Management of Financial Contributions through Planning Support Systems (PSS) for the Effective Delivery of Infrastructure for Urban Development

by

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Abstract

This research project aims to understand the current role of Planning Support Systems (PSS) to inform the development of a web-based PSS tool to improve and better support the current infrastructure planning system in Victoria, Australia. It seeks to introduce a more efficient approach to the planning and management of financing of urban infrastructure. The purpose of the PSS tool is to provide practitioners, mainly urban planners, with a platform to effectively manage financial contributions and deliver infrastructure and planning in a transparent and coordinated manner. It will also allow rapid responses to information queries and support decision-making through scenario testing by both experts and non-experts alike.

To investigate the functionalities and information required for the PSS tool, the project references several land use plans implemented in Melbourne’s growth areas to design and create a simplified hypothetical land use plan. In addition, the Victorian infrastructure planning guidelines and toolkit are used to specify data inputs, requirements, and models, The approach developed within this thesis seeks to advance the science of PSS by improving urban planning methods for sustainable urban development with a transparent and widely accessible information flow.

Chapter 1: Introduction

The thesis aims to provide the basis for and the development of a web-based Planning Support Systems (PSS) tool to assist in managing financial contributions to effectively deliver urban infrastructure in the context of greenfield developments. It seeks to provide a tool that further supports urban planners in identifying and responding to the challenges currently faced in the financial collection system.

The initial stages of this research will demonstrate the importance of infrastructure planning as population and urban development continues to increase over time. A solid understanding and analysis will then be built around the capabilities of PSS, as well as existing conditions and functions of the infrastructure planning system in Melbourne, Victoria, Australia. The research will also demonstrate the core aspect of PSS, which is using spatial technologies to support complex urban planning tasks using data visualisation and user interaction for better communication.

Victoria needs an overarching framework in its current system that captures the value and delivery of new infrastructure (Victorian Auditor-General's Office, 2020). This is highly recognised by multiple state agencies seeking to address these issues by undertaking appropriate solutions (e.g., system procedures or software) (Mesh Planning, 2022).Building upon the understanding of PSS and infrastructure planning for urban development, this research will seek to develop a web-based spatially enabled (i.e., the ability for users to retrieve data from map interaction) PSS platform tool for practitioners to undertake infrastructure planning tasks such as testing development scenarios and sequencing the timing of infrastructure delivery.

As a result, the PSS tool will also aim to inform users of the financial implication of the tested scenario against a cash flow analysis of urban development over time.

Setting the Scene

Over the next three decades, more than half the global population is expected to live in urban areas (D. o. E. a. S. A. United Nations, 2018). As the world has reached over 8 billion inhabitants, it is significant to note that 56% of the global population lives in cities (The World Bank, 2022). These cities only occupy 3% of Earth’s total land mass (United Nations, 2022). Furthermore, these cities have a significant economic footprint generating 80% of the actual global Gross Domestic

Product (GDP) (Dobbs et al., 2011). Hence, cities have an ever-increasing role in ensuring sustainable systems are in place so that future generations can continue to flourish.

As the expansion of cities increases (i.e., denser or more spread out developments) to accommodate upcoming growth in the future, it is crucial to ensure that the provision of primary and shared infrastructure from utility services to roads, open space and community facilities are well accounted for (Ruming, Gurran, & Randolph, 2011). This is so communities can continue striving towards quality living and achieve a stronger sense of belonging within their local neighbourhoods. The alternative is future communities potentially exposed to the risk of being underserved by basic urban infrastructure as delivery of timely infrastructure faces the challenge of exponential growth rates (World Economic Forum, 2015). This is illustrated by the provision of active recreation centres (e.g., aquatic centres etc.) in Melbourne, where new urban developments currently need more adequate access to these centres due to the impact of high urban growth rates experienced today (Infrastructure Victoria, 2021) (see Figure 1 below).

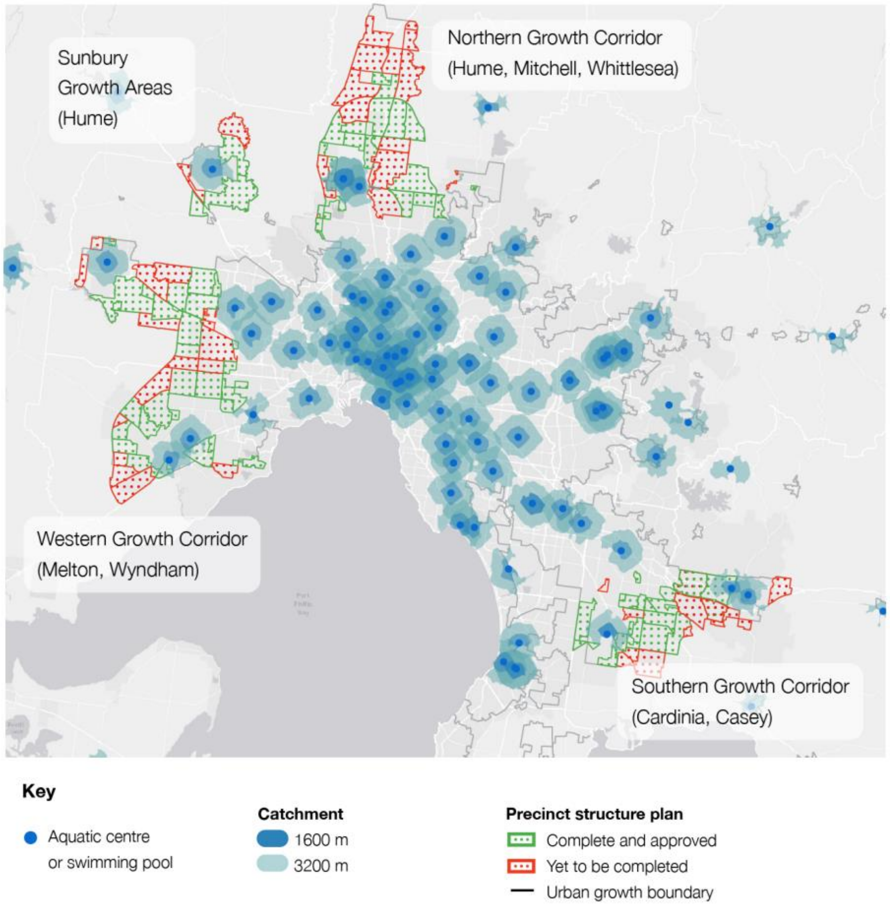


Figure 1: Accessibility gaps to active recreation centres in Melbourne (Infrastructure Victoria, 2021)

Nevertheless, there is still an opportunity for urban planners, in partnership with other professions, to create and plan for liveable and healthy communities supporting a high quality of living (Zapata-Diomedi et al., 2019).

Fundamentals of Infrastructure Planning for Growing Cities

To ensure future communities have access to essential services, one of the fundamental concerns for urban planners and policymakers is coordinating public infrastructure investments whilst managing urban growth and development (Knaap, Ding, & Hopkins, 2001). For example, planners work towards balancing the increased demand for new or improved urban infrastructure as urban development occurs (De Gruyter & Robinson, 2017). Hence, local governments seek out a variety of options to collect or generate funds to provide these new infrastructures. This includes bank loans, federal or state grants, developer contributions and taxes (Wilmoth, 1990).

Whilst it is vital to ensure the collection of sufficient funds for delivering urban infrastructure for growing communities, it is crucial to understand the limits of urban growth without beginning to compromise the liveability of existing or future neighbourhoods. There are three aspects to understand and consider in infrastructure planning which are (1) who are we planning for (i.e., to what extent of growth the city can contain), (2) what urban infrastructure currently exists, and (3) what additional infrastructure does a city need to accommodate future growth (Lewis & Parker, 2021). Each aspect is further illustrated in the following section.

The Extent of Urban Growth

Most cities today are expected to have an established state-wide spatial policy or program to define an urban growth boundary (UGB) for managing future urban growth (Ma et al., 2022). A UGB aims to ensure an adequate land supply to house future populations while supplying adequate urban-level infrastructure and protecting external valuable lands (Lewis & Parker, 2021). As an established city is usually contained within the extent of the UGB, planners must be aware of the amount of land allowed to be developed. Moreover, it should focus on how and where growth will occur whilst ensuring the timely delivery of urban infrastructure for these areas.

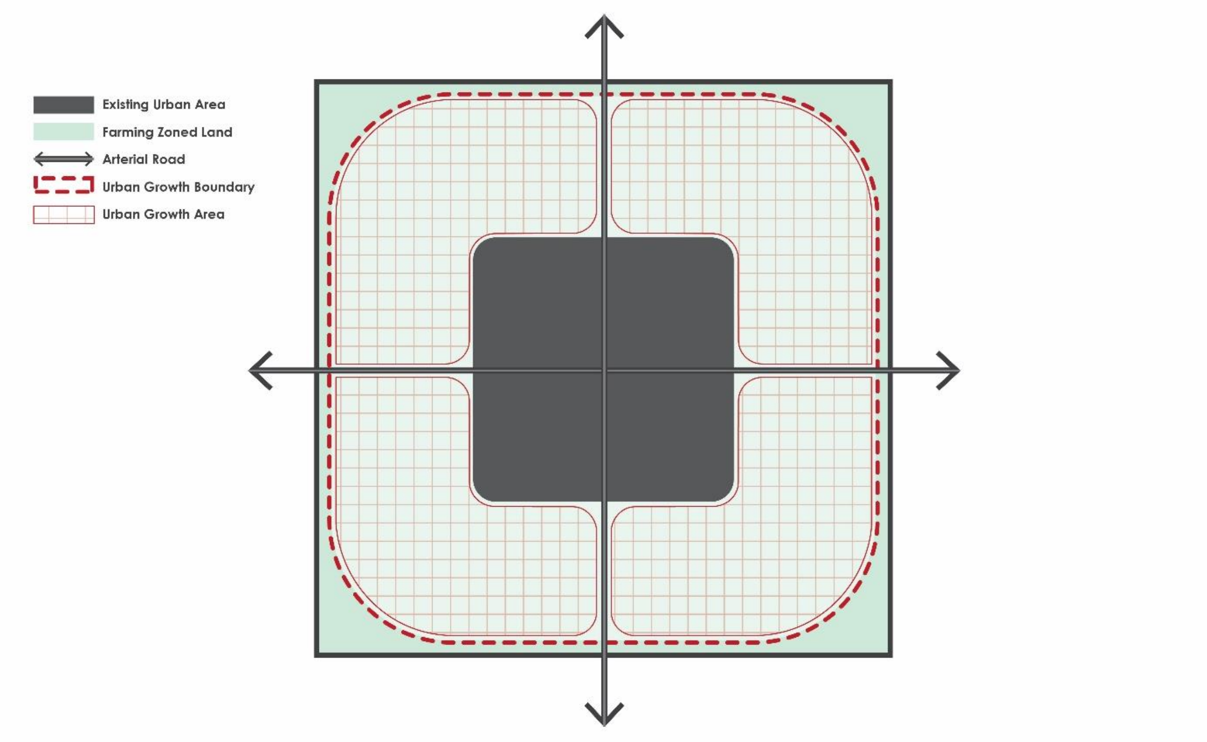


Figure 2: Spatial relationship between established urban area and urban growth boundary.

Existing Urban Infrastructure

Before delivering new infrastructure outside existing urban areas, it is crucial to oversee existing public infrastructures and how they perform in these established areas. Planners must consider the status of these assets and their capacity to continue meeting the demand of existing residents and assess if there is additional capacity to accommodate future residents or communities (Victorian Planning Authority, n.d.). The identification of extra capacity in these essential infrastructures can assist future neighbouring communities in benefiting from this capacity.

This can assist larger neighbourhoods, whether they are already established or in the planning stage, in providing stronger justification for funding and delivering higher-tiered infrastructure, which neighbouring communities can also benefit from.

On the other hand, an audit of existing infrastructures, such as transport for enhancing connectivity, open space for recreational purposes, and community hubs for social gathering, will prevent local authorities or developers from the over provision of urban infrastructure.

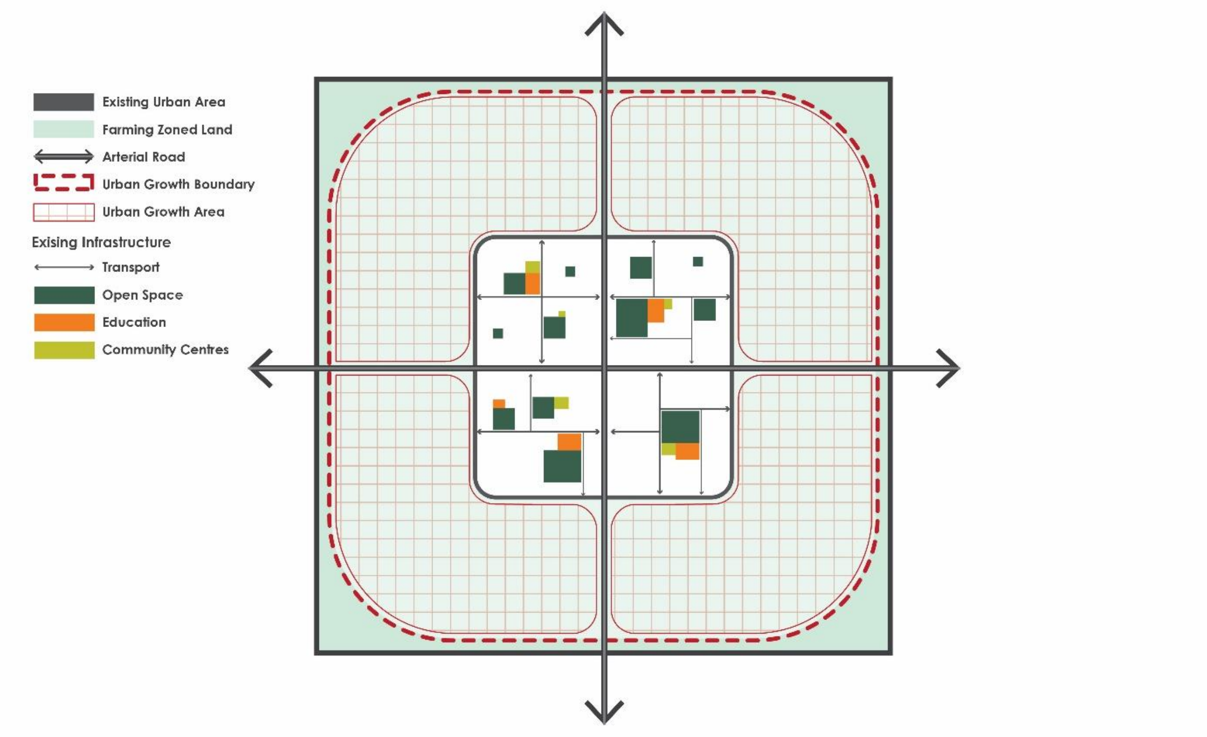


Figure 3: Existing infrastructure within established areas.

Accommodating Future Growth

Once there is more clarity around who and where growth will occur and the knowledge and understanding of where existing infrastructure within established areas is servicing existing residents, planners can start planning new infrastructure in these neighbourhoods. A community needs assessment is then required to be undertaken to analyse the new infrastructure it will require to service future residents reflective of the neighbourhood's projected growth and demographic profile. Identifying the entire infrastructure a new neighbourhood needs to be serviced with will need to be strategically planned and coordinated for its timely delivery to unlock urban developments (Victorian Planning Authority, 2021).

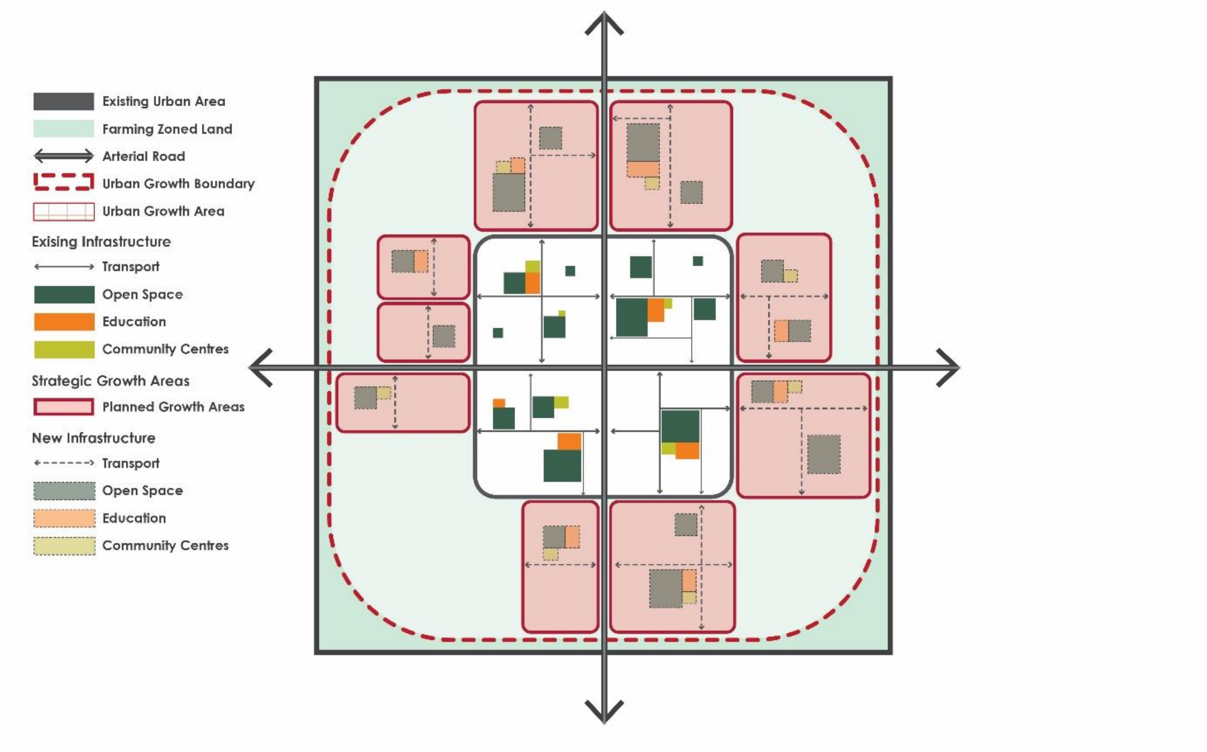


Figure 4: Future/new infrastructure to be planned for in growth areas.

The Concept of Value Capture

What is value capture, and how does it support infrastructure funding and delivery

Infrastructure Australia (2016) defines value capture as the reclamation value of land in terms of monetary worth in exchange for helping fund the investment of public infrastructures. This is important as the infrastructure provision increases the value of its surrounding properties due to the amenity upgrade it offers within its proximity (Lee & Locke, 2021). For instance, the construction of public transport connections adjacent to residential developments is expected to cause land value or rent to increase due to improved access and connectivity. Therefore, the neglect towards value capture will result in the private sector gaining back the majority of the localised benefits of new infrastructure (Infrastructure Australia, 2016). Hence, the government has an important role to play at a policy level to ensure that existing and future communities recapture the value of land as urban development occurs.

The benefits of value capture in infrastructure planning

During the infrastructure decision-making process, it is crucial for infrastructure planners to account for undertaking value capture (Infrastructure Australia, 2016). This is because a range of benefits value capture can help realise better support in funding infrastructure provision. First, value capture can secure a fairer system for infrastructure funding whereby the party which benefits the most due to the new infrastructure must be more liable than the others who do not (Roukouni & Stephanis, 2016). This ensures that certain private landholdings get only some credits and not fully from those infrastructure provisions. However, it is essential to note that the government is limited to the subset of that neighbourhood for infrastructure funding and cannot expect them to cover infrastructure costs far beyond their local context. For example, there must be adequate nexus to a community's use and demand for particular localised infrastructure (DELWP, 2007). Nonetheless, this approach helps balance both public and private interests in developing or improving their local community in an equitable funding manner.

Secondly, value capture increases the opportunity to collect more funding from the private sector, which can also be expressed or undertaken through several types of value capture. The types of value capture in current practice or literature include but are not limited to taxes on both land value and property transactions, developer contributions, leveraging government land, and betterment levies (SGS Economics & Planning, 2016). It can be illustrated that there is a broad range of value capture types that the government can choose to undertake as a funding approach to reducing the financial burden on the government's budget (Infrastructure Australia, 2016). Hence, the government must carefully scope the appropriate implementation of value capture approaches to fund different types of infrastructure according to its scale, location, and timing (Abelson, 2018).

Infrastructure Planning System for Greenfield Developments in Victoria, Australia

One of the many ways of undertaking value capture for infrastructure funding is through development contributions, that is, payments by developers towards new infrastructure as development is carried out. This section describes the process from planning future neighbourhoods through an urban precinct structure planning stage to planning infrastructure via an appropriate funding mechanism.

Urban Precinct Structure Planning

Melbourne’s development context is distinguished between infill (i.e., strategic development sites), growth areas (i.e., greenfield developments) and regional areas (i.e., outside metropolitan

Melbourne). The Metropolitan Melbourne region comprises infill and growth area development types within its urban growth boundary, ensuring the protection of the supply of farming land.

Before the preparation and development of an infrastructure plan for a newly planned neighbourhood, the preparation for an urban Precinct Structure Plan (PSP) is first undertaken. A PSP is a long-term plan to guide urban developments and applies to all identified greenfield development growth areas. This strategic plan includes how and where services should be located to support future residents with high-quality living (Victorian Planning Authority, 2021).

A PSP is usually complemented with a range of technical reports such as land capability assessment, traffic modelling, community infrastructure needs assessment, integrated water management, heritage, economic and habitat assessments etc. All these reports are essential for gathering land and environment information to justify planning decisions, such as assigning appropriate land uses across the precinct for urban development and infrastructure requirements. In addition, key elements in a PSP typically consist of a precinct land budget (i.e., land calculation of the precinct broken down into land use categories) and policy and guidelines for guiding future urban development regarding housing density, neighbourhood character, heritage etc. Furthermore, the PSP provides the strategic basis for a list of infrastructures within the precinct to be delivered and begin undertaking preliminary scoping and design of those infrastructures.

Infrastructure Planning

Somewhere between preparing a PSP, the forming of a Development Contributions Plan (DCP) or an Infrastructure Contributions Plan (ICP) is commenced. DCP and ICP are funding mechanisms that undertake a formal program and process for determining a list of local infrastructures that need funding. The latter chapter of this research will describe other funding mechanisms available under the Victorian planning jurisdiction. It is important to note that the ICP can only be applied in defined development settings such as infill strategic development sites, greenfield growth areas and regional areas. This is made effective beginning in mid-2018 by the Planning and Environment Act 1987, Victoria's legislative framework for the use and development of land, which states all PSPs (i.e., new precincts in existing greenfield growth areas) prepared after 2017 must adopt the ICP system. The State recently adopted this new ICP system to streamline infrastructure contributions by introducing a standardised levy and simplifying the land acquisition calculation method. Nonetheless, it is expected that many existing DCPs prepared in the past will continue to operate and be implemented in areas that ICPs could not (Victorian

Planning Authority, 2018). Although a DCP differs from an ICP, whereby it adopts different approaches and methodologies for funding infrastructure under the same jurisdiction, they function towards the same purpose.

Furthermore, a DCP or ICP is not a planning instrument. To illustrate, it does not set out policies for the planning or development of an area. Instead, it is a planning implementation tool to enable the equitable funding and delivery of higher-order infrastructure (DELWP, 2007). Therefore, the preparation of an infrastructure plan will require many inputs and cooperation across a government body. The plan is typically carried out by refining the scope, design, and costs of infrastructure requirements specified in the PSP. These tasks usually comprise detailed engineering plans, quantity surveying and land valuation. They are then consolidated into a complete infrastructure project list grouped into their categories (e.g., transport, open space, community etc.).

In addition, a more detailed land budget calculation is calculated following the PSP to further specify the classification of land use types, calculating the amount of land dedicated to public purpose land and allowable land for development (i.e., net developable area – NDA). These two main inputs, the infrastructure project list and the land budget, form the basis for calculating the development charge rate for the land. This then forms the total liability developers are accountable for as development occurs for funding the required infrastructure.

This process, from the commencement of a PSP preparation to the completion of a DCP or ICP, typically runs for two to three years. Despite that, the ongoing management of both documents can lead to a fifteen to twenty-year horizon. Hence, the complexity of this system lies upon the prioritisation of infrastructure delivery and timing, development activity staging and the type of infrastructure delivery (i.e., council or developer).

Figure 5 below summarises the formulation and preparation of a PSP and DCP/ICP under the Victorian Planning System for precinct and infrastructure planning.

On the other hand, Figure 6 shows the status of PSP across Metropolitan Melbourne growth areas in 2018, and the amount of land area planners are managing. Additionally, a massive volume of infrastructure development contributions plans is pending completion. Similarly, Figure 7 presents the amount of development that occurred and the contributions collected in 2018 (Mesh Planning, 2019). It is important to note that the levies collected and managed by planners range between $1 - $65 million on top of the total asset value from developers. This shows a significant financial and delivery obligation on local governments to ensure essential infrastructure is delivered on time.

