benefits and opportunities available. Understanding and putting value on the wider benefits these systems can provide will help us build more supportive environments for people, nature and therefore the economy.

Figure 3: **Potential Street cross section**
Source: **The Urbanist**

Beyond stormwater management, structural tree pits contribute to various environmental benefits in urban areas. They can aid in carbon sequestration, improve air quality, support tree growth reducing the urban heat island effect and providing UV protection. Enhanced aesthetic appeal of urban landscapes is known to aid the transition to active transport options and improve mental wellbeing leading to both improved health and wellbeing outcomes and improved productivity in the workplace.

In some designs, structural tree pits are integrated with other water sensitive design or green infrastructure elements, such as permeable paving or bioswales. This integration can further enhance the overall efficiency of urban water management and create more sustainable and resilient urban environments. Properly designed structural tree pits can be more durable and require less maintenance than traditional tree planting methods in urban areas. They can protect trees from common urban stressors and reduce the need for frequent replacements or intensive care.

This work has reviewed the original designs from Stockholm, Sweden, including design components, available structural soils, our biochar suitability and availability, and street trees that will be appropriate for these growing conditions.

A collaborative approach has been taken to developing draft design specifications and design guidance documentation ensuring that those involved in assets, infrastructure and maintenance in the streetscape are part of the process and input. The three key Council departments with overlapping interests and responsibilities in Structural Tree Pits along with a team of consultants with urban design, landscape, planning, engineering and ecological expertise have worked together to identify the challenges from each perspective and resolve these into a workable design through finding areas of compromise and alignment.

The draft design includes the integration of various elements to foster healthy tree growth and efficient stormwater management and has been developed with a focus on the future operation and maintenance requirements. Key components include paved surface and base course; stormwater outlets; aeration well for the exchange of air and water; optional tree grate; mulch to help with moisture retention; aeration layer of clean stone being a crucial element for root health, allowing air to circulate within the soil and facilitating gas exchange; structural soil mix enriched with biochar and compost; potential geosynthetic clay liner to prevent water transfer under roading and outfall to stormwater management system if there is inadequate ground infiltration.

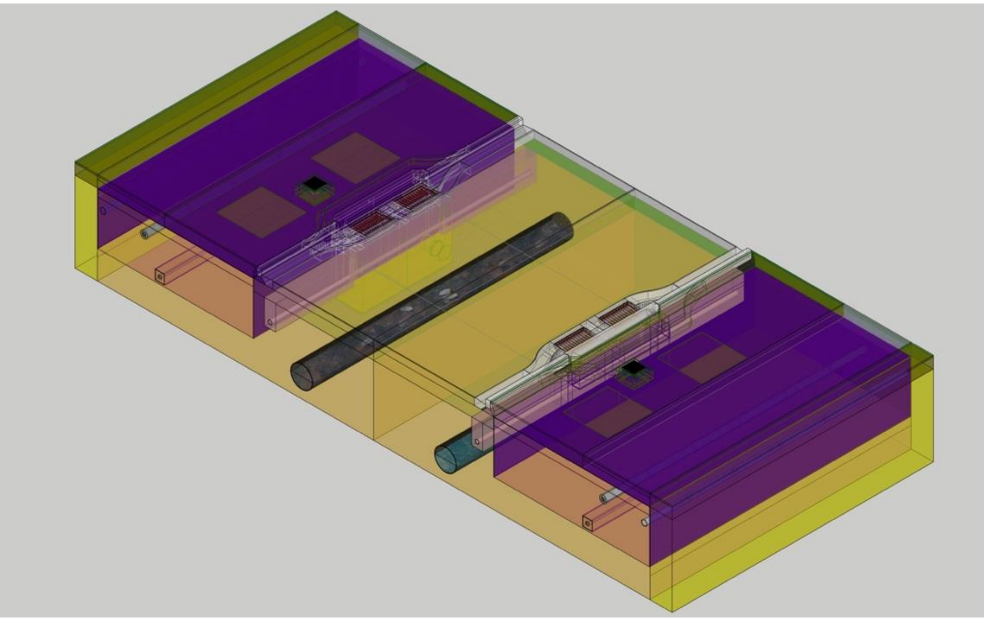

Figure 4: **Draft model of Tree Pit – Kerbside Catchpit (Longitudinal Section)**
Source: **The Urbanist**