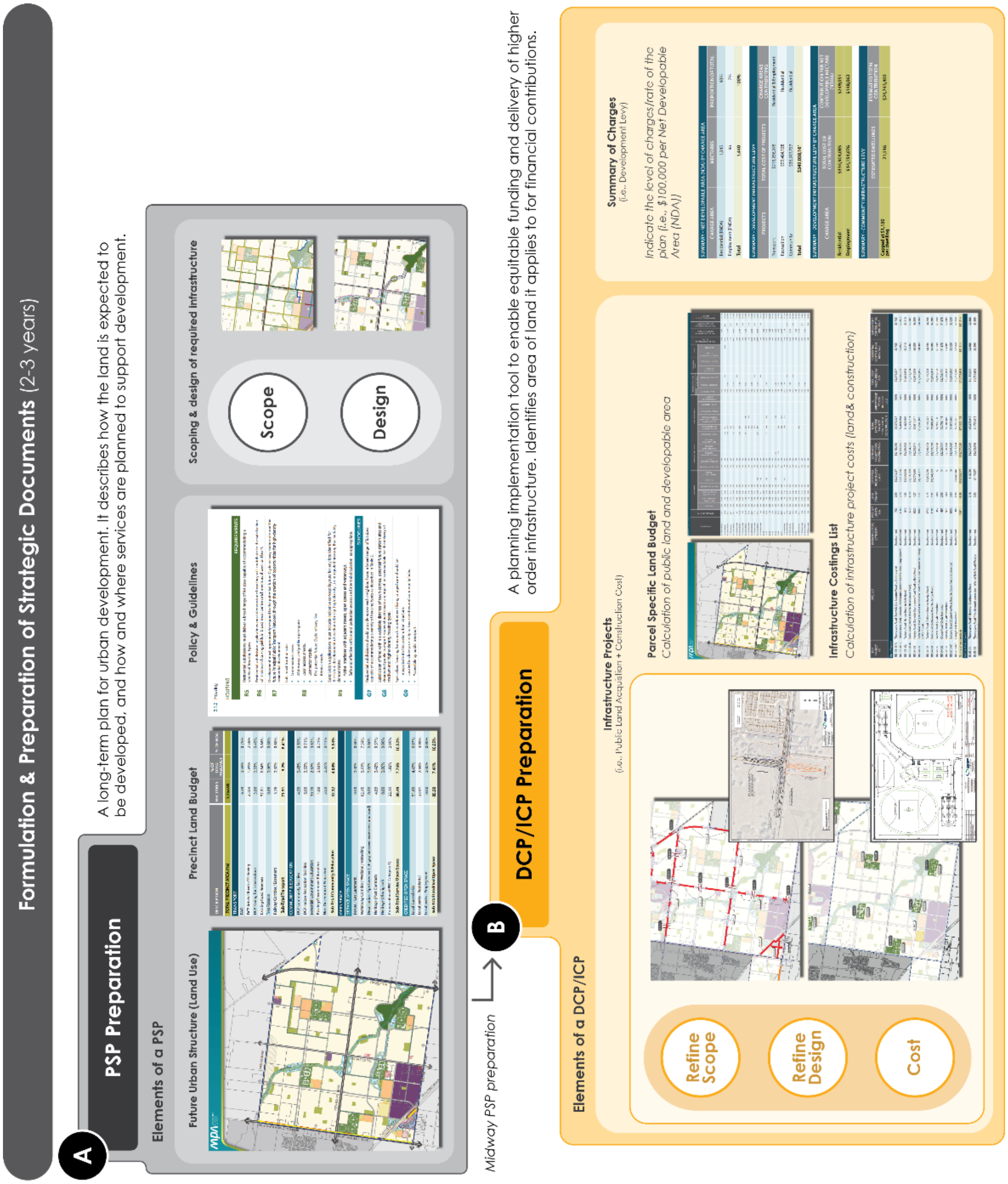


Figure 5: Urban precinct structure plan to the infrastructure planning process in Victoria.

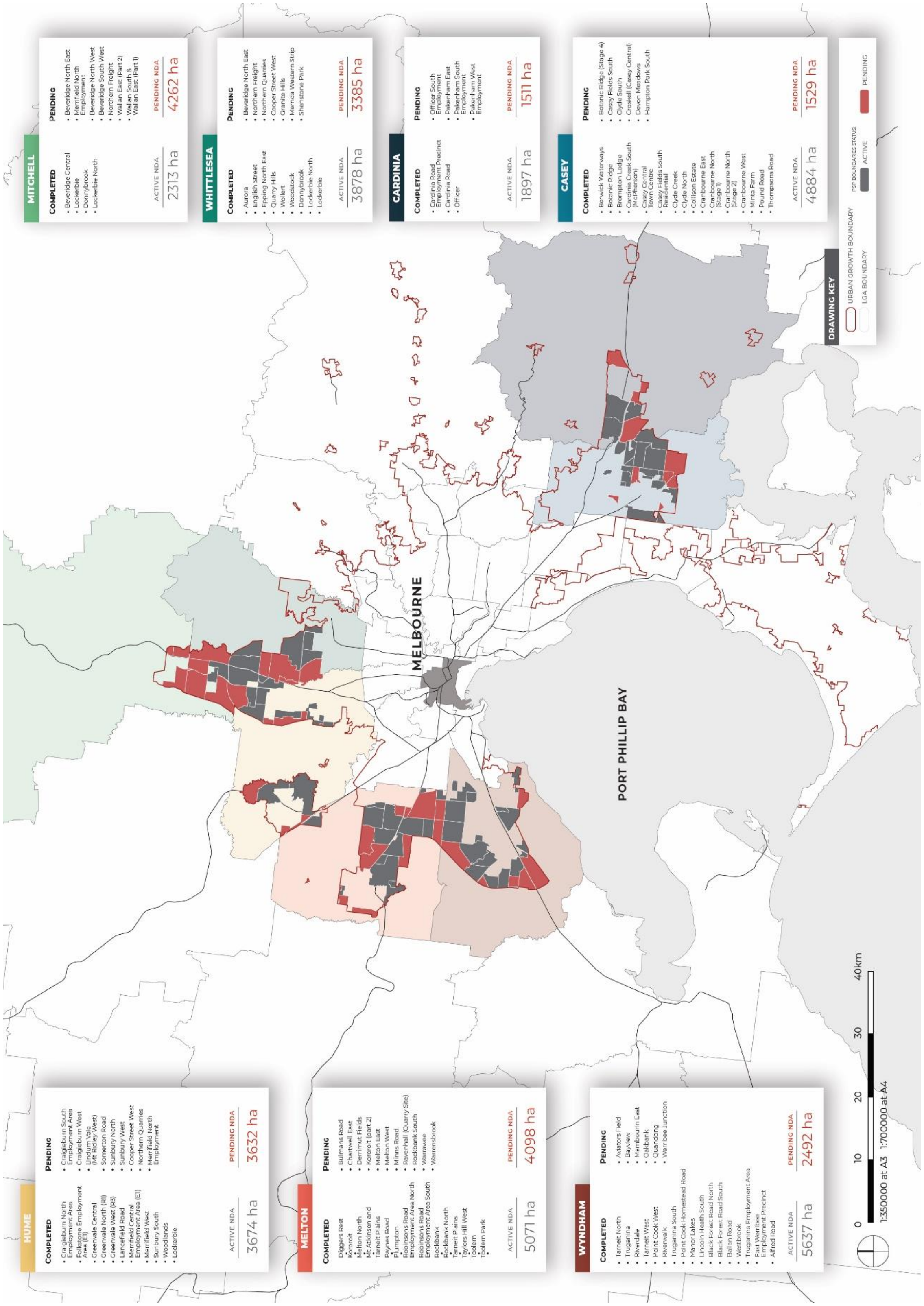
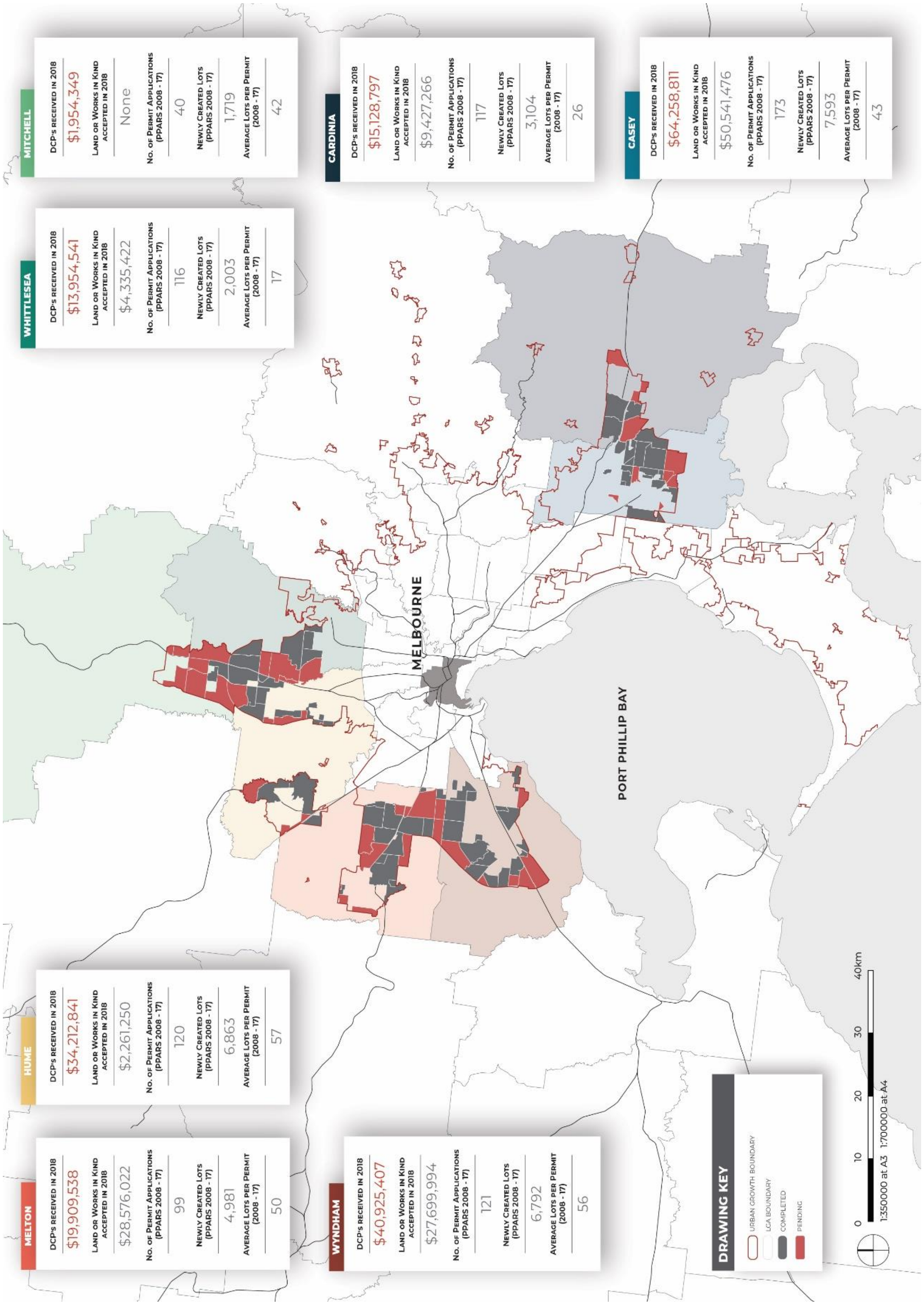


Figure 6: PSP status in 2018 across Metropolitan Melbourne Growth Areas (Mesh Planning, 2019).



	DCP's received in 2018	Land or Works in Kind accepted in 2018	No. of Permit Applications (PPARS 2008 - 17)	Newly Created Lots (PPARS 2008 - 17)	Average Lots per Permit (2008 - 17)
MITCHELL	$1,954,349	None	40	1,719	42
CARDINIA	$15,128,797	$9,427,266	117	3,104	26
CASEY	$64,258,811	$50,541,476	173	7,593	43
WHITTLESEA	$13,954,541	$4,335,422	116	2,003	17
HUME	$34,212,841	$2,261,250	120	6,863	57
MELTON	$19,909,538	$28,576,022	99	4,981	50
WYNDHAM	$40,925,407	$27,699,994	121	6,792	56

Figure 7: Development activity and DCP income (cash and asset) received in 2018 by each growth area (Mesh Planning, 2019).

Major issues in Victoria’s infrastructure planning system

As much as there is a system in place for ensuring the coordination and delivery of infrastructure in Melbourne, Victoria, the infrastructure planning system needs to perform more adequately, delivering sufficient infrastructure to support existing and future neighbourhoods (Victorian Auditor-General's Office, 2020). The list below is a summary of key issues in the system that will be further discussed in the latter part of the thesis;

1. The inadequate public infrastructure required by growing communities,
2. A lack of an overarching infrastructure strategy and coordination,
3. Barriers and participation risk in formal infrastructure delivery program,
4. Transparency and accessibility of information to track the funding and delivery of infrastructure.

As a result, this research seeks to address some of these significant issues and identify opportunities to effectively manage infrastructure delivery and planning for local communities moving forward using geospatial technologies and solutions.

Problem Statement

The current system and procedures in managing financial contributions towards infrastructure provision lack flexibility and require substantial resources to coordinate multiple stakeholders. Planning systems related to infrastructure planning and delivery are inefficient and need a better solution to carry them out.

In addition, infrastructure is inherently spatial; however, handling this information falls short in the spatial aspect involved. This separation between infrastructure elements and their spatial context makes it challenging for practitioners to manage and track infrastructure contributions. This is because a clear and coherent (spatial) overview of the collection of funds and the status of infrastructure delivery is in deficit.

Research Aim

This research aims to investigate an alternative approach to managing urban infrastructure financing using spatial technologies and concepts, such as a PSS, for greater accessibility to information, communication, and better decision-making. The purpose is to improve existing methods and practices in infrastructure planning that seek a more robust and centralised system to manage and track infrastructure contributions and delivery effectively.

There needs to be more integration between non-spatial and spatial aspects in the current system, which can significantly benefit in practice from combining those two aspects coherently. To achieve the research aim formulated above, one closely related research question must be answered, which is: How do the spatial component and characteristics of a PSS better support infrastructure planning processes more effectively?

Research Methodology

To answer the research question, several methods will be used such as below:

1. **Undertake a literature review** that covers the following field:
    a. PSS principles, role, function and success in urban planning. Several existing PSS case studies will be examined to assess it against PSS principles and function.
    b. Urban infrastructure finance and planning, its principles, objectives, and spatial planning concepts. The crucial components and inputs necessary for preparing and implementing infrastructure planning will be examined.
2. **Complete a gap analysis** that assesses and compares the implementation challenges of PSS and infrastructure planning and then identify the opportunities for integrating both fields. This step includes analysing surveyed data with practitioners and utilising the results to inform function and software requirements.
3. **Utilise geospatial and application development techniques** and methods to develop and implement a web-based PSS platform tool informed by the literature review and gap analysis.
4. **Investigate the use of a multi-tiered system architecture** consisting of a database, business logic and presentation layer for the planning, designing, and deploying of the PSS tool.
5. **Assessment of the PSS tool according to a user-design fit model** (i.e., utility and usability) and record user feedback using the tool to determine any arising similarities of issues using the tool.

Thesis Outline

The remainder of this thesis is divided into five other main chapters, beginning in **Chapter 2**, exploring the concept, principles, and role of both PSS and urban infrastructure finance. It will also seek to review the measure for success in both fields and examine several PSS case studies and critical information essential for infrastructure financing.

After being well-informed about the role and objectives of PSS and infrastructure finance, **Chapter 3** consists of a gap analysis that investigates existing implementing challenges and opportunities of both PSS and urban infrastructure finance. While planning urban infrastructure requires several tools for ongoing urban development management, the implementation challenges experienced by practitioners today will also be reviewed. During this process, it seeks to identify opportunities for how both systems can be further integrated and complement each other.

Chapter 4 contains methods for developing a web-based PSS platform tool. This will demonstrate the integration between the inputs for infrastructure planning and financing with digital infrastructure, such as spatial databases and GIS, to support the development of the tool.

The result of Chapter 4 will be further discussed in **Chapter 5**, where several use cases will be tested using the PSS tool. The tool will be further assessed against a user-design fit model and user feedback from using the tool.

The final chapter in **Chapter 6** will summarise the essential findings and results of the methodology used. It will also review the limitations and recommendations of this research, including some closing remarks and future considerations to move forward.

Figure 8 shows the summary of the outline of this thesis.

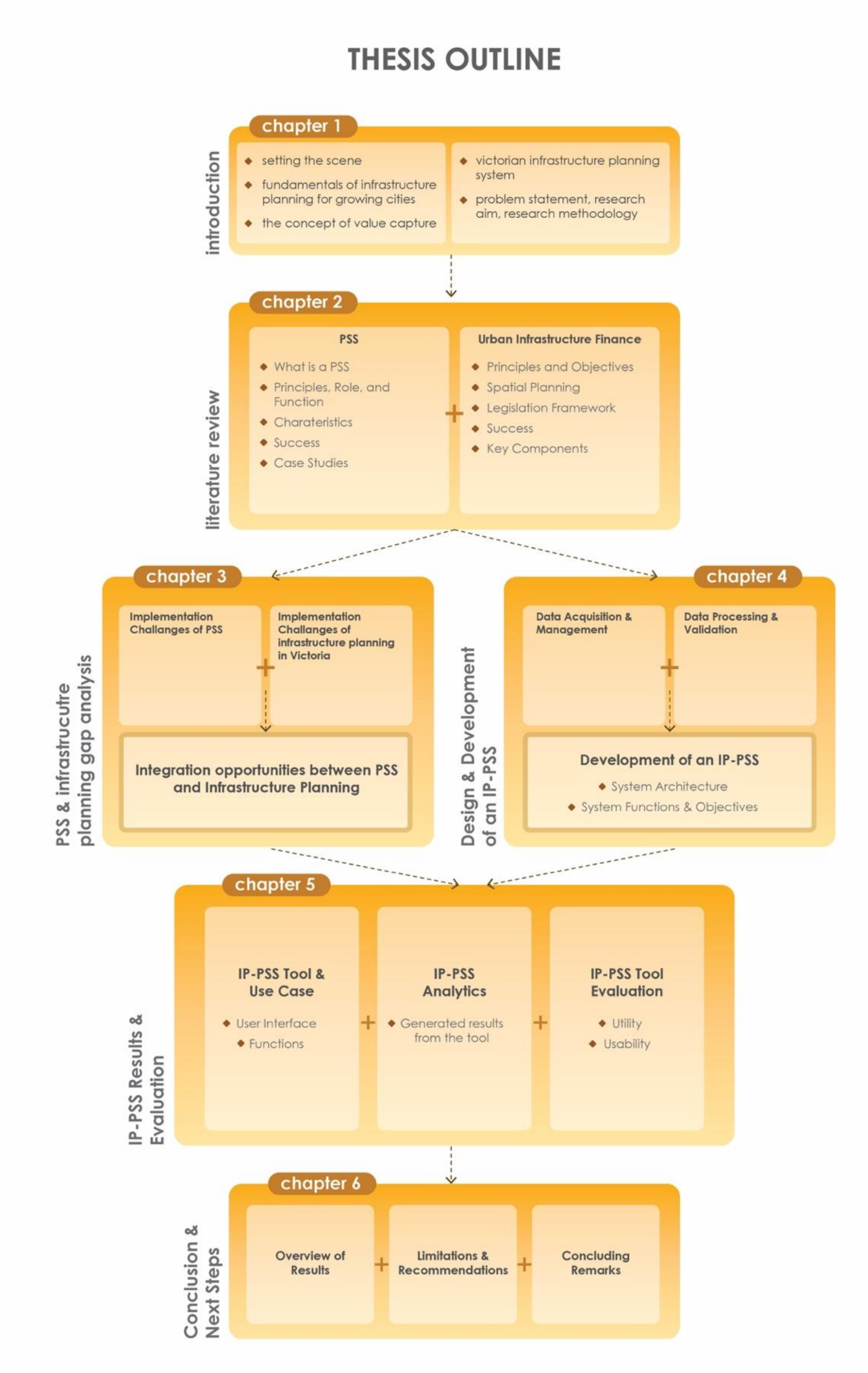


Figure 8: Graphical overview of the thesis outline.

Chapter 2: Literature Review

This chapter aims to gain a solid insight into the field of PSS and urban infrastructure finance to assist in developing an infrastructure planning PSS (IP-PSS). Although the amount of literature that contains direct linkages between PSS and infrastructure planning is scarce, there is an extensive volume of research on both fields individually. Therefore, this review's goal is first to exhibit the principles, roles, and characteristics, including what success would look like in their respective fields. Several PSS case studies will be presented to demonstrate how it performs against its principles, role, and function. In addition, key components and inputs for the preparation and implementation of infrastructure financing and delivery will be examined using examples in the context of Victoria.

Planning Support Science & Systems

What is a PSS

The term PSS was first coined by Harris (1989), which refers to the leverage of digital technology capabilities for spatial planning that goes beyond the basic function of microcomputer usage, such as document preparation and record keeping. The concept of PSS originates from the broader field of Spatial Decision Support Systems (SDSS), which combines geographic information systems (GIS) with user interaction to process information in a format that users easily interpret to better inform decision-making (Crossland, 2008). More precisely, PSS at its core are computer-automated aided tools that aim to assist urban planners to effectively undertake planning-specific activities or complex planning decision-making (Geertman & Stillwell, 2020a) during planning processes.

Planners over the last decade recognise the increasing challenge in spatial planning processes due to the involvement of a wide range of stakeholders, government organisations, and the public and private sector. This led to the motivation to further investigate the application of PSS to support better planning processes on top of existing planning instruments (Geertman & Stillwell, 2020b). Consequently, there was a massive supply and production of various PSS types; however, the impact of these systems has yet to be widely accepted or applied in planning practice (Luque-Martín & Pfeffer, 2020). Nevertheless, the following section will discuss the functional nature and characteristics of a PSS and what it takes to succeed.

Principles, Role, and Function

The literature obtained concerning PSS principles, role, and function is consolidated and broken down into four distinct categories, which comprised of (1) a supporting spatial and technological tool, (2) optimising planning processes and tasks, (3) scenario testing and planning of urban realities, and (4) a standardised communicative platform for interaction among stakeholders.

Supporting Technology for Planning

The first principle of PSS is they do not exist to replace existing planning tools but rather to integrate and improve current systems (Richard E. Klosterman, 1997). For instance, PSS does not seek to substitute urban planners with automated technologies in strategic planning activities but instead further supports their professional role (Geertman & Stillwell, 2020a). Vonk and Geertman (2008) state that PSS are geo-information tools created to aid planners in carrying out complicated planning tasks. These tasks involve handling big data, communication, and analysis that usually cannot be handled well by regular programs within the planning process. Nonetheless, a true PSS must consist of user-friendly geo-locational properties and interactive spatial models without undermining planners' ability to carry out their day-to-day tasks (Harris, 1989). For instance, this can be demonstrated by the preparation of spatial plans and the management of land use and development activities by planners created through the urban planning process (Luque-Martín & Pfeffer, 2020). Hence, PSS can further elevate these tasks into a more coordinated and informed procedure.

Optimisation in Planning

Secondly, Harris (1989) stipulates that the demand for more robust planning tools is motivated by the objectives of planners constantly working towards optimising processes. This can be illustrated by pursuing more advanced technologies such as a PSS to streamline decision-making and increase operational efficiency within internal organisation structure and processes. Hence, from a technological perspective, developing a PSS to simplify planning tasks is crucial, allowing practitioners to efficiently achieve their planning goals with great satisfaction (Russo, Lanzilotti, Costabile, & Pettit, 2018). Thus, PSS has a role in reducing the complexity of planning tasks and issues into an appropriate decision-supporting framework for further enhancing the planning profession.

Scenario Testing and Planning

Thirdly, PSS provides practitioners with an understanding of plausible urban futures based on the effect of undertaking certain planning decisions (C. J. Pettit et al., 2013). This principle correlates with one of the planners' core activities, such as evaluating and managing the impact of urban processes due to policy changes, as highlighted by Harris (1989). The alternative futures that PSS may propose can be encapsulated as "What If?" scenarios which mean, as its name already suggests, what would happen if a particular decision were made and the assumption concerning what would happen comes to fruition (R. E. Klosterman, 1999). R. E. Klosterman (1999) further illustrates that such scenarios do not attempt to predict the future exactly but instead foster a bottom-up approach that partners with the public to 'plan with' and not 'plan for' during the process. This ensures that the planning process is supervised by the public and facilitates ongoing learning, debate, and compromise to achieve the desired future.

Communication and Accessibility

Lastly, PSS are essentially spatial-based tools (i.e., visual-based tools) (Vonk & Geertman, 2008), as discussed above, that incorporate geospatial data and information into planning instruments (S. Lieske, Lyons, Wall, & Wall, 2008). Geertman (2006) states that PSS exists under an integrative environment utilising multiple technologies available to create a standard interface shared among planners and stakeholders to support planning processes and communication. In addition, planners nowadays have abundant access to geodata and meta-geoinformation for making informed decisions; however, using these data to undertake more sophisticated planning tasks is limited (Vonk, Geertman, & Schot, 2005). Consequently, basic geospatial tools are rarely employed for tasks such as foresight narrative communication, forecasting, evaluation etc. (Couclelis, 2005).

Therefore, Vonk et al. (2005) assert that PSS formulates a consolidating framework that unites functionalities from geospatial systems, data visualisation and repository, analysis and structure to support better communication in planning. Given the many challenges experienced by planners today, such as balancing interests between several stakeholders, the aforementioned consolidating framework can be supported by a shared mapping interface. This framework can assist in visualising spatial plans and information from the data collected by planners to facilitate better interaction among stakeholders (Flacke, Boer, Bosch, & Pfeffer, 2020). This is critical as most planners are visually oriented, and information is most meaningful to them when it is conveyed through spatial distribution and their interrelationship in a format that is easy to understand (Harris, 1989).

As a result, this method can be most helpful in communicating complex spatial planning concepts in a simplified manner that can be comprehended easily by both practitioners and the public. Furthermore, this notion concurs with the different usages of PSS for communication, such as (1) one-way information provision interaction, (2) communication processes as a two-way interaction for collaborative tasks and (3) modelling interaction for analytical tasks (Vonk, Geertman, & Schot, 2006).

Characteristics of PSS

Map Based

PSS are computer-based planning systems that must consist of a geographic information system (GIS) with mapping and display spatial information capabilities at its core (Harris, 1989). This facilitates common ground and a medium where information, analysis and results are shared and communicated. Additionally, it is a system that combines spatial and non-spatial information into a single platform where data is stored to effectively support planning tasks (R. E. Klosterman, 1999), such as retrieving information and spatial modelling. Furthermore, it is crucial to point out that the spatial component of PSS enables planners the capacity to map events or development processes through spatial visualisation and data manipulation during the planning process (Harris, 1989). Conversely, the spatial capabilities that PSS seeks to support cover a spectrum of multi-dimensional visualisation (i.e., 2D and 3D), including space and time (4D) using spatial data, which can bring additional value into tasks carried out by planners (S. N. Lieske, 2020).

Simplified User Interface

In terms of user interfaces, a PSS is the opposite of a GIS software application, which contains a suite of functionalities and sophisticated interfaces to create, manipulate, store, and share information. The PSS interface users must engage with should be minimal, intuitive, and easy to use (Pan, Geertman, & Deal, 2020). As such, this concept helps prepare an inclusive system and platform for practitioners with solid technical backgrounds, other professions, and the public. Therefore, such an approach can assist in widening the horizon of potential users and increases the opportunity for more collaborative planning. For instance, PSS with simple interfaces finds it easier to communicate complex models and data to users, allowing users to interact with parameters and model generation processing (Yang, Chang, Saha, & Chen, 2020). Nevertheless, it is with great emphasis that the usability of PSS must be well designed so that the barriers to adopting such a system can be overcome (Harris, 1989; Russo et al., 2018). Moreover, the benefit of such technology or tool is always displayed as a prototype and has ample space for user inputs and feedback for further improvements.

Planning Specific Functions

The functions within PSS focus solely on specific tasks for urban planning instead of generic GIS that covers a broad range of functionalities (Vonk et al., 2005). The designed PSS should incorporate theories, information, and methods to undertake and support a range of unique planning tasks (S. Lieske et al., 2008). This can be illustrated by planners utilising PSS to process and analyse the massive volume of data, linking them with different aspects of urban planning to formulate rational reasoning in making effective action plans (Page et al., 2020). The described planning-specific tasks above are projecting future land use patterns and structure (R. E. Klosterman, 1999), testing and communicating alternative planning scenarios (Couclelis, 2005), and facilitating planning with the community as a bottom-up approach.

Success in PSS

Planning over technological problems

It is argued that technological considerations for developing a planning tool must be counterbalanced first with the conceptualisation of the planning issue and the operational role of the tool (Richard E. Klosterman, 1997). PSS tools and functionalities created in laboratories must be tailored to the scoped problems in planning rather than the technology itself (or developing new tools) to ensure greater adoption of such tools in practice (Luque-Martín & Pfeffer, 2020; Vonk et al., 2005). Vonk and Geertman (2008) stress that it is crucial for system developers to engage and partner with practitioners to determine the needs and support required in their professional role to enhance the quality of PSS further.

Contextualisation

PSS are inherently context-specific and are designed as bespoke systems that should be adapted appropriately according to their context for utilisation (Hersperger & Fertner, 2020). The challenge arises from the fact that planning practice functions under a multi-facet arena, balancing various types of knowledge and adopting different jurisdiction systems worldwide, including within the state (Vonk & Geertman, 2008). Hence, if the goal and objective of the PSS tools are defined, the practical application of the tool will be fully realised.

Ongoing experimentation and improvements

The implementation of PSS in the industry involves a much larger pool of users and stakeholders, including both tool's usability and the transfer of information. Since PSS operates within a collaborative environment, it allows the system to be used and tested by many users. System developers should leverage the accessibility of this platform as a critical strength to engage in dialogue with users for feedback and improvement (Vonk & Geertman, 2008). This can be illustrated by Rittenbruch et al. (2022), who have adopted a co-design workshop with several government bodies and private stakeholders to undertake specific planning tasks and help raise questions and the tool's integrity. Hence, PSS not only attempts to address issues with a particular solution but also assists in broadening the thinking of planners in the decision-making process.

PSS Case Studies

The following PSS case studies selected for review will be described in the sections below. This review aims to assess existing PSS regarding their role and planning tasks they aspire to solve. Each case study aims to unravel the purpose and objective of the tool, what planning tasks it is trying to support, and the features and user interface of the tool.

CommunityViz

To begin with, CommunityViz is one of the few PSS in the world with world-class standards (Vonk & Geertman, 2008). The tool seeks to undertake the modelling of land suitability analysis by analysing various factors with dynamic dashboards and performance indicators (Campagna, 2020). This task's significance lies in the planning field during the spatial planning and visioning process. This process aims to ensure that planners understand the geographical context of future planning areas and account for their natural and physical constraints limited to future development. Conversely, the platform allows users to interact with various social, economic, and environmental indicators to weigh their importance for determining areas most suitable for growth and places to protect.

As the tool can quickly generate scenarios according to the parameters defined by the user, planners can effectively test and evaluate the impact of those decisions. Additionally, the short time for retrieving these results in a spatially visual format allows for utilisation in co-design workshops or preliminary planning discussions, where planning ideas are still in the conceptualisation stage. On top of that, the scenarios generated in the platform report back to the user in a format of analytical plans and statistics, which become helpful in supporting evidence-based decision-making.

This PSS tool is not standalone and depends on another proprietary software known as ArcGIS Desktop. As such, the tool is an ArcGIS extension equipped with a suite of geoprocessing functions consolidated into a simplified interface specific to planning tasks. The interface of the tool also leverages the mapping capabilities of ArcGIS and shows a different toolkit and dashboard panels on top of the default ArcGIS functions (see Figure 9).

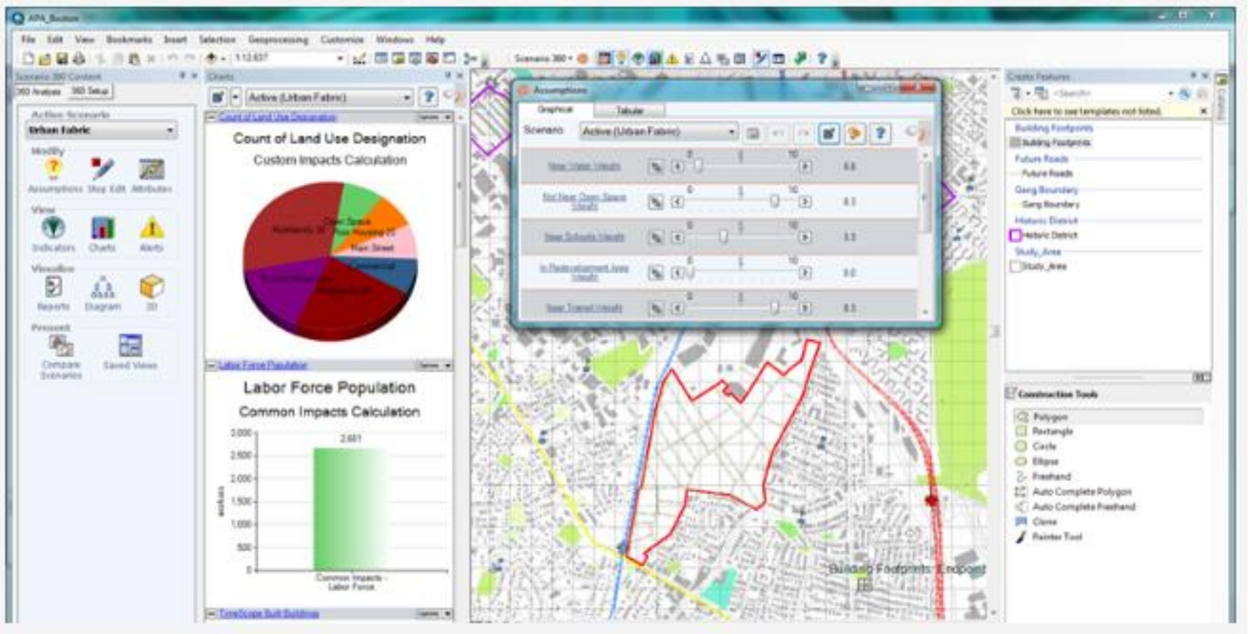


Figure 9: CommunityViz user interface in ArcGIS Desktop.

Rapid Analytics Interactive Scenario Explorer (RAISE) Toolkit

The development of the RAISE toolkit is to support urban and transport planners in carrying out value uplift modelling against the provision of urban transport infrastructure in neighbourhoods (Rittenbruch et al., 2022). This research initiative aims to investigate opportunities for subsidising or reducing the need for public funding through value capture. This is a crucial strategic task in infrastructure planning to assist in identifying the most suitable location for allocating public infrastructure. Moreover, the RAISE toolkit enables users to effectively estimate and automatically value land with immediate feedback in a spatially visual format (Rittenbruch et al., 2022). This toolkit allows the government to significantly save funding and timing for such analysis.

The toolkit is a perfect example of a PSS tool that draws together and combines spatial datasets within an organisation database harnessing intelligence that can support planning decision-making better (Rittenbruch et al., 2022). In addition, such a highly integrated system allows for powerful interactive scenario explorations, enabling planners to formulate hypothetical scenarios and evaluate their impact rapidly (C. Pettit, 2010). The result of the system's capabilities is precious for planners as it supports optimising complex tasks.

The tool's interface is simple, with a shared 3D mapping interface and a series of functionalities along the side panel (see Figure 10). Users can quickly interact with the mapping canvas and side panel to adjust the parameters and location of infrastructure to generate and compare development scenarios. Additionally, the tool is hosted on a cloud-based platform where the software is not limited to the local desktop environment but through the web. Cloud-based software allows the communication and sharing of results and information with stakeholders more effectively and saves time significantly.

Figure 10: RAISE Toolkit user interface.

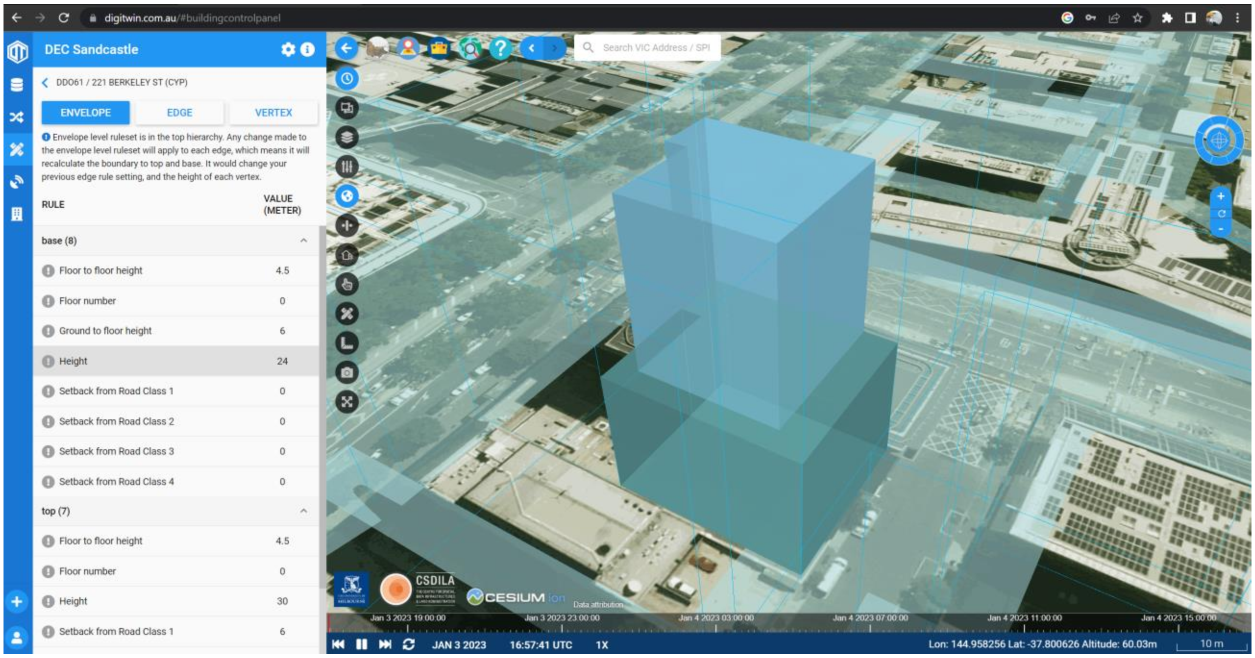
Development Envelope Control (DEC) Tool

The DEC tool, developed by the Centre for Spatial Data Infrastructures and Land Administration (CSDILA), aims to visualise planning policies that provide direction and control over the built form of future developments (Sabri, Chen, Lim, Rajabifard, & Zhang, 2022). These policies are essential in ensuring proposed developments respect their surrounding character and the quality of open spaces and streetscapes. For instance, in the case of Victoria, Australia, design parameters are specified in the Victorian Planning Scheme, typically described by written descriptions, static plans or diagrams. However, the lack of digital representation opens up the danger of misinterpretation, especially for more sophisticated built-form controls. Therefore, as urban developments become more complex and nuanced with their design, there is a need for a more robust and efficient system to test and implement planning rules in urban development processes.

Hence, the role of the DEC PSS tool is to provide planners with a platform with parametric design and automated generative capabilities to visualise and adjust design control parameters and then evaluate their impacts (Sabri et al., 2022). Furthermore, it is important to highlight that this tool integrates a 'geodesign' process as part of the generative framework in the platform. A geodesign refers to a design approach that assists in facilitating planning decision-making through design tasks incorporating spatial analytical processes and multidisciplinary collaboration (Gu & Deal, 2020). As such, the tool's objective also seeks to enable planners who mainly need to gain 3D modelling skills to adjust and visualise multi-dimensional design parameters and retrieve their results quickly.

The DEC tool is hosted on a web-based Digital Twin platform – an emerging technology for modelling a digital replica of the physical realm. It comprised a multi-dimensional mapping canvas with a simplified design control ruleset panel. The panel only requires the user to insert design parameters such as ground-level and upper-level setbacks as well as slope planes for each edge of a lot (see Figure 11). Additionally, users can utilise this tool to generate development envelopes from small to large-scale neighbourhoods with the assignment of pre-defined design control rulesets.

In summary, this PSS tool proposed an innovative approach for planners to evaluate and test design parameters in planning policies. The tool demonstrates how urban development processes can be streamlined and increases the accuracy and optimisation of this planning task.



Envelope level ruleset is in the top hierarchy. Any change made to the envelope level ruleset will apply to each edge, which means it will recalculate the boundary to top and base. It would change your previous edge rule setting, and the height of each vertex.

RULE	VALUE (METER)
base (8)	
Floor to floor height	4.5
Floor number	0
Ground to floor height	6
Height	24
Setback from Road Class 1	0
Setback from Road Class 2	0
Setback from Road Class 3	0
Setback from Road Class 4	0
top (7)	
Floor to floor height	4.5
Floor number	0
Height	30
Setback from Road Class 1	6

Figure 11: CSDILA DEC Tool user interface.

Summary & Key Findings of Case Studies

The PSS case studies illustrated above show the tool's utilisation covering the various aspects of urban planning, such as land suitability analysis, value capture modelling and 3D volumetric design. Each case study demonstrated the importance of incorporating the spatial visualisation dimension of the tool as its core component. In addition, the spatial integration component of the tool helps visualise the analysis's outcomes, further assisting in communicating complex spatial ideas.

In conjunction with the importance of spatial visualisation and integration, simplifying the tool's usability is crucial to ensure its intuitiveness of usage by planners. This typically comprises limiting user inputs, functional widgets, and a highly interactive, responsive rate, as shown above.

Urban Infrastructure Finance

Urban infrastructure financing is the process cities undergo to secure funding sourcing from various areas for delivering and upgrading infrastructure (USAID, 2011). Most residents will eventually have adequate access to essential services during the infrastructure financing process, supporting communities to continue developing and thriving. Furthermore, financing these infrastructures can range from minor to large-scale projects. Hence, the scale of these projects will determine the varying levels of capital funding required.

There are two distinct contexts for urban infrastructure provisions, being urban expansion or urban development, where one refers to new infrastructure and the second to upgrade or maintenance (Wilmoth, 1990). Although the specification and requirements of infrastructure may differ in both development contexts, they undertake similar financing principles and approaches. While this research considers the broad infrastructure finance view, it focuses on the financing perspective in the context of the urban expansion or greenfield development.

Principles and Objectives

There are various ways to finance new or upgraded infrastructure, and each one may be used to further particular urban policy goals. For instance, direct government expenditure (i.e., revenue generated from taxation or bank loans), user-pays model (i.e., the end user – existing or new residents pays for costs of infrastructure and services) and development contributions (i.e., developers make payments contributing to a range of shared infrastructure, facilities, and services) (Howe, 1998). The principles explored in this research investigate the financing aspect of development contributions whereby this process is implemented and managed through the planning process.

Equity & Apportionment

The development contribution towards infrastructure item costs should be distributed relatively among development proponents (Kirwan, 1990). These proponents are likely to be located within an area with an equal need for particular infrastructure to unlock their development sites. Moreover, the apportionment of such liability should be relative to the yield and demand it generates from the development (De Gruyter & Robinson, 2017). As such, this ensures that the user or developer accounts for more contributions when there is more significant development potential on their site.

Need & Nexus

As a population generates the basis for the need and demand for development and infrastructure; it is crucial to project the estimated growth that is to occur. Understanding expected growth could provide a solid justification for providing particular infrastructure items. Furthermore, different infrastructure tiers and their categories can be determined to ensure they are fit for purpose and address future communities' needs.

Conversely, local governments should demonstrate a substantial nexus of usage by developments for charged infrastructure items (De Gruyter & Robinson, 2017). For instance, developers should not be required to be liable for funding or delivering infrastructure that is beyond the context of their site and has no value uplift on their land.

Certainty & Time

Determining the required infrastructure and costs is essential for providing the managing authority and the private sector with clear and explicit expectations of what needs to be delivered and the amount of funding it will require. For instance, in the case of Victoria, infrastructure costs typically consist of a combination of the construction cost of the infrastructure and private land acquisition costs for public land purposes. In addition, these costs should be formally costed through a proper estimator (e.g., quantity surveying) or land valuation. Hence, a PSP and DCP can consolidate all this information, acting as a centralised local strategic plan and as a reference as development occurs.

Infrastructure should be funded and delivered within a reasonable timeframe (Kirwan, 1990). Setting a timeframe ensures that the delivery agency, mainly the council, is committed to delivering the required infrastructure for servicing new residents on time. Additionally, it can assure local authorities of the recovery costs of financing these infrastructures in a more manageable manner. Furthermore, the indicative timeframe allows for mitigating under and over-payments for shared infrastructure by developers, ensuring all levied infrastructure items are well underway during development activity.

Transparency & Accountability

The rationale for funding a series of infrastructures, including its specifications, costs, and apportionment, should be transparent (Kirwan, 1990). This practice promotes transparency between the public and private sectors, establishing mutual trust and expectations for both parties. Moreover, the information display of infrastructure cost should employ a straightforward and easy-to-understand process, including calculating levies. The benefit of this procedure is it streamlines and expedites communication and facilitates more meaningful discussions with stakeholders.

On the other hand, responsibility and all financial risk should fall on the agency entrusted with gathering and delivering all planned infrastructure (De Gruyter & Robinson, 2017). The public and financial accountability held by the responsible agency has the obligation to manage these finances (i.e., income and expenditure) and keep proper transactional reports for monitoring by higher-up government institutions. The monetary collection should only be used to fund planned infrastructure, and additional collection should be redistributed back to payers or to negotiate benefits at the discretion of local authorities.

Spatial planning in Infrastructure Planning

Spatial planning in this research context refers to the process of assigning future land uses that include guidance on land development and the location of services required. This process is described as the planning process of formulating a PSP introduced in Chapter 1. An integrated land use plan is one of the primary methods planners use as a guiding framework to support their professional role and better manage change in communities. The framework can bring together stakeholders and communities to agree on a shared vision and help coordinate infrastructure investments. Furthermore, developing a long-term plan can enable the market to gain greater confidence in decision-making related to development activity and financing infrastructure that aligns with government objectives (Infrastructure Victoria., 2021).

The intent for developing land according to specific applied land uses can assure greater certainty where development is encouraged to accommodate future growth. Additionally, adjacent infrastructure to these development areas can be identified and delivered sequentially when needed. In the view of infrastructure planning, it is crucial to identify catalyst infrastructure within local plans to unlock development and determine if any up-front capital funding is needed or to undertake a public-private partnership delivery method (Ruming et al., 2011). In addition, the spatial distribution of infrastructure and its types in these plans helps address how growth will be prioritised and better prepare planners to manage these processes in the future.

Hence, spatial planning is valuable in the infrastructure planning process in terms of knowledge and foresight in the delivery and funding of infrastructure. The relationship between the management of land and the required services proves their importance in making informed planning decisions. Therefore, both fields should not be isolated but strongly complement each other to enable better communication and development outcomes.

Legislation Framework for Infrastructure Contributions

The legislation for infrastructure planning and contributions is implemented based on the Planning and Environment Act 1987 (the Act) passed by the Parliament of Victoria. The purpose of the Act is to provide a legislative framework for urban planning (i.e., the use and development of land) across the state.

The Act specifies three formal programs and one legal instrument as types of funding mechanisms for collecting financial contributions from developers, which are the following:

- Infrastructure Contributions Plan (ICP) – inserted since 2015 and amended in 2018 (Part 3AB of the Act) – formal
- Development Contributions Plan (DCP) – since 1995 (Part 3B of the Act) – formal
- Voluntary Agreements/Section 173 Agreements (s173) (Part 9 Section 173 of the Act) – legal
- Growth Areas Infrastructure Contribution (GAIC) – since 2010 (Part 9B of the Act) – formal

These funding mechanisms are then implemented through a Planning Scheme, which affects state planning strategies and policies. For instance, a specialised land use control (i.e., planning overlays) such as the Infrastructure Contributions Plan Overlay (ICPO) and Development Contributions Plan Overlay (DCPO) is applied to the land that is subject to the use and development rates specified in the ICPs or DCPs. In addition, the use of s173 agreement as a legal instrument undertakes a smaller-scale funding collection method through negotiation with a developer on a project-by-project basis. Conversely, GAIC, unlike the other three funding mechanisms, does not have site-specific charges for funding local infrastructure. This mechanism applies to any land within Metropolitan Melbourne’s growth areas (i.e., seven in total) using a standardised charge for funding infrastructure at a broader level across the growth areas.

Method for Spatial Planning in Victoria

The spatial planning process in Victoria undergoes a systematic classification of land uses to determine suitable or unsuitable areas for development. It typically consists of three primary levels of spatial examination that define (1) the total precinct area, (2) land already dedicated for existing infrastructure, and (3) land to be dedicated for public purposes. After deducting land requirements for existing infrastructure, the remaining land defines the developable area and encourages land development. Any land area with development potential or forecast yield will become the charging basis as demand units to fund the required infrastructure proportionately and equitably across the precinct.

Total Precinct Area

The first step for spatial planning begins with establishing the extent of an area at a scale suitable to accommodate a substantial amount of residential and employment growth. The scale and extent of urban growth sought to be assessed within the precinct area usually range between 5,000 to 30,000 people or 2,000 to 10,000 jobs or a combination of both (Victorian Planning Authority, 2021). Moreover, these precinct areas are typically contained within a defined urban growth boundary. The scale of these precinct areas is also designed to be limited, making it more manageable for planners to monitor growth and infrastructure provision.