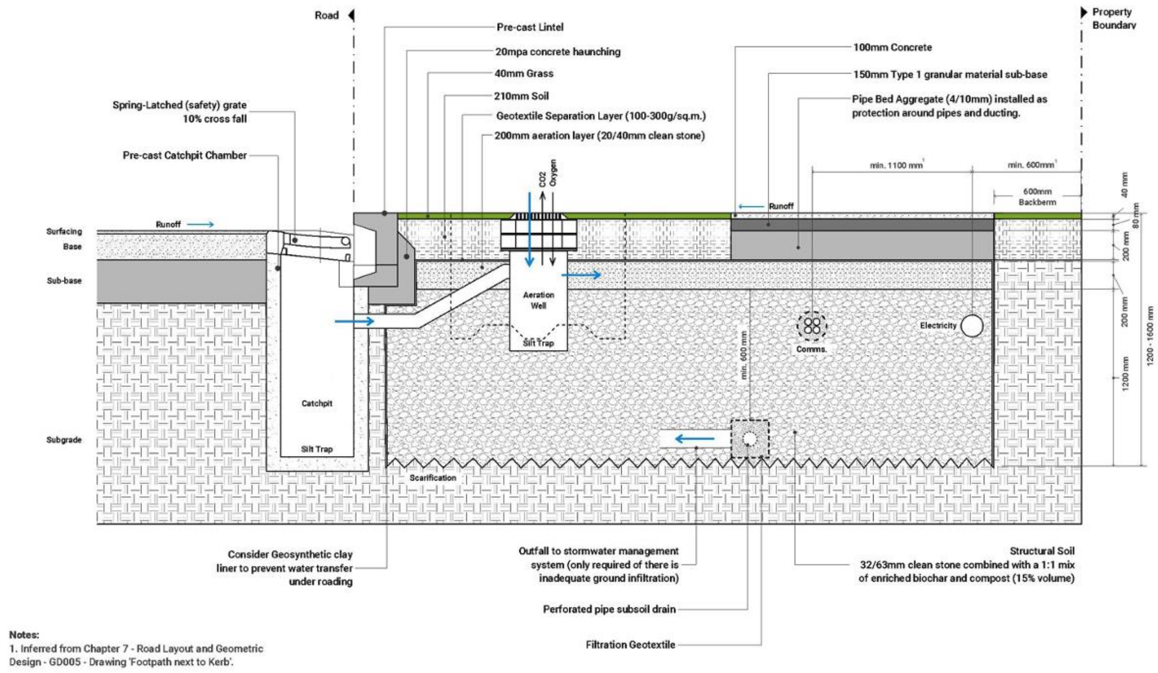

Figure 5: **Draft section of Tree Pit – Kerbside Catchpit (Longitudinal Section)**
Source: **The Urbanist**

Several trial sites are being considered to construct tree pits in accordance with the guidance and test the functionality of the design through the construction phase and for ongoing maintenance and tree health. These include sites that are part of both private subdivision development and public urban regeneration projects. Water quality sampling will also be undertaken to quantify the water quality performance of the devices. The guidance will be revised and improved based on the results from the trial sites. Ultimately the guidance will be incorporated into Auckland's established stormwater device design guidance document GD01 (Stormwater Management Devices in the Auckland Region, Guideline Document 2017/001).

The draft design guidance will be released for input and feedback in the second half of 2024 and we invite all who are interested in this innovative stormwater management opportunity to participate. A range of perspectives and knowledge from industry experts, community and mana whenua will help us deliver even better results for this project.

KEYWORDS

Stormwater mitigation, green infrastructure, street trees, nature-based solutions, collaboration, device design, climate resilience, stormwater management, sustainability, urban heat island effect, biodiversity.