Encumbered Land and Gross Developable Area

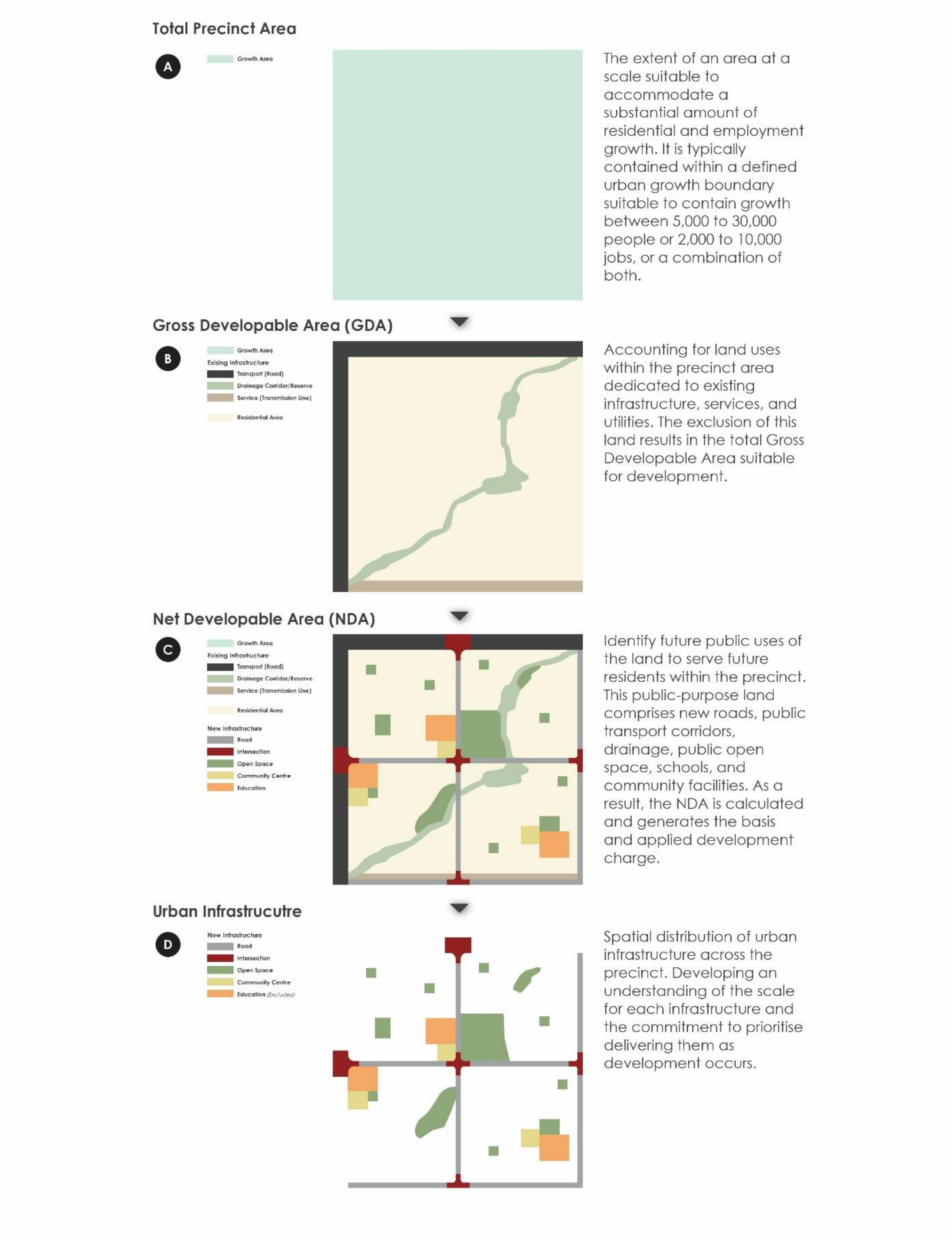
Secondly, examining land uses within the precinct area dedicated to existing infrastructure, services, and utilities must be accounted for. These areas are defined as encumbered areas which refer to non-privately owned land used to service an urban area. For instance, examples of encumbered areas are arterial roads or roads with more than four lanes, significant railway corridors, heritage areas, recreational and drainage reserves, utility servicing areas etc. (Victorian Planning Authority, 2022). This step is essential to ensure that future developments are not affecting these areas that may impact the liveability and functionality of external neighbourhoods. This step resulted in a Gross Developable Area (GDA), which excludes all encumbered land that may be defined as suitable for urban development within the precinct area.

Unencumbered Land and Net Developable Area

As well as identifying existing land uses and the formulation of GDA, it is also important to identify future public uses of the land to serve future residents within the precinct. This public-purpose land comprises new roads, public transport corridors, drainage, public open space, schools, and community facilities (DELWP, 2007; Wilmoth, 1990). The land classification category of this public land they fall under refers to unencumbered land – privately owned land acquired for public purposes. As such, the planning of this public-purpose land is defined and distributed across the precinct area, ensuring its servicing catchment is within accessible distance by future residents. Hence, after accounting and deducting land requirements from both encumbered and unencumbered land, a Net Developable Area (NDA) is established. The NDA in the context of greenfield development is usually expressed in the area units as hectares. However, due to more significant built-form development outcomes, infill development areas will use other appropriate planning units, such as floorspace area or the number of dwellings, to calculate yield and growth.

On the other hand, the extent of the public-purpose land for each type determines the quantum of infrastructure required in the precinct area and is to be scoped and costed for development contributions. The detail of each infrastructure with more refined land acquisition and construction cost is carried forward into a DCP to implement funding and deliver these infrastructures.

Figure 12 below summarises the spatial planning process as a diagrammatic representation to demonstrate the examination and classification of land in new development sites.



The extent of an area at a scale suitable to accommodate a substantial amount of residential and employment growth. It is typically contained within a defined urban growth boundary suitable to contain growth between 5,000 to 30,000 people or 2,000 to 10,000 jobs, or a combination of both.

Accounting for land uses within the precinct area dedicated to existing infrastructure, services, and utilities. The exclusion of this land results in the total Gross Developable Area suitable for development.

Identify future public uses of the land to serve future residents within the precinct. This public-purpose land comprises new roads, public transport corridors, drainage, public open space, schools, and community facilities. As a result, the NDA is calculated and generates the basis and applied development charge.

Spatial distribution of urban infrastructure across the precinct. Developing an understanding of the scale for each infrastructure and the commitment to prioritise delivering them as development occurs.

Figure 12: Land use classification in the spatial planning process.

Measuring success in urban infrastructure finance

Successful adoption of principles & infrastructure coordination

Adhering to the principles in infrastructure financing, as mentioned above, is the first step to ensuring success in the funding and delivery of infrastructure. While local strategic plans (e.g., PSP) provide direction on how urban development should occur, the coordination and orderly delivery of infrastructure will be essential to enable these processes to thrive (Victorian Planning Authority, 2021). An example of infrastructure coordination is prioritising and staging infrastructure provision according to the preferred development pattern controlled by planners.

Public-Private Partnership

Collaboration and partnership between the public and private sectors should be encouraged to facilitate sustainable development activities and opportunities for up-front capital funding by developers (Ruming et al., 2011). Local authorities undertaking an active engagement approach with developers, service providers and utility agencies can better determine the required infrastructure's triggering points to ensure development aligns with the timely provision of infrastructure (Victorian Planning Authority, 2021). In addition, it is vital that planners have an overview and perspective of development activities and monitor infrastructure development progress to fulfil their professional roles better.

Key Components in Urban Infrastructure Financing

This section examines the required inputs and components for two separate processes: the (1) preparation and (2) implementation of urban infrastructure financing. These key components are determined based on the framework and practice in Victoria's infrastructure development contributions plan. Therefore, this analysis details the key inputs and components in each process.

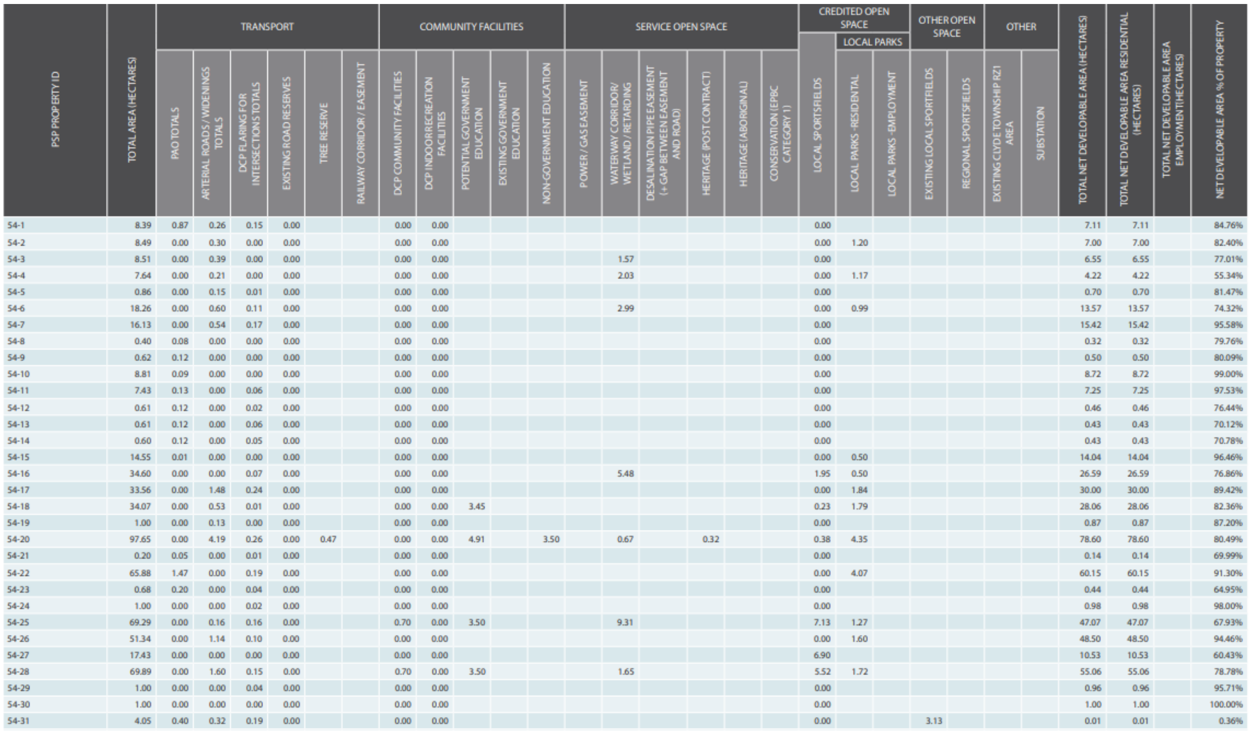
Preparation

The preparation process of an infrastructure contributions plan requires significant time and resources. It often involves an iterative process of Council including and excluding infrastructure items whilst being aware of the financial obligations it will place. Nevertheless, there are three core steps or components that are compulsory to calculate developers' liability for infrastructure contributions which are (1) property specific land budget, (2) infrastructure project list, and (3) summary of development charge. Each of these components is discussed below.

Property Specific Land Budget

A property specific land budget calculates the land use area for each property outlined in the future urban structure plan based on the designated PSP. It sets out a systematic flow of calculating areas based on their land use classification. The calculation process follows the spatial planning method in infrastructure planning, as illustrated above in Figure 12. This land budget aims to determine and quantify the amount of land dedicated for public purposes and development. The calculated NDA ensures that the levies are properly apportioned across all properties within the PSP/DCP area. The land budget also specifies the total yield of the developable area (e.g., NDA) as demand units denoting the demand it generates for the utilisation of new or upgraded infrastructure. Hence, this component is vital at the primary stages of preparation to understand the development potential that assists in generating revenue and collecting funds.

Figure 13 shows an example of a property specific land budget table in an infrastructure contributions plan to detail areas of various land use classes on every property. Figure 14 presents a land use budget plan similar to a future urban structure plan specified in a PSP with a unique property identifier to show its link with the land budget table.



PSP PROPERTY ID	TOTAL AREA (HECTARES)	TRANSPORT						COMMUNITY FACILITIES					SERVICE OPEN SPACE						CREDITED OPEN SPACE			OTHER OPEN SPACE		OTHER		TOTAL NET DEVELOPABLE AREA (HECTARES)	TOTAL NET DEVELOPABLE AREA RESIDENTIAL (HECTARES)	TOTAL NET DEVELOPABLE AREA EMPLOYMENT(HECTARES)	NET DEVELOPABLE AREA % OF PROPERTY
																				LOCAL PARKS									
		PAO TOTALS	ARTERIAL ROADS / WIDENINGS TOTALS	DCP FLARING FOR INTERSECTIONS TOTALS	EXISTING ROAD RESERVES	TREE RESERVE	RAILWAY CORRIDOR / EASEMENT	DCP COMMUNITY FACILITIES	DCP INDOOR RECREATION FACILITIES	POTENTIAL GOVERNMENT EDUCATION	EXISTING GOVERNMENT EDUCATION	NON-GOVERNMENT EDUCATION	POWER / GAS EASEMENT	WATERWAY CORRIDOR/ WETLAND / RETARDING	DESALINATION PIPE EASEMENT (+ GAP BETWEEN EASEMENT AND ROAD)	HERITAGE (POST CONTRACT)	HERITAGE (ABORIGINAL)	CONSERVATION (EPBC CATEGORY 1)	LOCAL SPORTSFIELDS	LOCAL PARKS -RESIDENTAL	LOCAL PARKS -EMPLOYMENT	EXISTING LOCAL SPORTFIELDS	REGIONAL SPORTSFIELDS	EXISTING CLYDE TOWNSHIP RZ1 AREA	SUBSTATION				
54-1	8.39	0.87	0.26	0.15	0.00			0.00	0.00										0.00							7.11	7.11		84.76%
54-2	8.49	0.00	0.30	0.00	0.00			0.00	0.00										0.00	1.20						7.00	7.00		82.40%
54-3	8.51	0.00	0.39	0.00	0.00			0.00	0.00					1.57					0.00							6.55	6.55		77.01%
54-4	7.64	0.00	0.21	0.00	0.00			0.00	0.00					2.03					0.00	1.17						4.22	4.22		55.34%
54-5	0.86	0.00	0.15	0.01	0.00			0.00	0.00										0.00							0.70	0.70		81.47%
54-6	18.26	0.00	0.60	0.11	0.00			0.00	0.00					2.99					0.00	0.99						13.57	13.57		74.32%
54-7	16.13	0.00	0.54	0.17	0.00			0.00	0.00										0.00							15.42	15.42		95.58%
54-8	0.40	0.08	0.00	0.00	0.00			0.00	0.00										0.00							0.32	0.32		79.76%
54-9	0.62	0.12	0.00	0.00	0.00			0.00	0.00										0.00							0.50	0.50		80.09%
54-10	8.81	0.09	0.00	0.00	0.00			0.00	0.00										0.00							8.72	8.72		99.00%
54-11	7.43	0.13	0.00	0.06	0.00			0.00	0.00										0.00							7.25	7.25		97.53%
54-12	0.61	0.12	0.00	0.02	0.00			0.00	0.00										0.00							0.46	0.46		76.44%
54-13	0.61	0.12	0.00	0.06	0.00			0.00	0.00										0.00							0.43	0.43		70.12%
54-14	0.60	0.12	0.00	0.05	0.00			0.00	0.00										0.00							0.43	0.43		70.78%
54-15	14.55	0.01	0.00	0.00	0.00			0.00	0.00										0.00	0.50						14.04	14.04		96.46%
54-16	34.60	0.00	0.00	0.07	0.00			0.00	0.00					5.48					1.95	0.50						26.59	26.59		76.86%
54-17	33.56	0.00	1.48	0.24	0.00			0.00	0.00										0.00	1.84						30.00	30.00		89.42%
54-18	34.07	0.00	0.53	0.01	0.00			0.00	0.00	3.45									0.23	1.79						28.06	28.06		82.36%
54-19	1.00	0.00	0.13	0.00	0.00			0.00	0.00										0.00							0.87	0.87		87.20%
54-20	97.65	0.00	4.19	0.26	0.00	0.47		0.00	0.00	4.91		3.50		0.67		0.32			0.38	4.35						78.60	78.60		80.49%
54-21	0.20	0.05	0.00	0.01	0.00			0.00	0.00										0.00							0.14	0.14		69.99%
54-22	65.88	1.47	0.00	0.19	0.00			0.00	0.00										0.00	4.07						60.15	60.15		91.30%
54-23	0.68	0.20	0.00	0.04	0.00			0.00	0.00										0.00							0.44	0.44		64.95%
54-24	1.00	0.00	0.00	0.02	0.00			0.00	0.00										0.00							0.98	0.98		98.00%
54-25	69.29	0.00	0.16	0.16	0.00			0.70	0.00	3.50				9.31					7.13	1.27						47.07	47.07		67.93%
54-26	51.34	0.00	1.14	0.10	0.00			0.00	0.00										0.00	1.60						48.50	48.50		94.46%
54-27	17.43	0.00	0.00	0.00	0.00			0.00	0.00										6.90							10.53	10.53		60.43%
54-28	69.89	0.00	1.60	0.15	0.00			0.70	0.00	3.50				1.65					5.52	1.72						55.06	55.06		78.78%
54-29	1.00	0.00	0.00	0.04	0.00			0.00	0.00										0.00							0.96	0.96		95.71%
54-30	1.00	0.00	0.00	0.00	0.00			0.00	0.00										0.00							1.00	1.00		100.00%
54-31	4.05	0.40	0.32	0.19	0.00			0.00	0.00										0.00			3.13				0.01	0.01		0.36%

Figure 13: Property Specific Land Budget table (Victorian Planning Authority, 2017).

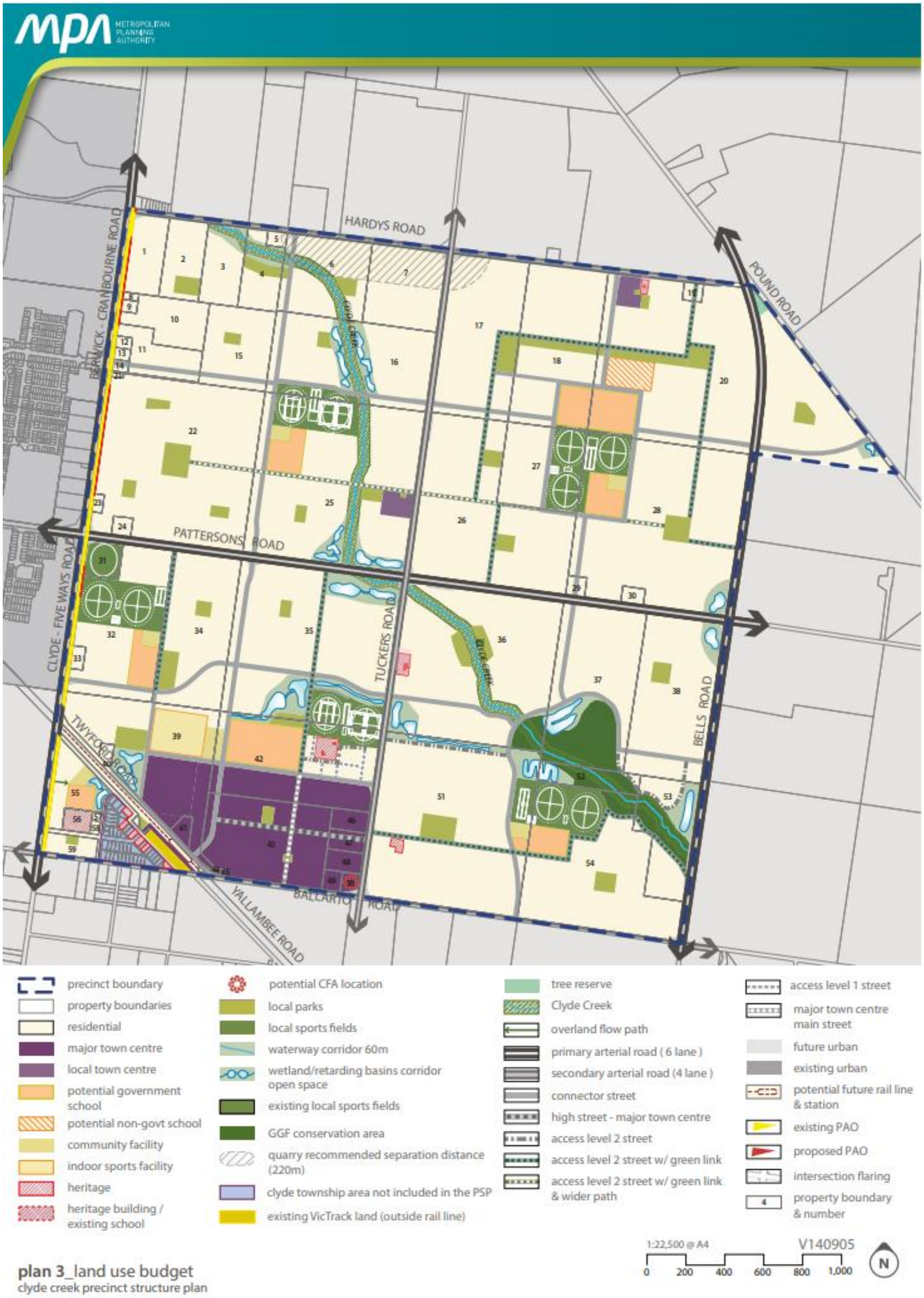
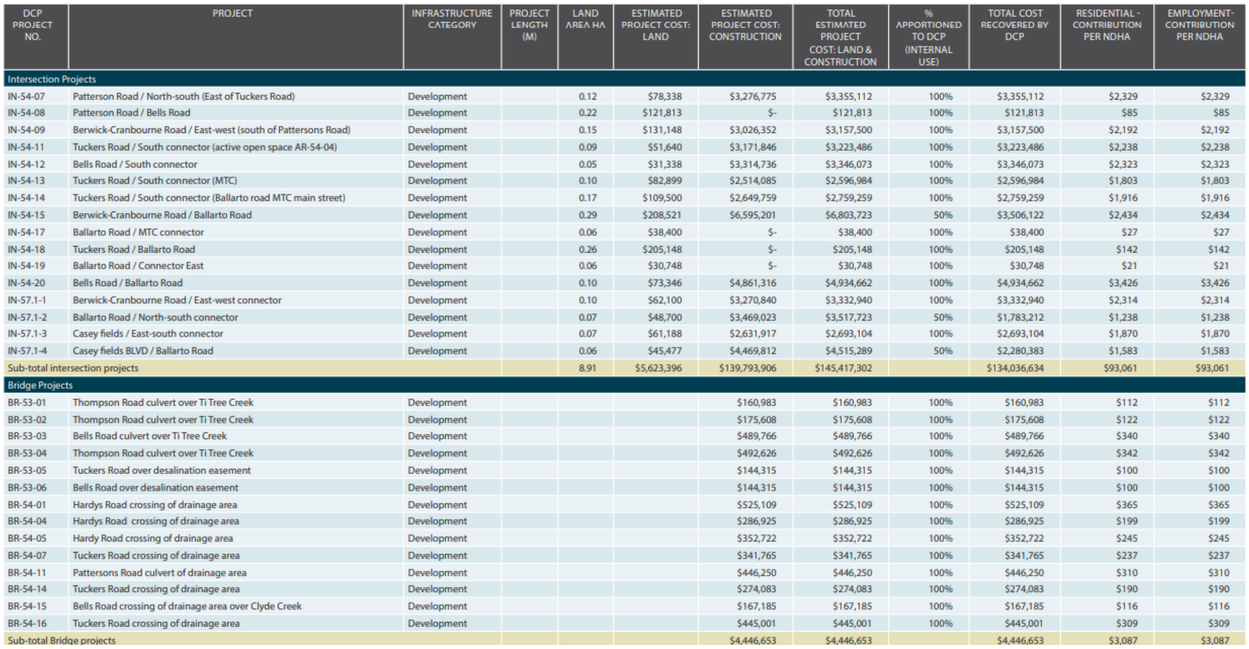


Figure 14: Land Use Budget plan (Victorian Planning Authority, 2017).

Infrastructure Project List

An infrastructure project list contains every infrastructure project necessary to service the precinct area and to be funded by developers. The list's purpose is to inform each infrastructure item's specifications and costs, comprising construction costs and land acquisition if required. Furthermore, it also seeks to identify any external apportionment of funding that is involved and should be deducted from the overall cost calculation. An external apportionment is applied when an additional need is generated by existing or external demand (e.g., established area or neighbouring towns) for an infrastructure. Undertaking an apportionment evaluation is crucial to ensure a more equitable funding approach for infrastructure provision. Publishing the project list allows the public to scrutinise developers regarding the scope and expectation of the infrastructure type to be delivered. Furthermore, feedback from the private sector is welcome to query and comment on a specific infrastructure project that seems inconsistent in cost or scope.

Figure 15 shows an extract of an infrastructure project list with the description of the project and its detailed costings and dimension, if applicable, for each project item. It also shows the contribution rate per planning unit (e.g., NDA) to be collected from developers to fund that specific infrastructure. Figure 16 is an infrastructure project plan showing the location and extent of projects matching the project list.



DCP PROJECT NO.	PROJECT	INFRASTRUCTURE CATEGORY	PROJECT LENGTH (M)	LAND AREA HA	ESTIMATED PROJECT COST: LAND	ESTIMATED PROJECT COST: CONSTRUCTION	TOTAL ESTIMATED PROJECT COST: LAND & CONSTRUCTION	% APPORTIONED TO DCP (INTERNAL USE)	TOTAL COST RECOVERED BY DCP	RESIDENTIAL - CONTRIBUTION PER NDHA	EMPLOYMENT-CONTRIBUTION PER NDHA
Intersection Projects											
IN-54-07	Patterson Road / North-south (East of Tuckers Road)	Development		0.12	$78,338	$3,276,775	$3,355,112	100%	$3,355,112	$2,329	$2,329
IN-54-08	Patterson Road / Bells Road	Development		0.22	$121,813	$-	$121,813	100%	$121,813	$85	$85
IN-54-09	Berwick-Cranbourne Road / East-west (south of Pattersons Road)	Development		0.15	$131,148	$3,026,352	$3,157,500	100%	$3,157,500	$2,192	$2,192
IN-54-11	Tuckers Road / South connector (active open space AR-54-04)	Development		0.09	$51,640	$3,171,846	$3,223,486	100%	$3,223,486	$2,238	$2,238
IN-54-12	Bells Road / South connector	Development		0.05	$31,338	$3,314,736	$3,346,073	100%	$3,346,073	$2,323	$2,323
IN-54-13	Tuckers Road / South connector (MTC)	Development		0.10	$82,899	$2,514,085	$2,596,984	100%	$2,596,984	$1,803	$1,803
IN-54-14	Tuckers Road / South connector (Ballarto road MTC main street)	Development		0.17	$109,500	$2,649,759	$2,759,259	100%	$2,759,259	$1,916	$1,916
IN-54-15	Berwick-Cranbourne Road / Ballarto Road	Development		0.29	$208,521	$6,595,201	$6,803,723	50%	$3,506,122	$2,434	$2,434
IN-54-17	Ballarto Road / MTC connector	Development		0.06	$38,400	$-	$38,400	100%	$38,400	$27	$27
IN-54-18	Tuckers Road / Ballarto Road	Development		0.26	$205,148	$-	$205,148	100%	$205,148	$142	$142
IN-54-19	Ballarto Road / Connector East	Development		0.06	$30,748	$-	$30,748	100%	$30,748	$21	$21
IN-54-20	Bells Road / Ballarto Road	Development		0.10	$73,346	$4,861,316	$4,934,662	100%	$4,934,662	$3,426	$3,426
IN-57.1-1	Berwick-Cranbourne Road / East-west connector	Development		0.10	$62,100	$3,270,840	$3,332,940	100%	$3,332,940	$2,314	$2,314
IN-57.1-2	Ballarto Road / North-south connector	Development		0.07	$48,700	$3,469,023	$3,517,723	50%	$1,783,212	$1,238	$1,238
IN-57.1-3	Casey fields / East-south connector	Development		0.07	$61,188	$2,631,917	$2,693,104	100%	$2,693,104	$1,870	$1,870
IN-57.1-4	Casey fields BLVD / Ballarto Road	Development		0.06	$45,477	$4,469,812	$4,515,289	50%	$2,280,383	$1,583	$1,583
Sub-total intersection projects				8.91	$5,623,396	$139,793,906	$145,417,302		$134,036,634	$93,061	$93,061
Bridge Projects											
BR-53-01	Thompson Road culvert over Ti Tree Creek	Development				$160,983	$160,983	100%	$160,983	$112	$112
BR-53-02	Thompson Road culvert over Ti Tree Creek	Development				$175,608	$175,608	100%	$175,608	$122	$122
BR-53-03	Bells Road culvert over Ti Tree Creek	Development				$489,766	$489,766	100%	$489,766	$340	$340
BR-53-04	Thompson Road culvert over Ti Tree Creek	Development				$492,626	$492,626	100%	$492,626	$342	$342
BR-53-05	Tuckers Road over desalination easement	Development				$144,315	$144,315	100%	$144,315	$100	$100
BR-53-06	Bells Road over desalination easement	Development				$144,315	$144,315	100%	$144,315	$100	$100
BR-54-01	Hardys Road crossing of drainage area	Development				$525,109	$525,109	100%	$525,109	$365	$365
BR-54-04	Hardys Road crossing of drainage area	Development				$286,925	$286,925	100%	$286,925	$199	$199
BR-54-05	Hardy Road crossing of drainage area	Development				$352,722	$352,722	100%	$352,722	$245	$245
BR-54-07	Tuckers Road crossing of drainage area	Development				$341,765	$341,765	100%	$341,765	$237	$237
BR-54-11	Pattersons Road culvert of drainage area	Development				$446,250	$446,250	100%	$446,250	$310	$310
BR-54-14	Tuckers Road crossing of drainage area	Development				$274,083	$274,083	100%	$274,083	$190	$190
BR-54-15	Bells Road crossing of drainage area over Clyde Creek	Development				$167,185	$167,185	100%	$167,185	$116	$116
BR-54-16	Tuckers Road crossing of drainage area	Development				$445,001	$445,001	100%	$445,001	$309	$309
Sub-total Bridge projects						$4,446,653	$4,446,653		$4,446,653	$3,087	$3,087

Figure 15: Infrastructure project list table (Victorian Planning Authority, 2017).

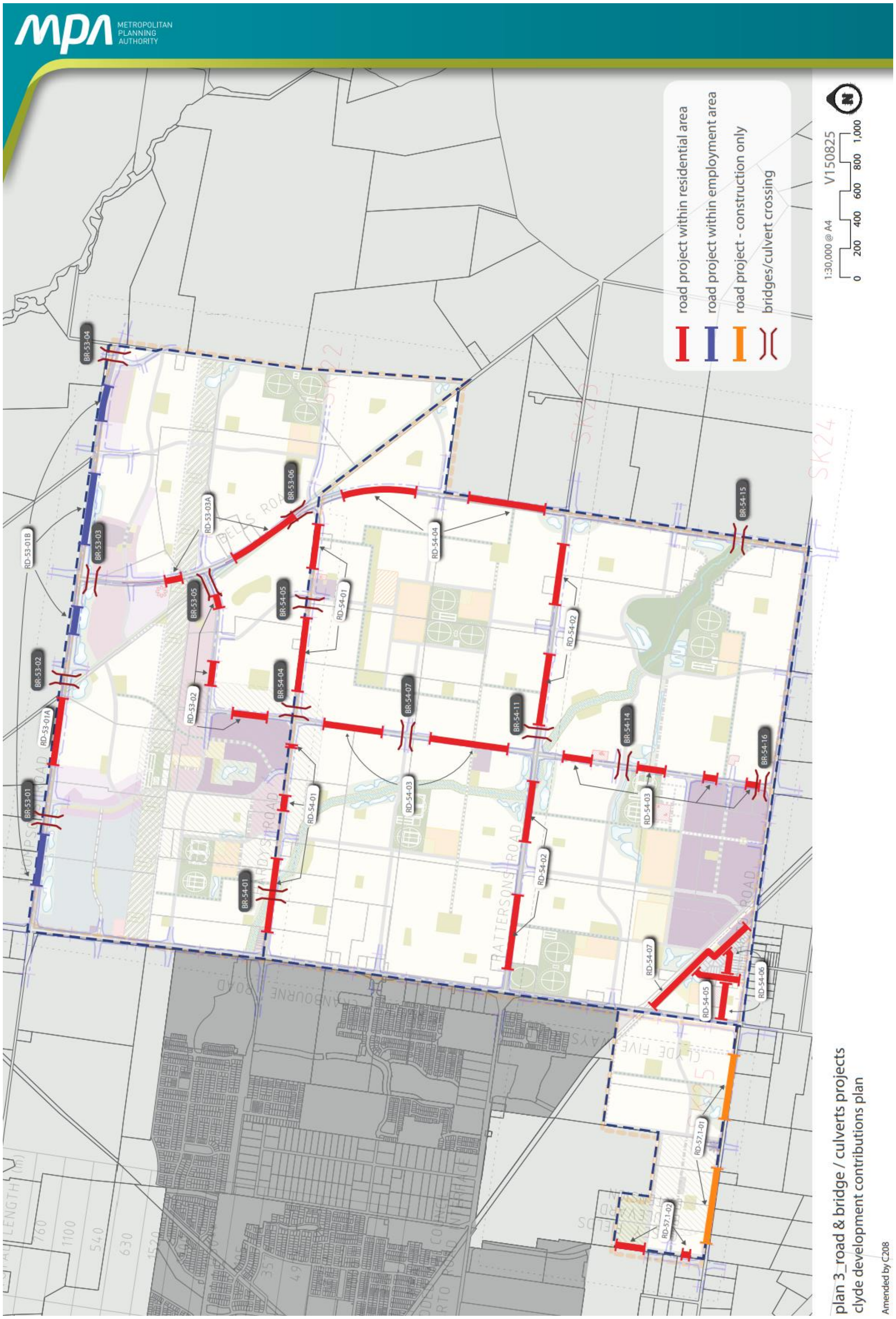
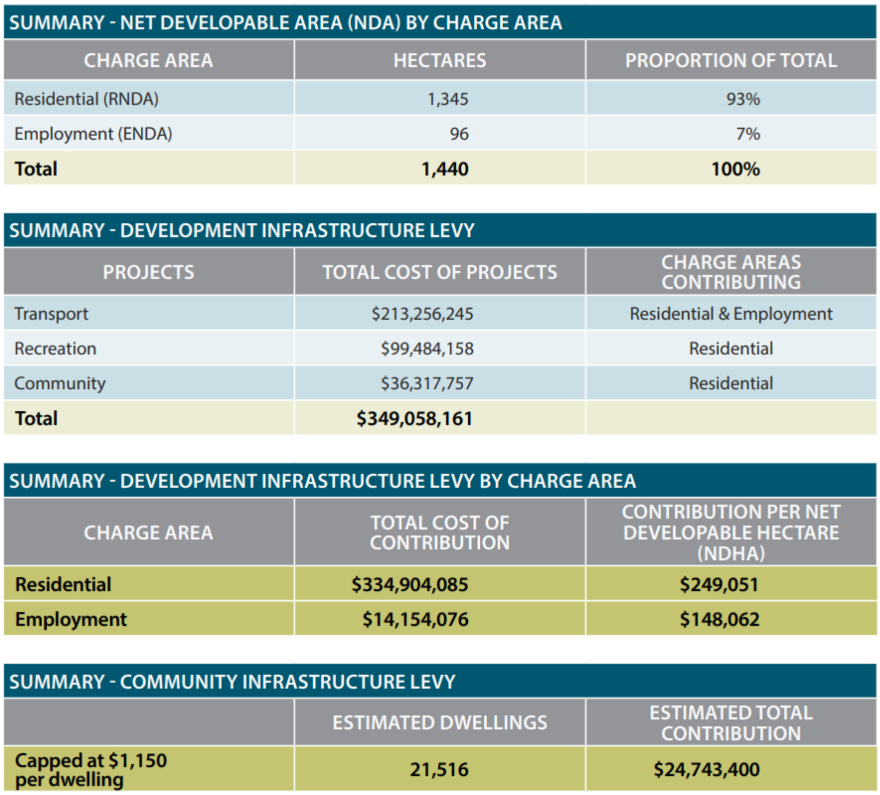


Figure 16: Transport infrastructure projects plan (Victorian Planning Authority, 2017).

Summary of Development Charges

The development charges summary provides an overview of the amount of land on which infrastructure levies are calculated and charged and the infrastructure costs per project categories, such as transport, recreation, community, and drainage. In short, this summary compresses the calculations and information from the property specific land budget and infrastructure project list. Therefore, the public or interested parties, such as developers, can easily retrieve key development charges information and calculate their potential liability for contributions.

Figure 17 demonstrates a development charge summary table containing the summarised land and infrastructure project costings in a table format.



SUMMARY - NET DEVELOPABLE AREA (NDA) BY CHARGE AREA

CHARGE AREA	HECTARES	PROPORTION OF TOTAL
Residential (RNDA)	1,345	93%
Employment (ENDA)	96	7%
Total	**1,440**	**100%**

SUMMARY - DEVELOPMENT INFRASTRUCTURE LEVY

PROJECTS	TOTAL COST OF PROJECTS	CHARGE AREAS CONTRIBUTING
Transport	$213,256,245	Residential & Employment
Recreation	$99,484,158	Residential
Community	$36,317,757	Residential
Total	**$349,058,161**	

SUMMARY - DEVELOPMENT INFRASTRUCTURE LEVY BY CHARGE AREA

CHARGE AREA	TOTAL COST OF CONTRIBUTION	CONTRIBUTION PER NET DEVELOPABLE HECTARE (NDHA)
Residential	**$334,904,085**	**$249,051**
Employment	**$14,154,076**	**$148,062**

SUMMARY - COMMUNITY INFRASTRUCTURE LEVY

	ESTIMATED DWELLINGS	ESTIMATED TOTAL CONTRIBUTION
Capped at $1,150 per dwelling	**21,516**	**$24,743,400**

Figure 17: Summary of Development Charge in a DCP (Victorian Planning Authority, 2017).

Implementation

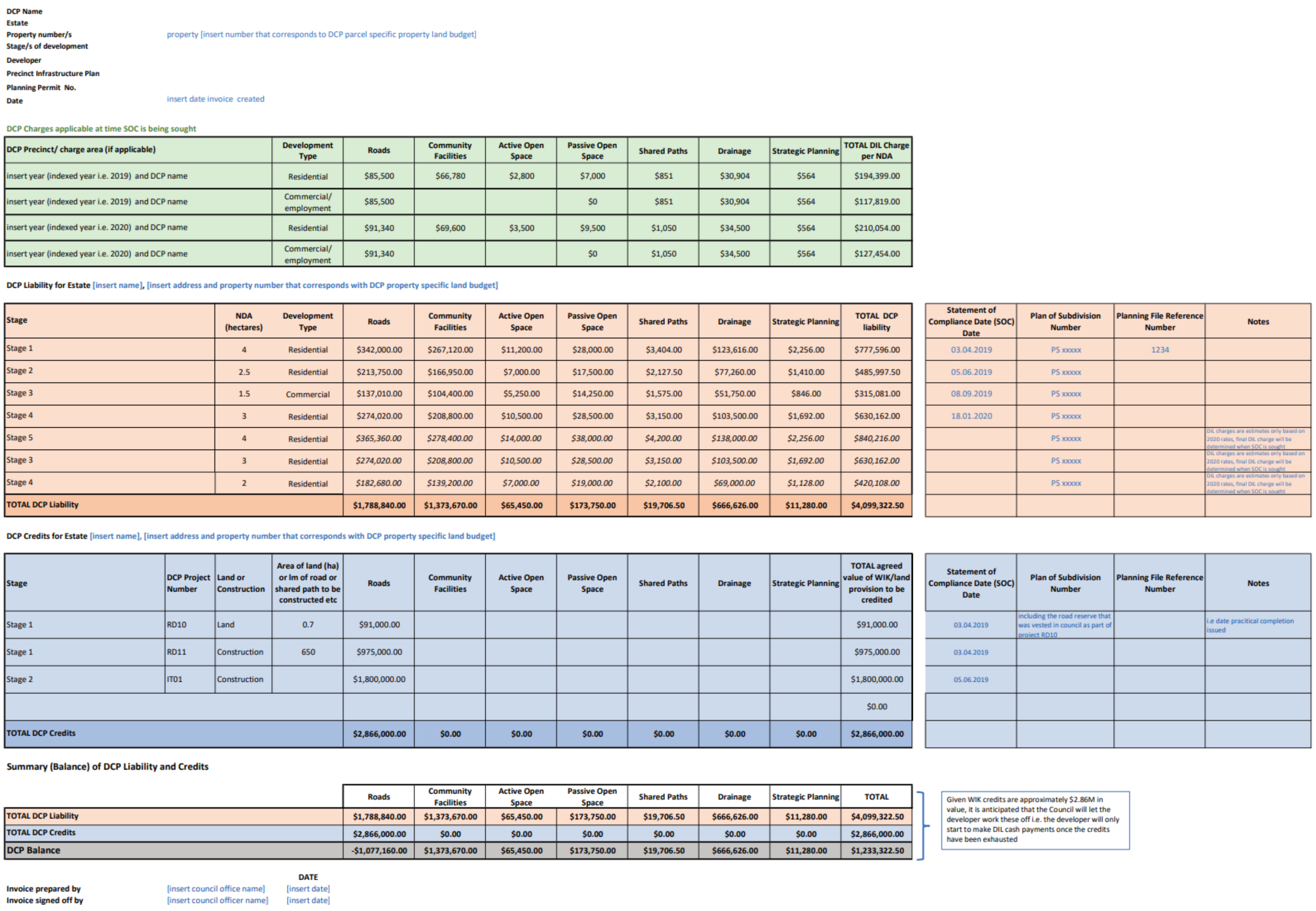
The implementation process is an ongoing task by planners to manage the collection, funding and delivery of infrastructure based on the inputs completed in the preparation phase. It seeks to administer infrastructure contributions and delivery through the timing of payment, provision of works-in-kind (WIK) projects - payments in assets in lieu of cash payments, indexation, and annual reporting. A considerable part of this process mainly monitors the monetary and asset transactions between developers and planning authorities. Nonetheless, the key components of the system that can assist planners in making informed decisions and transactional activities in terms of the timely delivery of infrastructure whilst mitigating the increase of financial risk are (1) development staging and crediting schedule, (2) an infrastructure priority list, and (3) cash flow modelling.

Development Staging and Crediting Schedule

The trigger for developer contributions is only during the development of land. It is important to highlight that developers typically activate the course of their development in stages. Hence, a development staging schedule seeks to contain a record or input of development activity to track each property. The schedule details the amount of land for each stage, including its timing and the total liability for which it needs to be accountable. Furthermore, in some instances, certain developers may choose to deliver WIK and be entitled to development credits if an overcontribution is made. Therefore, a credit schedule is prepared to account for those cases, which may offset consequent payments by developers in the future.

The development staging and crediting schedule is an important input for keeping a record of what development activity has occurred and the credits developers are entitled to so that reimbursement can be arranged. On the other hand, authorities can also use this schedule to forecast development activity and the likely revenue they would collect at a particular time. Undertaking this forecasting task can assist planners in gaining a more robust understanding of their financial capacity for delivering infrastructure within the delivery timeframe of the infrastructure plan. It can also provide planners with financial implications based on negotiations with developers seeking to undertake WIK projects.

Figure 18 shows an example of a development staging and crediting schedule to monitor and record development activities and payments across the precinct area.



DCP Name
Estate
Property number/s property [insert number that corresponds to DCP parcel specific property land budget]
Stage/s of development
Developer
Precinct Infrastructure Plan
Planning Permit No.
Date insert date invoice created

DCP Charges applicable at time SOC is being sought

DCP Precinct/ charge area (if applicable)	Development Type	Roads	Community Facilities	Active Open Space	Passive Open Space	Shared Paths	Drainage	Strategic Planning	TOTAL DIL Charge per NDA
insert year (indexed year i.e. 2019) and DCP name	Residential	$85,500	$66,780	$2,800	$7,000	$851	$30,904	$564	$194,399.00
insert year (indexed year i.e. 2019) and DCP name	Commercial/ employment	$85,500			$0	$851	$30,904	$564	$117,819.00
insert year (indexed year i.e. 2020) and DCP name	Residential	$91,340	$69,600	$3,500	$9,500	$1,050	$34,500	$564	$210,054.00
insert year (indexed year i.e. 2020) and DCP name	Commercial/ employment	$91,340			$0	$1,050	$34,500	$564	$127,454.00

DCP Liability for Estate [insert name], [insert address and property number that corresponds with DCP property specific land budget]

Stage	NDA (hectares)	Development Type	Roads	Community Facilities	Active Open Space	Passive Open Space	Shared Paths	Drainage	Strategic Planning	TOTAL DCP liability	Statement of Compliance Date (SOC) Date	Plan of Subdivision Number	Planning File Reference Number	Notes
Stage 1	4	Residential	$342,000.00	$267,120.00	$11,200.00	$28,000.00	$3,404.00	$123,616.00	$2,256.00	$777,596.00	03.04.2019	PS xxxxx	1234	
Stage 2	2.5	Residential	$213,750.00	$166,950.00	$7,000.00	$17,500.00	$2,127.50	$77,260.00	$1,410.00	$485,997.50	05.06.2019	PS xxxxx		
Stage 3	1.5	Commercial	$137,010.00	$104,400.00	$5,250.00	$14,250.00	$1,575.00	$51,750.00	$846.00	$315,081.00	08.09.2019	PS xxxxx		
Stage 4	3	Residential	$274,020.00	$208,800.00	$10,500.00	$28,500.00	$3,150.00	$103,500.00	$1,692.00	$630,162.00	18.01.2020	PS xxxxx		
Stage 5	4	Residential	*$365,360.00*	*$278,400.00*	*$14,000.00*	*$38,000.00*	*$4,200.00*	*$138,000.00*	*$2,256.00*	*$840,216.00*		PS xxxxx		DIL charges are estimates only based on 2020 rates, final DIL charge will be determined when SOC is sought
Stage 3	3	Residential	*$274,020.00*	*$208,800.00*	*$10,500.00*	*$28,500.00*	*$3,150.00*	*$103,500.00*	*$1,692.00*	*$630,162.00*		PS xxxxx		DIL charges are estimates only based on 2020 rates, final DIL charge will be determined when SOC is sought
Stage 4	2	Residential	*$182,680.00*	*$139,200.00*	*$7,000.00*	*$19,000.00*	*$2,100.00*	*$69,000.00*	*$1,128.00*	*$420,108.00*		PS xxxxx		DIL charges are estimates only based on 2020 rates, final DIL charge will be determined when SOC is sought
TOTAL DCP Liability			**$1,788,840.00**	**$1,373,670.00**	**$65,450.00**	**$173,750.00**	**$19,706.50**	**$666,626.00**	**$11,280.00**	**$4,099,322.50**				

DCP Credits for Estate [insert name], [insert address and property number that corresponds with DCP property specific land budget]

Stage	DCP Project Number	Land or Construction	Area of land (ha) or lm of road or shared path to be constructed etc	Roads	Community Facilities	Active Open Space	Passive Open Space	Shared Paths	Drainage	Strategic Planning	TOTAL agreed value of WIK/land provision to be credited	Statement of Compliance Date (SOC) Date	Plan of Subdivision Number	Planning File Reference Number	Notes
Stage 1	RD10	Land	0.7	$91,000.00							$91,000.00	03.04.2019	including the road reserve that was vested in council as part of project RD10		i.e date pracitical completion issued
Stage 1	RD11	Construction	650	$975,000.00							$975,000.00	03.04.2019			
Stage 2	IT01	Construction		$1,800,000.00							$1,800,000.00	05.06.2019			
											$0.00				
TOTAL DCP Credits				**$2,866,000.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$2,866,000.00**				

Summary (Balance) of DCP Liability and Credits

	Roads	Community Facilities	Active Open Space	Passive Open Space	Shared Paths	Drainage	Strategic Planning	TOTAL
TOTAL DCP Liability	**$1,788,840.00**	**$1,373,670.00**	**$65,450.00**	**$173,750.00**	**$19,706.50**	**$666,626.00**	**$11,280.00**	**$4,099,322.50**
TOTAL DCP Credits	**$2,866,000.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$2,866,000.00**
DCP Balance	**-$1,077,160.00**	**$1,373,670.00**	**$65,450.00**	**$173,750.00**	**$19,706.50**	**$666,626.00**	**$11,280.00**	**$1,233,322.50**

Given WIK credits are approximately $2.86M in value, it is anticipated that the Council will let the developer work these off i.e. the developer will only start to make DIL cash payments once the credits have been exhausted

		DATE
Invoice prepared by	[insert council office name]	[insert date]
Invoice signed off by	[insert council officer name]	[insert date]

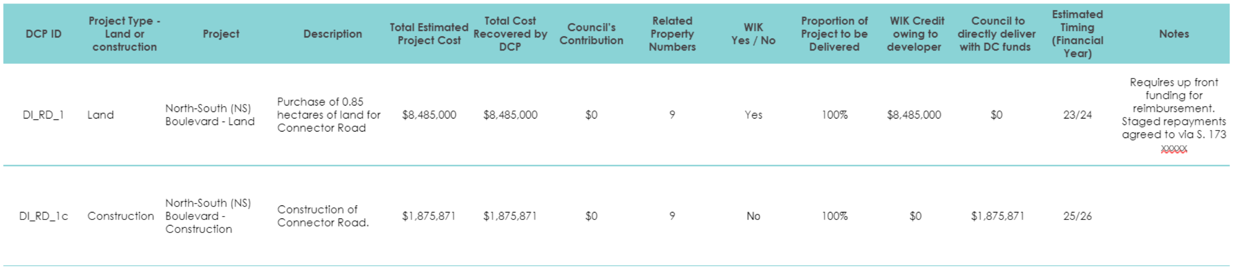
Figure 18: Development Staging and Crediting Schedule (Mesh Planning, 2020).

Infrastructure Priority List

The objective of an infrastructure priority list (IPL) is to identify short, medium, and long-term projects and identify an indicative timeframe for infrastructure delivery. It is an input and tool necessary for planners to use in order to have oversight of developers' and councils' infrastructure commitments across the lifespan of the contributions plan. In addition, council will be able to understand when infrastructure is likely to be needed and when it will have sufficient funds to pay for it. However, it is essential to note that an IPL is not a static tool but instead undertakes an interactive process that continues to inform councils' overall development cash flow analysis. The proper utilisation of an IPL can assist planners with negotiation tasks with developers seeking WIK to ensure that it aligns with the overall development sequence and their impact.

Conversely, an IPL should be aimed to be the key centre of information for forecasting infrastructure delivery and the record of infrastructure delivered by developers. This is because it links back to the timing of development activity and the demand it triggers. Thus, an IPL can be a powerful tool that provides authorities with an overall picture of the entire infrastructure plan and become more prepared when they must undertake expenditure and reimbursement for infrastructure.

Figure 19 shows a sample entry in an IPL. It comprises information on a specific infrastructure project to be delivered in a specific financial year, the project's portion to be funded, and by whom.



DCP ID	Project Type - Land or construction	Project	Description	Total Estimated Project Cost	Total Cost Recovered by DCP	Council's Contribution	Related Property Numbers	WIK Yes / No	Proportion of Project to be Delivered	WIK Credit owing to developer	Council to directly deliver with DC funds	Estimated Timing (Financial Year)	Notes
DI_RD_1	Land	North-South (NS) Boulevard - Land	Purchase of 0.85 hectares of land for Connector Road	$8,485,000	$8,485,000	$0	9	Yes	100%	$8,485,000	$0	23/24	Requires up front funding for reimbursement. Staged repayments agreed to via S. 173 XXXXX
DI_RD_1c	Construction	North-South (NS) Boulevard - Construction	Construction of Connector Road.	$1,875,871	$1,875,871	$0	9	No	100%	$0	$1,875,871	25/26	

Figure 19: Example of an IPL table and its attributes (Mesh Planning, 2020).

Cash Flow Modelling

A cash flow model aims to understand the financial implications of planners' decisions when undertaking negotiations for WIK and the timing of infrastructure delivery. The model should assist planners in identifying funding shortfalls and forecasting the magnitude of councils' financial gap at the end of the infrastructure plan lifespan. It is vital for the council to constantly review the cash flow model to monitor the financial impact of a particular decision on the type of infrastructure delivery. This is because the sequencing of development activity is not fixed and will change over time which has implications on development charge rates and access to critical services such as roads, water, sewer etc.

On the other hand, the model is made possible through the proper implementation and inputs from development staging, credit scheduling, and the IPL. Thus, the cash flow model can aggregate these inputs, deciphering the incoming cash or asset and the expenditure or reimbursement of payments.

Figure 20 below presents a cash flow model illustrating a typical flow of incoming assets and cash payments at the early stages of development. As the council gains financial capacity over time, the infrastructure expenditure can be observed later in the years.

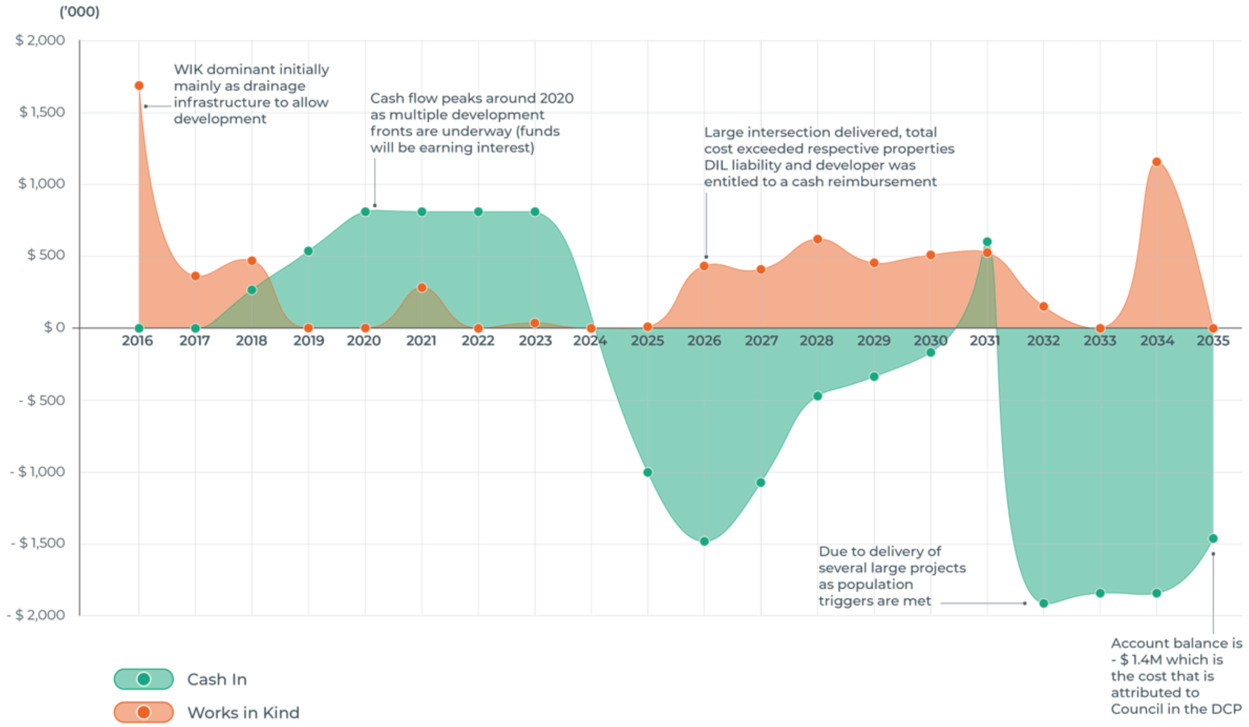


Figure 20: Example of a cash flow model (Mesh Planning, 2020).

Chapter 3: PSS & Infrastructure Planning Gap Analysis

This chapter is intended to evaluate the areas where PSS and infrastructure fall short and to examine the opportunities for integrating them through a gap analysis. The different dimensions of PSS will be introduced to assess the issues in the field to provide a stronger and more holistic understanding.

Furthermore, the implementation challenges for infrastructure funding and delivery in Melbourne will be discussed, including significant stakeholders in this system. In addition, existing tools and methods employed by practitioners will be reviewed by analysing survey results with council officers in Melbourne's growth and regional areas in partnership with a private urban planning firm in Melbourne, Australia, known as Mesh Planning. The survey seeks to identify software and tools currently used by council officers, gather feedback on key strengths and weaknesses of available tools, and understand the impact prioritising functions within the software can have on the administration and management of infrastructure delivery as a means of a software requirement analysis.

Implementation challenges of PSS

Although there are many benefits PSS can offer to enhance planning professional roles and duties, it can present several challenges in implementing them successfully in the planning realm. The three dimensions of the PSS presented by Geertman and Stillwell (2020b) will be used as a framework (see Figure 21) to assess these implementation challenges currently faced by existing PSS applications. The dimensions in this framework are (1) application – relevancy of the tool, (2) governance – acceptance and adoption of the tool, and (3) instrumentation – the quality of the tool. These dimensions are essential to demonstrate the dynamic relationships between the socio-political, environmental, and technological context in which PSS exist.

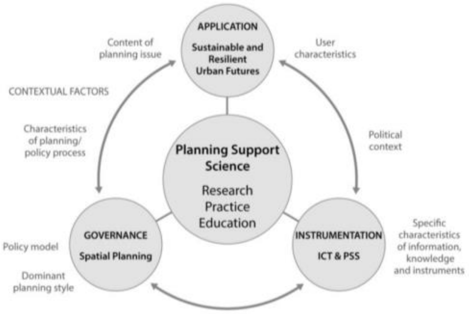


Figure 21: The dimensions and context of PSScience (Geertman & Stillwell, 2020b)

Planning is an activity that is inherently focused on the future, whereby the outcome of urban flows and developments is not fixed and is frequently subject to change (Geertman & Stillwell, 2020b). Therefore, planners constantly find themselves balancing these different agendas from various interest groups and sometimes need help making well-informed decisions with the support of appropriate knowledge and tools given to them (Batty, 2018).

The benefit of this framework is that it can provide a multi-faceted understanding of the issues around the field of PSS and their relation to the intricacies of planning activities. Hence, the sections below aim to investigate the implementation gap, and challenges using the three dimensions of PSS presented above.

Application – Diffusion to planning practice

The application of PSS in the decision-making process is hindered by the disconnect between research and practical use of these tools, resulting in limited integration and utilisation in the planning process. Traditionally, PSS is created by academic researchers for the use by planners (Brömmelstroet & Schrijnen, 2010), but many of these systems are found to be primarily used for scientific purposes and are rarely applied in practice (Vonk & Geertman, 2008). Additionally, the creation of PSS can sometimes be disconnected from the needs of the end users, such as planners, as developers may work in isolation in research laboratories without sufficient collaboration and feedback. Consequently, this lack of connection between the development and end-use of PSS makes it more difficult for practitioners to adopt the tool, as they want to see the direct relevance to their work.

Furthermore, because PSS is highly context-specific, unless there is sufficient cooperation and support from planners in informing the functionality of the tools, PSS will always find themselves with many implementation barriers and find it hard to adapt to the different contexts (Geertman & Stillwell, 2020b). This is important as tailoring the tool to its specific context is crucial for the success of PSS. Hence, the collaboration between researchers and planners in understanding planning issues before developing technological solutions can help address this issue (Richard E. Klosterman, 1997).

Governance – Acceptance of PSS

The lack of leadership and governance in elevating awareness, innovation, and encouragement in adopting modern technologies leads to the reluctance of implementing the use of PSS. Vonk et al. (2005) discovered that there is a minimal level of effort by managers in planning organisations to advocate for PSS, which can be attributed to the attitude of management towards it. Due to the unfamiliarity of PSS among planners, organisations are hesitant to adopt it, as they are concerned about the potential uncertainty and risks associated with using PSS within their operations (Jiang, Geertman, & Witte, 2020). Specifically, organisations or managers are hesitant about the potential financial and organizational risks associated with PSS implementation and its impact on time, resources, and trust in leadership. As a result, these governance concerns serve as obstacles to building confidence and increasing the utilisation of PSS, as it is not widely used currently and there are not enough successful case studies.

Furthermore, the development of PSS is driven by a bottom up approach that emphasises collaborative planning (Geertman & Stillwell, 2020a). For example, the field of planning which was once dominated by experts and top-down approaches is now becoming more participatory, breaking down barriers between the public and allowing them to shape the organisation of urban spaces (Healey, 1996). However, there is a tendency towards resistance towards communicative methods, with a preference for retaining traditional planning approaches, despite the potential benefits of integrating PSS and its collaborative opportunities (Vonk & Geertman, 2008). In addition, even though the government has made data repositories available and digitisation has emerged, current planning practices and tools have yet to fully recognize the potential of PSS (Geertman & Stillwell, 2020b). By embracing the digital paradigm, PSS has the potential to support urban and rural planning tasks on multiple scales. Therefore, there is a need for increased communication to practice awareness and generate exemplars of positive experiences by researchers to increase the acceptance of PSS.

Instrumentation – Quality of PSS

The limited adoption of PSS in the planning process is because they currently fail to meet the needs and expectations of planners due to a lack of contextualisation of the tools and an inability to align them with the specific requirements of planning practice. In addition to the difficulties in implementing PSS due to a lack of collaboration between researchers and practitioners, there are also issues related to the ease of use of PSS tools. For instance, it is revealed that the development progress of PSS is fast and heavily technologically focused, superseding the ability and skills of planners to comprehend and adopt its use quickly (Jiang et al., 2020). As an implication of that, there is a mismatch of PSS supply with the demand of users in terms of the program functionality and user capabilities to carry out simple to complex planning tasks (Vonk & Geertman, 2008). While the goal of PSS is to enhance decision-making in planning through advanced systems, there is a need for these systems to be more user-friendly.

Implementation Challenges of infrastructure planning in Victoria

The primary challenge in infrastructure finance and planning is that several funding mechanisms are available to be undertaken, as described in Chapter 1. Furthermore, developers are also offered the opportunity to deliver infrastructure projects as works-in-kind (WIK). It is important to note that WIK projects are greatly encouraged, when possible, rather than the direct delivery of infrastructure by the council. The rationale behind this agenda will be discussed in the later section below. Hence, a state can have multiple funding programs running simultaneously while attempting to coordinate the best delivery of infrastructure. The scope of this research investigates the DCP program, mainly as it is one of the most widely used mechanisms across Victoria, and its system infrastructure is entirely transferable to the other funding mechanism.

The following sections aim to investigate:

1. The major challenges present in the current infrastructure system,
2. The specific interests of various stakeholders within the system, and the
3. The current state of methods and tools practitioners use in managing financial contributions and infrastructure delivery.

Major problems in the current Victorian infrastructure system

The current infrastructure planning system needs to adequately deliver the infrastructure needed by growing communities in Victoria.

This issue shows that the provision rate of essential infrastructure currently needs to catch up with the pace of urban population growth (World Economic Forum, 2015). Hence, it is putting the risk on the government for not supporting future residents with liveable places or quality living. Furthermore, it is noted that local authorities need to strategically manage the available planning tools, such as policies and internal processes, to efficiently maximise their value and impact in infrastructure planning and delivery (Victorian Auditor-General's Office, 2020). However, local authorities lack the leadership and coordination to effectively administer the necessary policy and procedures to deliver infrastructure on time. As a result, local governments are finding themselves in a declining trend in their fiscal budget, given the obligation to renew and main infrastructure assets (Emily & Alan, 2018).

A lack of an overarching strategy and coordination

VAGO (2020) reported that over several decades of implementing this system, the tools local governments are using in the ongoing maintenance of the DC plan need more consideration for how they interact and interface. As a result, practitioners are carrying out infrastructure planning tasks by using and managing the tools in isolation, which is challenging for the state to develop an overarching strategy and coordination in measuring success collectively. Furthermore, the Department of Transport and Planning (DTP), formerly the Department of Environment, Land, Water and Planning (DELWP), Victoria's state planning department, which is the main acting manager in the management of the infrastructure planning system, has yet to provide an oversight system, coordination and evaluation that could best support infrastructure delivery across the state. Consequently, local governments are dealing with the duplication of effort and resources in managing multiple sources of information internally and externally under the lack of a clear direction or goal.

Barriers and risks in the participation of formal contributions plan by local governments (i.e., councils)

Local councils today remained hesitant in undertaking formal development contribution plans mainly because of the financial risks and position it will place them under in the long run. It is the principle that a development contributions plan, regardless of a DCP or ICP, is not a full-cost recovery model. This approach implies that there will always be a funding gap at the end, and the responsible authority (i.e., the council) is obligated to recover it entirely (DELWP, 2007). Consequently, it forms a barrier for smaller councils that need more financial capacity to undertake such a formal program to capture infrastructure funding and delivery for their administrative area and hence more difficult for them to promote growth and economic activity. To illustrate, the way to reduce the funding gap is to ensure that most development levies are collected at the start and that all infrastructure is delivered within a short time. However, because of (1) the uncertainty and the lack of clarity regarding when and where development will occur, (2) fluctuating inflation rates to development levies yearly and (3) the change in the value of land as a result of infrastructure slowly being delivered and the impacts of value capture within the precinct, cash flow fluctuates creating difficulties for smaller councils in managing finances for infrastructure development (Victorian Auditor-General's Office, 2020).

The limited transparency and accessibility of information in tracking the progress of infrastructure contributions and delivery

As much as information is published publicly concerning the type and costs of infrastructure it needs to be presented, including the total liability developers are liable for, the status and information streaming regarding the ongoing management of the infrastructure delivery is inadequate. Hence, developers can find themselves in the difficult position of knowing what and when certain infrastructure items will be delivered and by whom to better plan for their developments. There is a driving need for such information to be publicly available, which would also increase the opportunity for the private sector to partner with local councils in delivery infrastructure and help unlock development quicker.

Spatial Complexities of Infrastructure Planning in Victoria

A graphical representation of the infrastructure planning spatial process in Figure 12 illustrates how the infrastructure is planned. However, the complexity of delivering these infrastructures also comprises the understanding and coordination with one or multiple private landowners. For example, an infrastructure development plan typically functions over a fragmented property ownership pattern, and a specific infrastructure's construction may overlap between several properties (see Figure 22). This is one of the many challenging aspects that local governments must address when delivering an infrastructure that requires acquiring land from two or more properties. Hence, to understand the behaviour of the land development process and the evolution of cities, it is important to know who the stakeholders are and how they interact (Lai, 2020).

The uneven distribution of land for public purposes, which impacts the extent of development potential, further complicates the process of land compensation to ensure a balance of contributions by every landowner.

Furthermore, every privately owned land has a different development activity schedule and financial capacity for undertaking infrastructure delivery on the council’s behalf. Therefore, it is crucial to ensure that there is management on sequencing development that also aligns with the delivery timing of essential infrastructure. Consequently, it is challenging for the council in some instances to be in a position to commit up-front capital funding so that specific development sites can be carried out (Ruming et al., 2011), especially when the location of these infrastructures is external to the site. Thus, councils need to balance these interests while making informed decisions with the slightest implication of negatively impacting future developments and infrastructure.

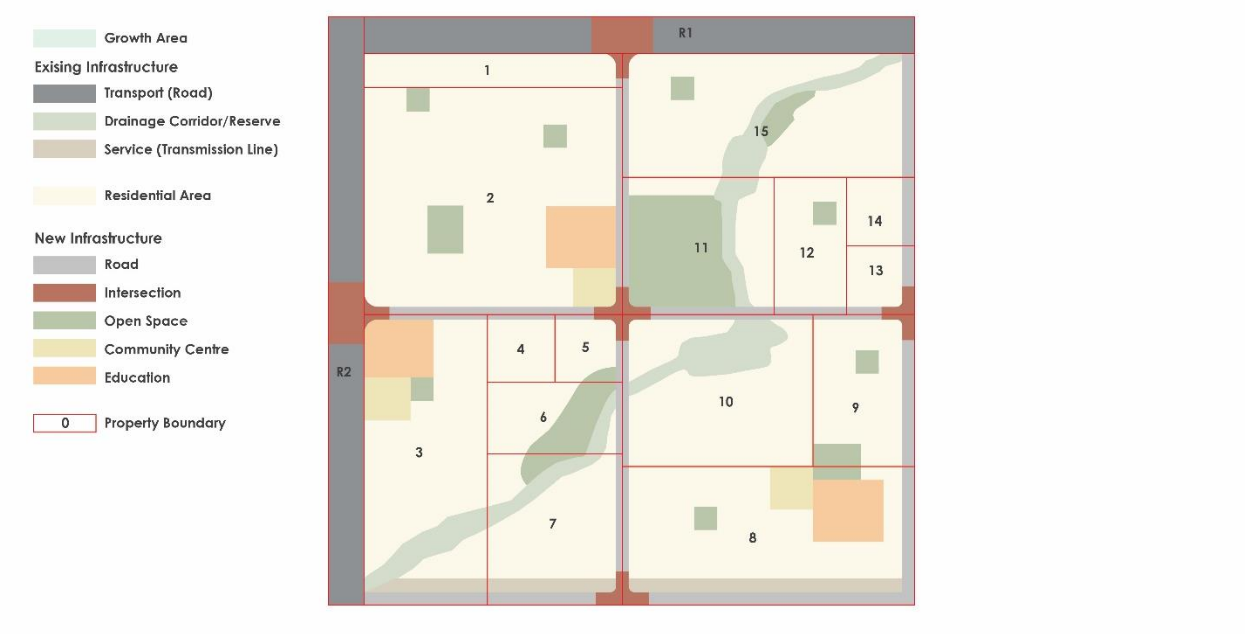
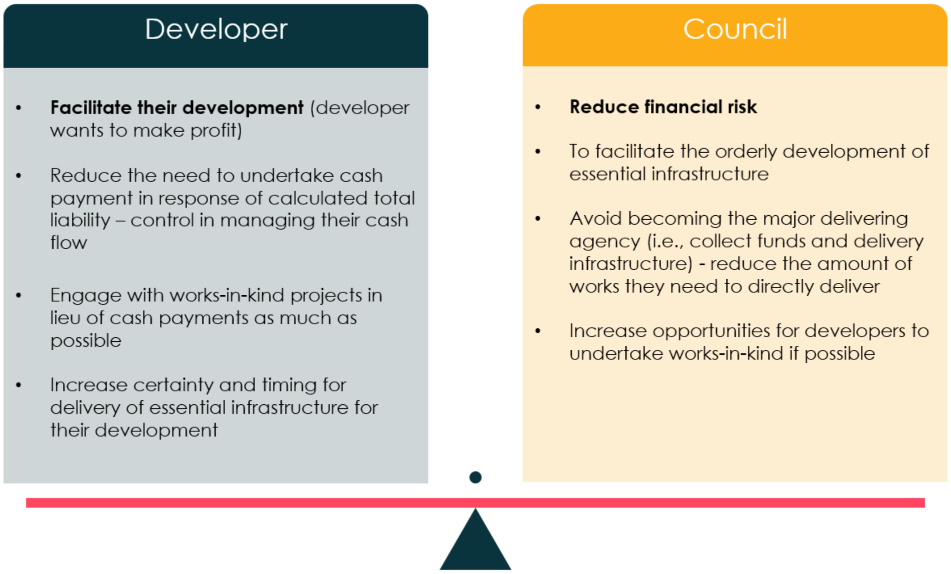


Figure 22: Fragmented ownership pattern and overlapping of infrastructure land requirements across multiple properties of an infrastructure development plan.

Stakeholder interests and interaction

The infrastructure planning system has two main stakeholder groups: developers and council (i.e., local governments). Figure 14 below shows the scale balancing between the interests of both groups behind the funding and delivery of infrastructure. Both parties are motivated by different agendas and objectives to gain greater certainty or reduce financial risk during urban development. For instance, developers mainly desire to facilitate their development better, and they can achieve that if they opt to deliver infrastructure as WIK on behalf of council.

On the one hand, there is legislation that developers are liable in terms of paying cash to planning authorities, but on the other, council wants to reduce their financial risk by encouraging developers to undertake WIK projects as much as possible. Hence, the interaction of this relationship shows that a high level of partnership is greatly needed between the public and private sectors to proceed with a smooth and favourable development process and outcome.



Developer

- **Facilitate their development** (developer wants to make profit)
- Reduce the need to undertake cash payment in response of calculated total liability – control in managing their cash flow
- Engage with works-in-kind projects in lieu of cash payments as much as possible
- Increase certainty and timing for delivery of essential infrastructure for their development

Council

- **Reduce financial risk**
- To facilitate the orderly development of essential infrastructure
- Avoid becoming the major delivering agency (i.e., collect funds and delivery infrastructure) - reduce the amount of works they need to directly deliver
- Increase opportunities for developers to undertake works-in-kind if possible

Figure 23: The balance between developer and council interests in funding infrastructure.

Infrastructure Delivery Matrix

The relationship between developers and council for delivering infrastructure is expanded by developing a stakeholder Infrastructure Delivery Matrix based on two axes of different functions. The definition of these axes takes into consideration the following:

1. **Residual Cash Payments** – developers remaining liability in terms of cash payments for funding infrastructure specified in a DCP/ infrastructure development plan. Developers undertaking more WIK projects can reduce residual cash payments after proper negotiation with council.
2. **Infrastructure Delivery Obligation** – every developer is obliged to fund the delivery of infrastructure. However, the delivery agency could be either developer or council, depending on the developers' decision to pay more in cash or undertake WIK.

These factors are vital to understanding who the main actors are in delivering or funding for infrastructure during the timeframe of managing financial infrastructure contributions. The benefit of this understanding can assist in better coordination between developers and council during the infrastructure financing process. Hence, four general delivery types of infrastructure provision are developed based on the function of the two defined axes (see Figure 24). This categorisation aims to illustrate the extreme spectrum of who will be mainly obliged for infrastructure delivery.

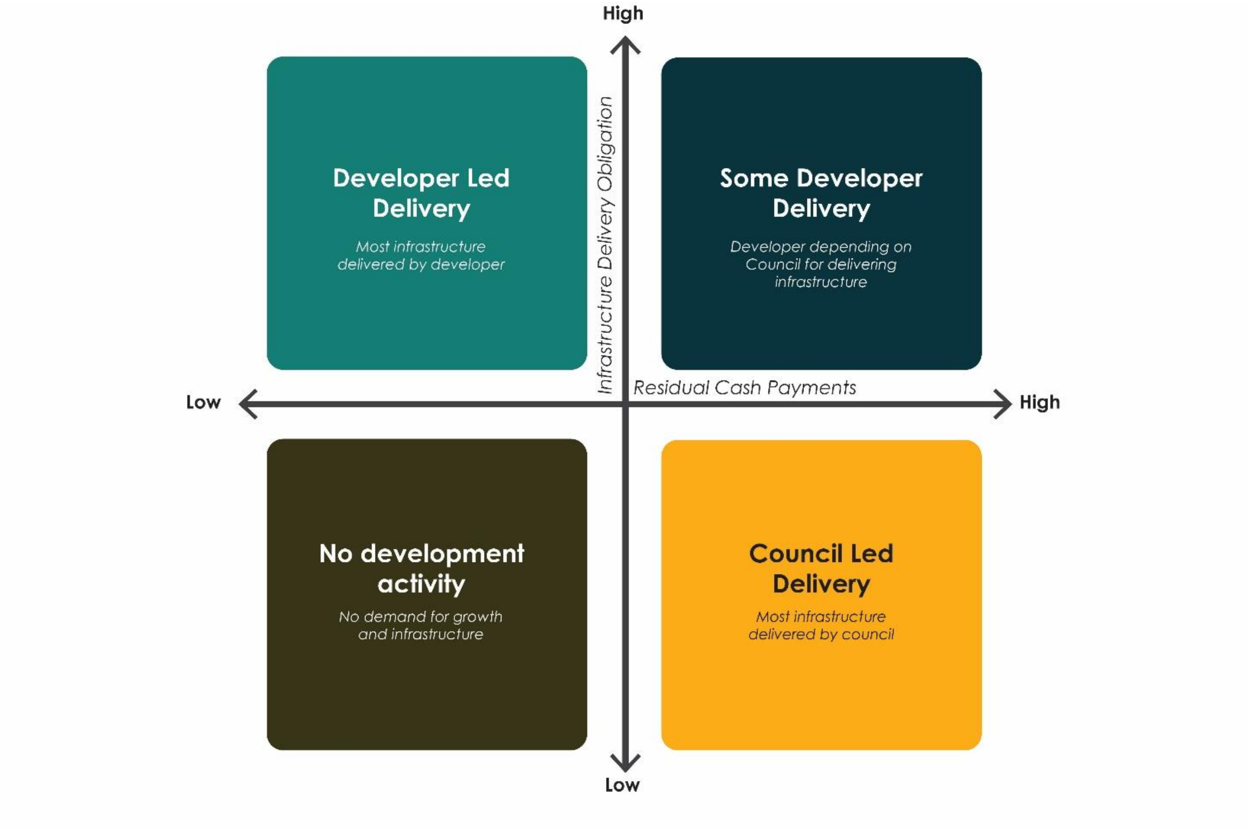


Figure 24: Stakeholder Infrastructure Delivery Matrix.

The description of the four delivery types is as below:

1. Developer Led Delivery

A ***Developer Led Delivery*** type is developers undertaking a high amount of WIK projects, or the total value of WIK projects is almost equal to their total liability as cash payments. This delivery type aims to support better planning in the scheduling of developers' development activity and reduces the financial risk of council.

2. Some Developer Delivery

A ***Some Developer Delivery*** type categorises developers who prefer to make cash payments to council to settle their liability for levied infrastructure items instead of delivering WIK projects.

3. Council Led Delivery

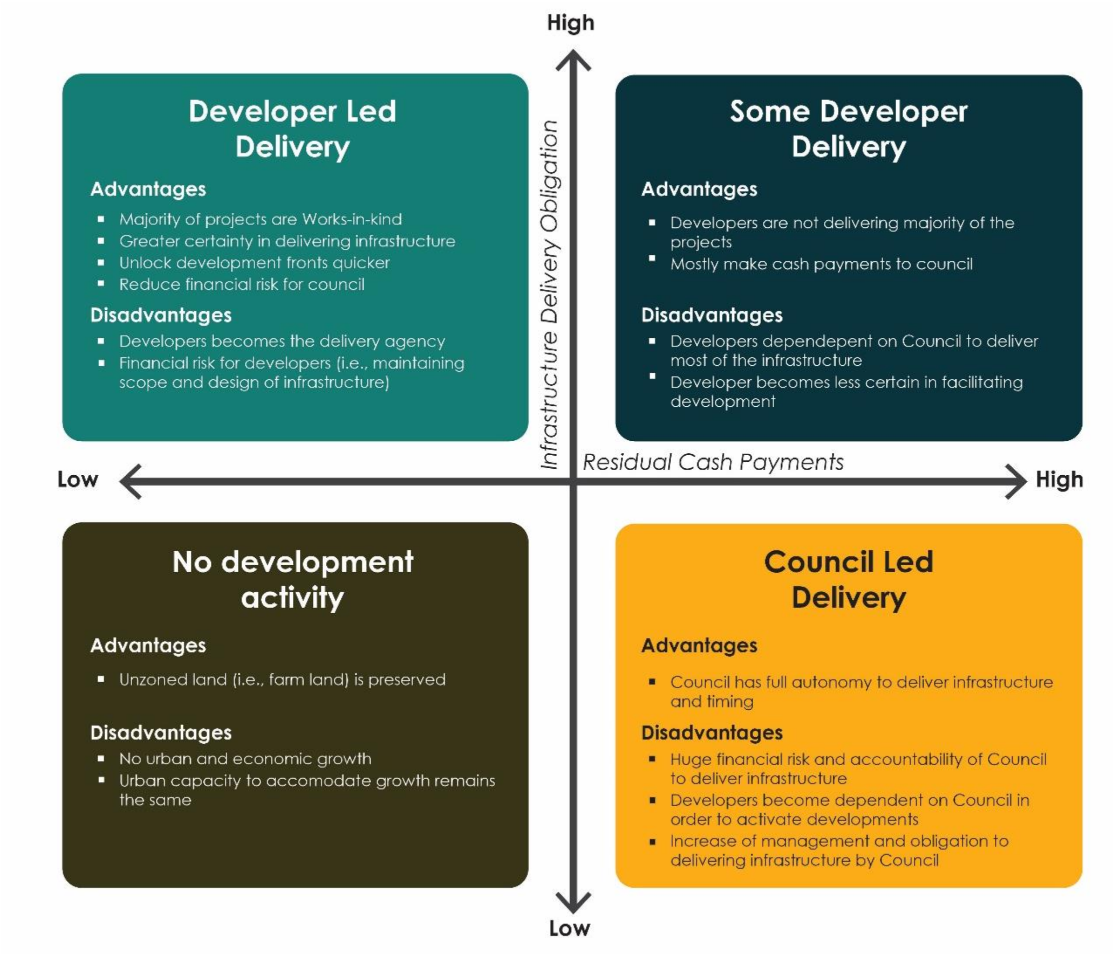
A ***Council Led Delivery*** type is where council takes on the leadership to deliver infrastructure themselves using the levies collected from developers as development is or has occurred. Council becomes the primary delivery agency and holds complete control and accountability for delivering infrastructure that best aligns with development activities.

4. No Development Activity

A ***No Development Activity*** type describes a situation where there is no projected growth in the area and hence does not require any spatial planning or required infrastructure for serving this area.

Key Advantages and Disadvantages of Delivery Type

Figure 25 below highlights each delivery type's key advantages and disadvantages in the delivery matrix. This purpose is to illustrate its positive and negative implications towards the infrastructure delivery process and how both actors are affected.



Developer Led Delivery

Advantages
- Majority of projects are Works-in-kind
- Greater certainty in delivering infrastructure
- Unlock development fronts quicker
- Reduce financial risk for council

Disadvantages
- Developers becomes the delivery agency
- Financial risk for developers (i.e., maintaining scope and design of infrastructure)

Some Developer Delivery

Advantages
- Developers are not delivering majority of the projects
- Mostly make cash payments to council

Disadvantages
- Developers dependepent on Council to deliver most of the infrastructure
- Developer becomes less certain in facilitating development

No development activity

Advantages
- Unzoned land (i.e., farm land) is preserved

Disadvantages
- No urban and economic growth
- Urban capacity to accomodate growth remains the same

Council Led Delivery

Advantages
- Council has full autonomy to deliver infrastructure and timing

Disadvantages
- Huge financial risk and accountability of Council to deliver infrastructure
- Developers become dependent on Council in order to activate developments
- Increase of management and obligation to delivering infrastructure by Council

Figure 25: Advantages and disadvantages of each delivery type.

It is important to note that there are certain traits that developers or councils should aim to have to undertake any of the delivery-type pathways. For example, it is generally more feasible for larger landholders with greater development yield to undergo a Developer Led Delivery type as they are usually in a more significant financial position to undertake such infrastructure investments directly. However, for smaller landholders that need more financial capacity to deliver infrastructure, it is more viable for them to take on the Some Developer Delivery type pathway. On the other hand, council should only undertake the Council Led Delivery type if they have a strong financial capacity to fund and deliver infrastructure independently.

Current state and challenges of tools and practices in managing financial contributions and infrastructure delivery

This section aims to study and comprehend the current state of how council officers handle financial contributions and infrastructure delivery, including the software they use and the challenges they face. In collaboration with Mesh Planning (Mesh), this research assisted in developing survey questions and the agenda for online workshops for both metropolitan and rural areas in Melbourne. A total of 6 Metropolitan and 16 Regional Councils with varying experience in managing infrastructure delivery or DCPs were included. Some have more expertise and maturity in implementing the contribution system, while others are new to this field or planning to begin. This approach allows for comparing different council settings and management styles and builds on the lessons learned from more mature Councils, including metropolitan Councils, to better understand current and future software systems for better support.

Framework

The core of this analysis employs a framework known as the "DCP Lifecycle" (the Lifecycle) developed by Mesh (see Figure 27), which sets out the key steps, stages, processes, and tasks required for effective DCP management. The Lifecycle defines a common language for the set of processes that the DCP software will follow, and the areas of Council will have to interact using the appropriate software systems.

Furthermore, implementing a DCP necessitates collaboration among various departments and skills within Council. As a result, the stages outlined in the Lifecycle will involve different departments performing the necessary tasks. Consequently, this framework identifies operational necessities and difficulties at each stage in the DCP process. It also helps narrow down priority tasks Council finds to be the most important to support their role in managing infrastructure funding and delivery. In addition, this analysis excludes the first two stages of the Lifecycle because they primarily involve developing a DCP through face-to-face interactions with stakeholders and council and undertaking spatial planning rather than focusing on managing systems and procedures.

The Lifecycle identifies particular skill sets in each stage essential to carry out the necessary tasks. It comprises four primary skills, which are (1) planning, (2) financial, risk and legal, (3) infrastructure needs and design, and (4) infrastructure delivery. The description of each skill and how it relates to the Lifecycle is presented in Figure 26. These skill sets can aid council in assigning tasks to the appropriate departments within their organisation for effective management. It is crucial to note that planning skill is necessary throughout all stages, highlighting its significance and the need for a planner with knowledge and skills to oversee the entire process of a DCP.

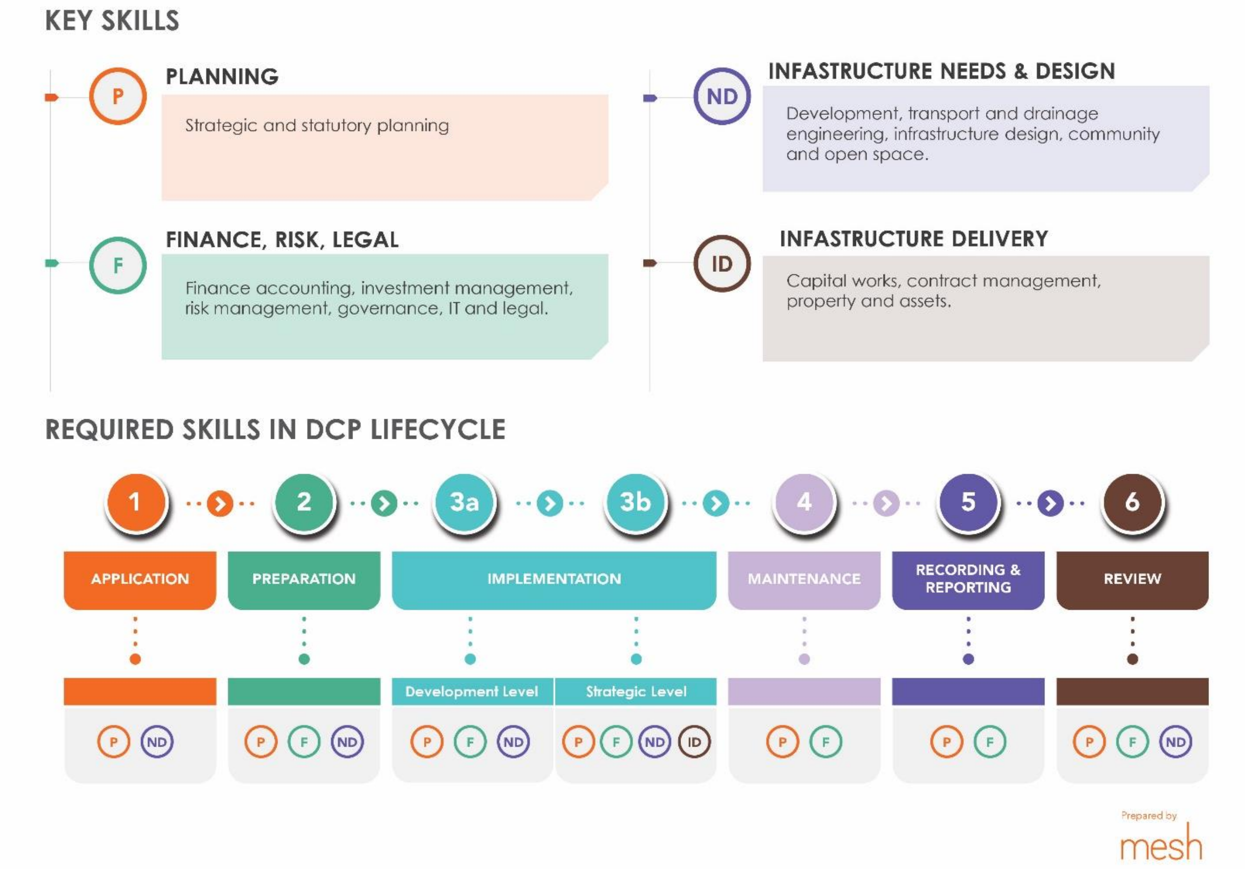
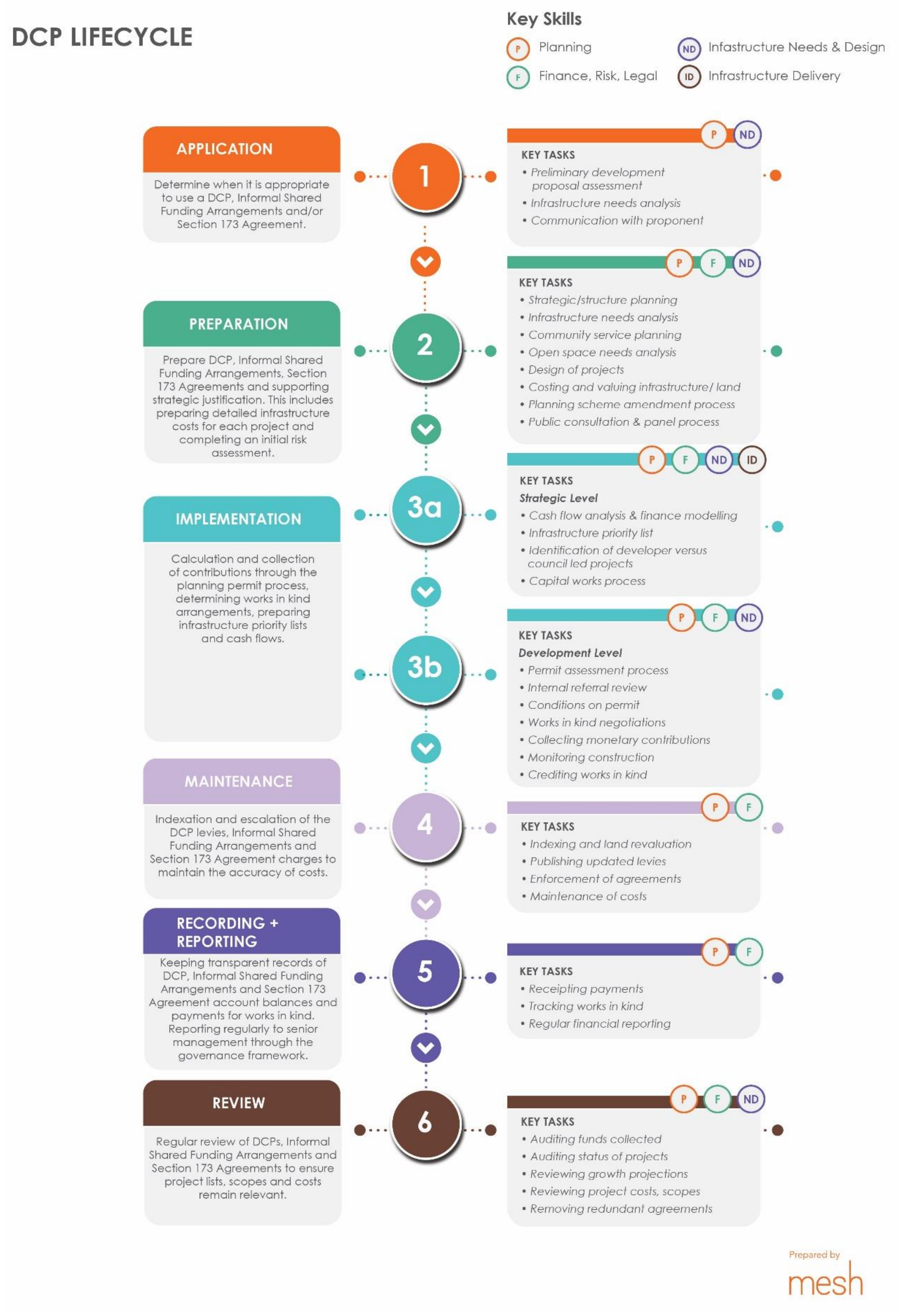


Figure 26: Description of skills required in the DCP Lifecycle (Mesh Planning, 2022).

Furthermore, the survey aims to understand the software systems used by council officers at each stage of the Lifecycle and any difficulties or dissatisfaction they have encountered with them. The survey is structured around specific tasks identified for each stage (see Figure 27), and council offices are asked to provide information regarding software systems and their strengths and weaknesses they use to manage these tasks.



DCP LIFECYCLE

Key Skills

- P Planning
- ND Infastructure Needs & Design
- F Finance, Risk, Legal
- ID Infrastructure Delivery

APPLICATION

1

Determine when it is appropriate to use a DCP, Informal Shared Funding Arrangements and/or Section 173 Agreement.

P ND

KEY TASKS

- *Preliminary development proposal assessment*
- *Infrastructure needs analysis*
- *Communication with proponent*

PREPARATION

2

Prepare DCP, Informal Shared Funding Arrangements, Section 173 Agreements and supporting strategic justification. This includes preparing detailed infrastructure costs for each project and completing an initial risk assessment.

P F ND

KEY TASKS

- *Strategic/structure planning*
- *Infrastructure needs analysis*
- *Community service planning*
- *Open space needs analysis*
- *Design of projects*
- *Costing and valuing infrastructure/ land*
- *Planning scheme amendment process*
- *Public consultation & panel process*

IMPLEMENTATION

3a

3b

Calculation and collection of contributions through the planning permit process, determining works in kind arrangements, preparing infrastructure priority lists and cash flows.

P F ND ID

KEY TASKS

Strategic Level

- *Cash flow analysis & finance modelling*
- *Infrastructure priority list*
- *Identification of developer versus council led projects*
- *Capital works process*

P F ND

KEY TASKS

Development Level

- *Permit assessment process*
- *Internal referral review*
- *Conditions on permit*
- *Works in kind negotiations*
- *Collecting monetary contributions*
- *Monitoring construction*
- *Crediting works in kind*

MAINTENANCE

4

Indexation and escalation of the DCP levies, Informal Shared Funding Arrangements and Section 173 Agreement charges to maintain the accuracy of costs.

P F

KEY TASKS

- *Indexing and land revaluation*
- *Publishing updated levies*
- *Enforcement of agreements*
- *Maintenance of costs*

RECORDING + REPORTING

5

Keeping transparent records of DCP, Informal Shared Funding Arrangements and Section 173 Agreement account balances and payments for works in kind. Reporting regularly to senior management through the governance framework.

P F

KEY TASKS

- *Receipting payments*
- *Tracking works in kind*
- *Regular financial reporting*

REVIEW

6

Regular review of DCPs, Informal Shared Funding Arrangements and Section 173 Agreements to ensure project lists, scopes and costs remain relevant.

P F ND

KEY TASKS

- *Auditing funds collected*
- *Auditing status of projects*
- *Reviewing growth projections*
- *Reviewing project costs, scopes*
- *Removing redundant agreements*

Prepared by mesh

Figure 27: DCP Lifecycle – Description and Tasks (Mesh Planning, 2022).

Software Systems and Functions

Figure 28 shows the proportion of councils and their usage of different software systems in carrying out each of the tasks for each step in the Lifecycle. The survey data is divided into three distinct groups:

1. Regional Anticipating – Regional Councils anticipating engaging with a DCP in the future.
2. Regional Existing – Regional Councils which currently have an operating DCP.
3. Metro – Metropolitan Councils which currently have one or more DCPs.

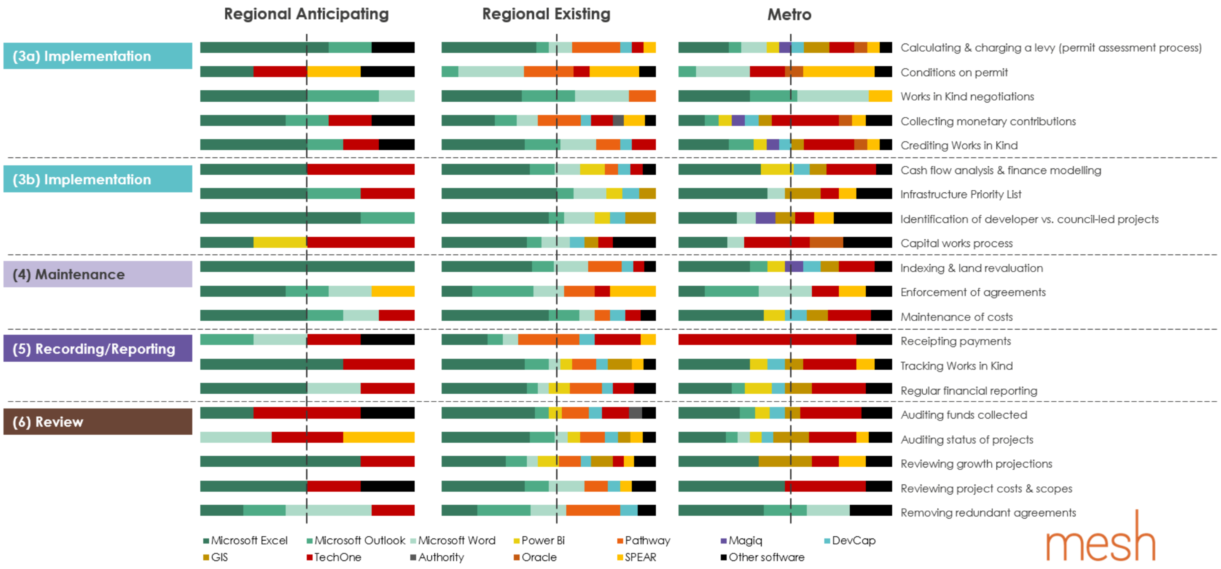
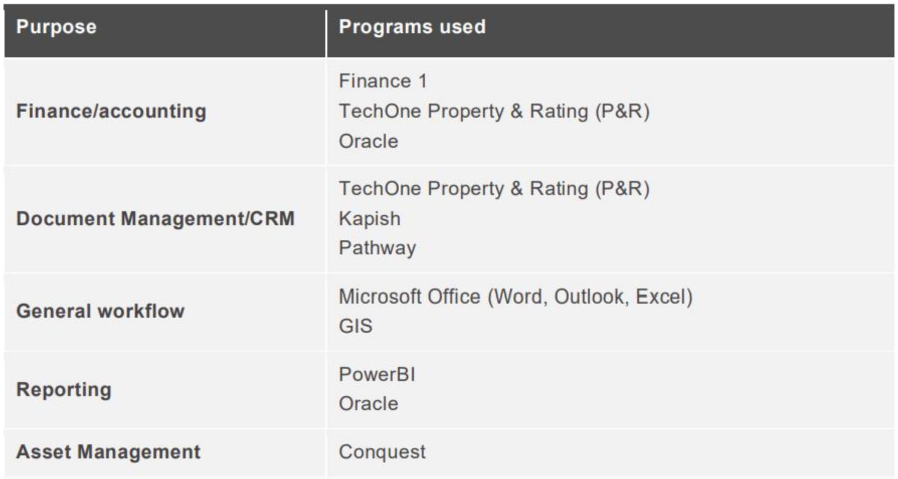


Figure 28: Survey results of software used for each task at each DCP Lifecycle stage (Mesh Planning, 2022).

The survey results reveal that both Metropolitan and Regional Councils use a variety of software throughout the DCP Lifecycle, with Metropolitan Councils utilising more tailored software and Regional Councils utilising more basic and simple software. For example, Regional Councils that already have DCPs in place commonly use Excel for most DCP tasks, supplemented by record keeping software (such as Pathway and TechOne), general Microsoft workflow products (such as Outlook, Office), GIS products and reporting software (such as Oracle and PowerBI).

A small number of regional Councils with larger scale DCPs in place used DevCAP, a specific DCP tool, primarily for implementation, maintenance, and recording/reporting tasks. On the other hand, Metro Councils were more likely to use tailored DCP software, such as Magiq or other tailored software. Figure 29 summarises the current software programs used by council officers in managing a range of general DCP-related tasks tailored to their purposes.



Purpose	Programs used
Finance/accounting	Finance 1 TechOne Property & Rating (P&R) Oracle
Document Management/CRM	TechOne Property & Rating (P&R) Kapish Pathway
General workflow	Microsoft Office (Word, Outlook, Excel) GIS
Reporting	PowerBI Oracle
Asset Management	Conquest

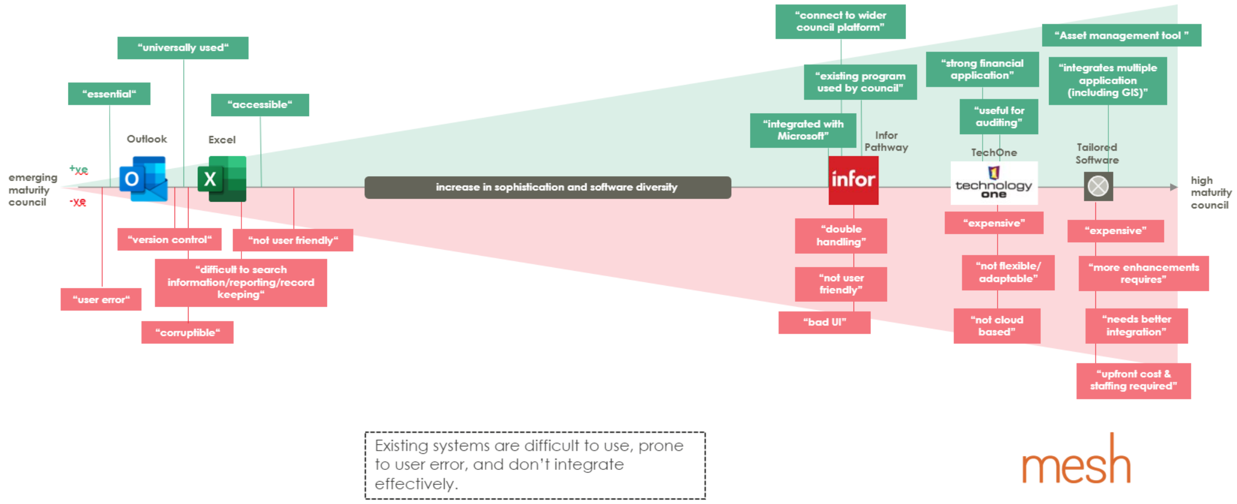
Figure 29: Software used across member Councils (Mesh Planning, 2022).

Challenges of current tools

Functionality:

The survey findings generally reflect a trend that as councils become more experienced in utilising DCPs, the range and complexity of software used for DCP-related tasks also increase. Survey respondents noted that each software they use has its strengths and weaknesses.

Figure 30 presents a comprehensive overview of the spectrum of council maturity levels in regards to handling DCPs, highlighting the various software systems utilised at each stage. Additionally, the figure includes key qualitative responses from participants that provide insight into the strengths and weaknesses of these systems.



Existing systems are difficult to use, prone to user error, and don't integrate effectively.

Figure 30: Software use and perceptions of functionality (Mesh Planning, 2022).

According to participant feedback, existing systems are difficult to use, prone to user error, and have ineffective integration with other systems. Even though more mature councils have invested and ventured into subscribing or developing their tools, users are unsatisfied with their interfaces and the frequency of user errors. They do not integrate with the broader authority system effectively. To illustrate, council officers find it challenging to support their role in strategic decision-making about WIK and capital works plan from the data collected during the administration of DCP in current software systems. In addition, there is a desire for the ability to undertake scenario tests of development activities and WIK options, which will be heavily dependent on inputs from components of a DCP such as land budget, infrastructure project list, IPL and forecast cashflows. Hence, massive improvements still need to be made regarding the usability and accuracy of existing tools.

Cost:

The greater the sophistication development of the tools by more mature authorities, the greater the value of the investment in software development. However, this can be a challenge for lower-resourced authorities, who may not have the same capacity to undertake similar investments and may often be limited by their own ability to implement the system in their smaller urban context.

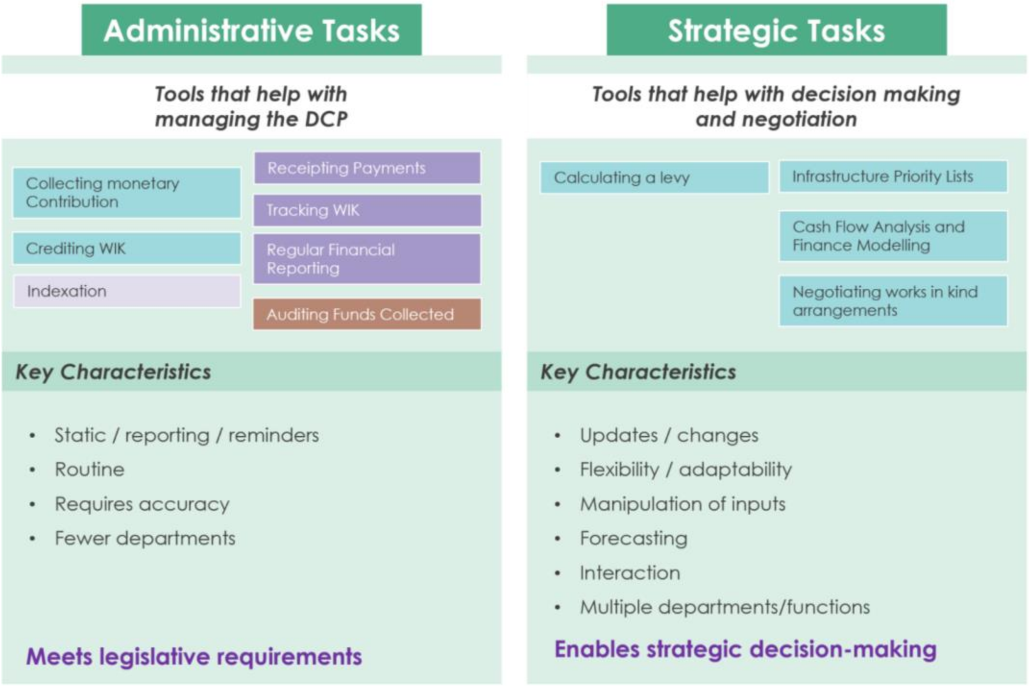
Software often comprises a significant upfront investment in cash and staff resources to design and set up a new system. For instance, ongoing lifecycle costs include subscription fees, ongoing maintenance, staff resources, and training. Furthermore, Metro Councils, who have or are going through the process of developing tailored software, have provided a high-level indication of costs which range from $100,000 to $150,000 for staff resourcing and ongoing license fees and $350,000 to $500,000 for software development. Nonetheless, it should be noted that these figures should only be used as a rough estimate, and the actual costs for a specific council's software development may vary.

Interpretation of results

Most existing tools and software primarily focus on administrative tasks and do not effectively address strategic objectives such as conducting informed negotiations with developers, which is considered a crucial aspect of the system. Therefore, there is a distinction between the administrative and strategic tasks involved in the infrastructure planning system. For example, administrative tasks focus on the routine tasks associated with administering financial reporting, indexation and invoicing. On the other hand, strategic tasks are targeted at enabling authorities to make practical and strategic decision making such as sequencing infrastructure delivery and cash flow forecasting.

Additionally, the survey results indicate that Regional Council members generally agreed there was a lack of strategic focus in their current DCP administration processes and software. This sentiment is echoed by Metro Councils with well-established DCP tools and processes which have also identified a deficiency in this area. Figure 31 shows the comparison of administrative and strategic tasks in terms of their purpose, relationship to tasks identified in the Lifecycle, and distinct characteristics.

Administrative tasks are typically associated with later stages of the Lifecycle, such as Maintenance and Recording and Reporting, where they help meet legislative requirements. On the other hand, strategic tasks are closely tied to the Implementation stage, which involves manipulating data inputs and forecasting to support strategic decision-making.



Administrative Tasks

Tools that help with managing the DCP

Collecting monetary Contribution

Crediting WIK

Indexation

Receipting Payments

Tracking WIK

Regular Financial Reporting

Auditing Funds Collected

Key Characteristics

- Static / reporting / reminders
- Routine
- Requires accuracy
- Fewer departments

Meets legislative requirements

Strategic Tasks

Tools that help with decision making and negotiation

Calculating a levy

Infrastructure Priority Lists

Cash Flow Analysis and Finance Modelling

Negotiating works in kind arrangements

Key Characteristics

- Updates / changes
- Flexibility / adaptability
- Manipulation of inputs
- Forecasting
- Interaction
- Multiple departments/functions

Enables strategic decision-making

Figure 31: Comparations of Administrative and Strategic Tasks (Mesh Planning, 2022).

Consequently, it is acknowledged that the software must effectively handle both tasks to be accountable and strategic. To achieve this, the new software must address current issues related to the inconsistent output of DCP documents (such as invoices, receipts, and schedules) and have the capability to forecast various cash flow scenarios.

Priority Tasks and Functionalities

As the Lifecycle comprises a range of tasks, the responses from the survey were able to identify priority tasks from the Lifecycle that a DCP software should address as a minimum requirement. Additionally, these priority tasks are those that are frequently identified as difficult to manage using current software or where a custom-designed solution or support system would bring significant benefits. As such, the survey participants were asked to rank each task in four categories of priority: not important, could be useful, nice to have and must have.

Figure 32 illustrates how tasks were filtered based on criteria of over 75% being labelled as "must have" and a combination of "must have" and "nice to have" being greater than 50%. As a result, nine priority tasks were identified and distributed across different stages of the Lifecycle.

Figure 32: Priority Tasks identified by council members.

It is noteworthy that identifying priority tasks is vital to understand the needs and demands from a practitioner or user perspective so that future solutions can be targeted to these areas and will be more widely adopted and practical. In addition, it is crucial to emphasise that council members commonly acknowledge that DCPs vary throughout the state, including within the same municipality. Therefore, future support systems must be adaptable and efficiently accommodate these variations by adhering to defined standards.

Integration Opportunities between PSS & Infrastructure Planning

Informed by the implementation challenges encountered in PSS and infrastructure planning, gaps were recognised in the process and will be leveraged to identify opportunities for integrating them to enhance the role of planning in this field. The examination of both PSS and infrastructure planning revealed some of the prevalent issues that practitioners in these fields are currently facing and aim to address. However, the literature review in Chapter 2 also revealed the key objectives these fields are striving to achieve, which were found to have a complementing nature. It was discovered that a synergistic relationship exists between PSS and infrastructure planning, which can be leveraged to achieve their respective objectives and ultimately drive success.

The table below (refer to Table 1) illustrates the gap analysis and opportunities for each component, showcasing the synergistic relationship between them.

Table 1: Gap analysis of PSS and Infrastructure Planning.

Aspect of Issue	Where is it now? Current state of issue	Where would it like to be?	Actions to take to bridge the gap
PSS			
Application	Not widely used in practice due to the gap between researchers and practitioners. Lack of contextualising planning issues and tasks. Not meeting the needs of end users – urban planners in undertaking planning tasks.	A support system that is well-targeted to undertake specialised planning tasks.	Strengthen the collaboration and understanding between research and practice. Researchers to have practical planning knowledge and understand the needs of planners in complex planning tasks seek to support.

Aspect of Issue	Where is it now? Current state of issue	Where would it like to be?	Actions to take to bridge the gap
Acceptance	Insufficient acceptance in the industry. Lack of awareness of the capabilities PSS has to offer in planning practice. Inadequate partnership between researchers and planning managers to showcase ongoing developments and upskilling of staffs in the broader organisations.	Strong acceptance and uptake rate of PSS in organisations by demonstrating relevancy to planning roles.	Established a partnership connection between researchers and planning managers to foster ongoing innovation and technological advancement within the organisation.
Instrumentation	Poor quality of PSS with non-user-friendly interfaces PSS is too complicated for planners to use – exceeding the skill sets of planners to undertake functions in the PSS tool.	Improve user interface and simplify PSS tool to ensure intuitive and clear inputs and outputs.	System developers engage with end users to formulate critical functions and tasks that are intuitive without a strong technical background.
Infrastructure Planning			
Planning oversight	Lack of an overarching strategy and coordination across council and state. Lack of skills to manage complex tasks. Inconsistent rate of development activity, fluctuating development charge rates due to inflation and yearly adjustment in land valuations.	An integrated system that collects and display of information that is easy to understand and quick to retrieve. A centralised data source to store updated data and calculations of rates.	Refine issues and needs within the planning realm to provide context for a system-oriented solution.

Aspect of Issue	Where is it now? Current state of issue	Where would it like to be?	Actions to take to bridge the gap
Tools	Existing tools are not implemented well and lack efficiency in managing infrastructure planning. Lack of strategic tools to support decision making, scenario testing to reduce financial risks. DCPs can vary across the municipality and within the state.	A spatially enabled DCP tool that integrates both spatial and non-spatial components. A PSS tool that incorporates scenario testing functionalities that can test the implication of WIK negotiation against cashflows. A modular DCP tool that can read any DCP and its associated attributes and information	Identify an appropriate methodology and system to undertake specific planning-related tasks (i.e., PSS). Determine and justify the purpose of the tool. Identify and formulate a constant data model throughout all DCPs to formalise a data standard and quality control.
Spatial Integration	Comprises a large data inventory consisting of land and infrastructure projects information. Inefficient management of data whereby it is mainly managed and represented through static plans and multiple reference tables.	The transfer and translation of static information, both spatial and non-spatial attributes, into a robust spatial database and environment.	Determine key attributes and information links in data associated with the management and reference fields in a DCP. Prepare an automated workflow that retrieves inputs to create the necessary data tables that comprise data linkages and updates.
Communication	Lack of efficiency in the sharing of information between stakeholders as well as within the internal organisation.	A common platform or environment where stakeholders and authorities can easily communicate the status of infrastructure projects and the liability of developers.	Investigate using a spatial environment as a foundation to display and interact with information accessible to anyone and anywhere.

Table 2 illustrates the possibilities for integration between PSS and infrastructure planning by showing how the objectives of PSS can enhance the current practices and requirements of the infrastructure planning system.

Table 2: Identification of integration opportunities between PSS and infrastructure planning.

PSS Objectives	Current state of infrastructure planning practice	Integration Opportunities
Seeks to support contextualised planning-specific tasks	The identification of a clear planning problem and a list of tasks that necessitate support through technological systems or enhanced policy and procedures.	A clearly defined planning problem is essential for the development of a PSS that aims to provide a well-targeted solution.
Map Based & data visualisation	Consists of a collection of static representations of maps and data attributes in DCP documents.	Spatial plans and their associated attributes in a DCP can be integrated into a more robust map-based platform through spatial integration.
Centralised platform for data storage and management	A DCP document that contains all information pertaining to the responsibilities of property owners and the expenses associated with infrastructure projects.	An existing central database that is highly adaptable can be used to store spatial and infrastructure data tables, which would enable an automated process for creating and updating the necessary tables within a DCP.
User Interface	The current software systems are challenging to use due to a lack of intuitive interface. Assistance is required in simplifying usage and facilitating easy retrieval of information.	The goal of PSS is to aid in completing planning tasks using user-friendly tools, which will help keep the interface of the PSS straightforward and easy to use.
Scenario Testing – What-If scenarios	Assist in decision-making during negotiations of WIK with developers and evaluate its impact on the overall DCP and cashflow.	Planners aim to perform scenario testing, and PSS can provide the means to do so by presenting the necessary concepts and objectives.

Chapter 4: Design and Development of an IP-PSS

The preceding chapters have explored the fundamental principles, challenges, and integration opportunities for both PSS and infrastructure planning. Built upon this understanding, the design and development of an Infrastructure Planning PSS (IP-PSS) can now be undertaken, focusing on addressing some of the more crucial planning tasks identified by practitioners in the field.

This chapter begins by explaining how the IP-PSS will be implemented as a web-based platform, which will be used as a tool for displaying, sharing, and conveying data to users through the internet. It then details the data inputs required for the IP-PSS, and the processing of these datasets. Finally, the chapter covers the complete development application approach, including the system architecture, features, and the steps involved in the execution process.

Web-based IP-PSS

The recent emergence of the internet and the World Wide Web (WWW) has resulted in a widespread acceptance of WebGIS in current GIS systems worldwide (Miao & Yuan, 2013). The utilisation of WebGIS enables the dissemination of map services, such as data visualisation and spatial analysis, on the internet. As a result, this method grants users’ access to the server's capabilities, eliminating the requirement for proprietary software and complex systems to be installed on individual devices.

Previous chapters have shown that some PSS case studies utilised WebGIS technologies in order to make GIS capabilities available for users without technical GIS expertise, enabling them to easily share and gain spatial insights from their data quickly. Additionally, the utilisation of advanced cartographic and geospatial visualisation tools, such as pan, zoom, and interactive maps, provided by WebGIS, increases the usability of these systems (Jankowski, Czepkiewicz, Młodkowski, Zwoliński, & Wójcicki, 2017). The ability to run models and simulate future scenarios in real-time using web-based PSS also enables planners to make more informed decisions based on the insights generated from their data. The case studies demonstrate the effectiveness of web-based PSS in supporting the allocation of resources by planners. Therefore, the implementation of a web-based approach in the design and development of an IP-PSS is considered an appropriate approach, given the need for efficient and user-friendly tools to address the needs of planning professionals involved in infrastructure planning and delivery.

The system architecture outlined later in this chapter facilitates the integration of interactive spatial querying and scenario planning for infrastructure development and delivery within a single platform. The incorporation of geocomputation algorithms and spatial querying capabilities enables real-time access to information pertaining to land use and infrastructure projects. This approach utilises an independent system architecture that primarily employs open-source frameworks, thereby catering to a wider audience and achieving cost-effectiveness.

Data Acquisition & Management

The accuracy of a model is contingent upon the quality of inputs. To ensure the reliability of the model, it is crucial that data is thoroughly validated and critically evaluated prior to its incorporation. Thus, the identification and validation of input data sources are of paramount importance before utilising them within the model. In the context of infrastructure planning, a diverse array of data must be obtained from various sources and subsequently consolidated into a standardised format.

Infrastructure Spatial Data Inputs

The formulation of a DCP is carried out through the planning process of a PSP. The PSP includes a land use plan that guides future developments and the placement of services. The land use plan, known as the future urban structure (FUS), encompasses infrastructure and other land uses and their relationship to the quantity of land area. This dataset is a crucial piece of information throughout the DCP Lifecycle, providing planners with an understanding of the amount of land that can be developed and charged on as well as the collect levies from as well as the amount of land that must be acquired from private ownership for public use.

In order to effectively conduct this research, a hypothetical DCP area is established, incorporating the standard components commonly found within a typical DCP document. This approach is undertaken to provide a simplified illustration and to effectively showcase the various elements included in a DCP, while remaining within the research's scope and limitations.

The process of digitising the hypothetical DCP as a spatial dataset necessitates the acquisition of two primary data inputs: property boundaries (e.g., cadastre) and the geometry of infrastructure elements within the DCP study area. Additionally, the spatial layer containing infrastructure items should include existing infrastructure not funded or managed by the DCP, such as existing road reserves, drainage reserves, utility and servicing areas, etc. In order to ensure the integrity of the individual layers, each dataset must include the following primary key:

1. Property Layer - a unique DCP property identifier (e.g., 1, 2, 3, etc.)
2. Infrastructure Layer - a unique DCP projects identifier (e.g., RD_01, OS_01, CU_01, etc.)

The unique identification for property and infrastructure items serves as the crucial connection to the attributes that will be added later and used to relate them spatially to the rest of the dataset. Once the attribute fields have been added and populated for both datasets, they are merged into a single spatial dataset layer through a spatial union process. Figure 33 graphically illustrates the process of creating and merging the separate property and infrastructure spatial layers, resulting in the final consolidated DCP spatial dataset.

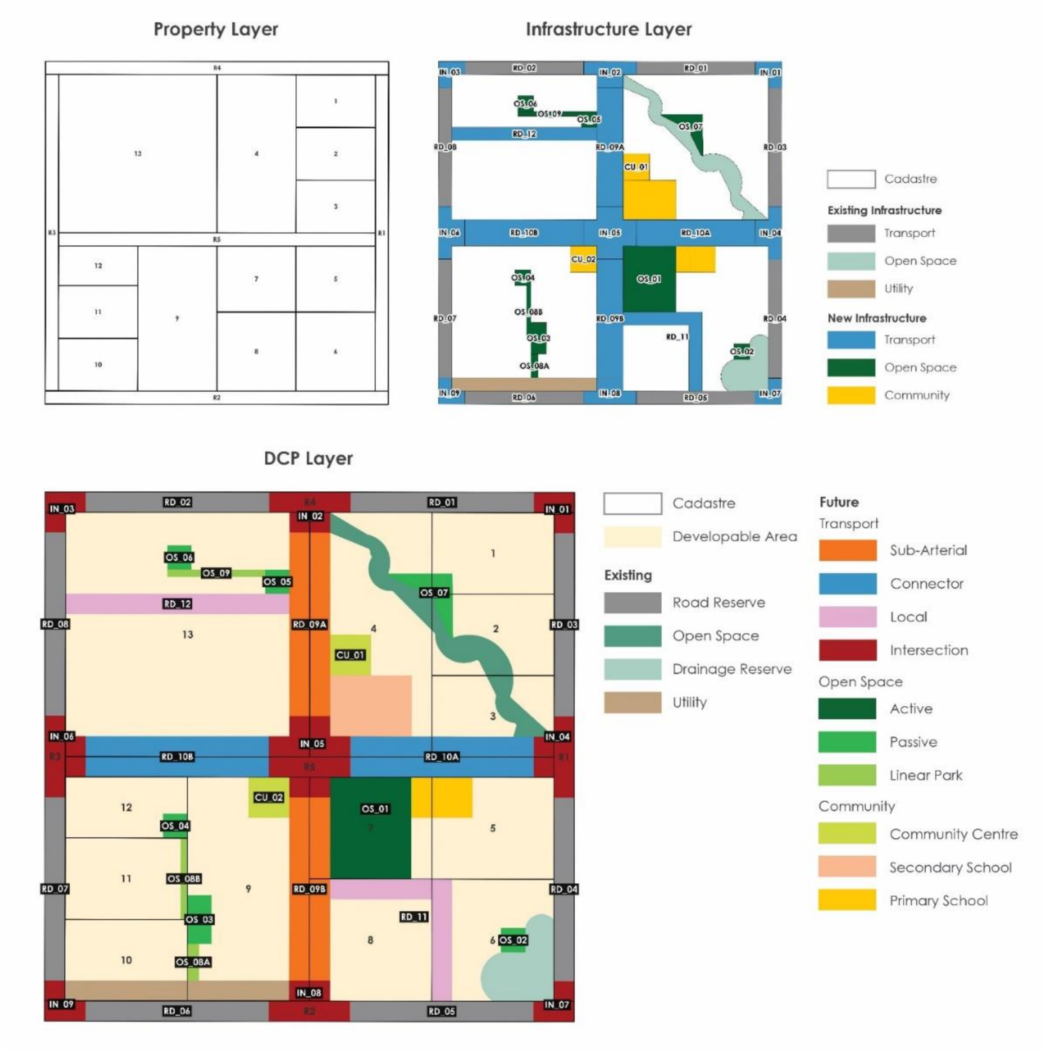


Figure 33: Hypothetical DCP – Property, Infrastructure and DCP Layer.

DCP Preparation Components – Fixed Inputs

Although different DCPs may differ, there are certain inputs that are constant and required across them all. The fixed components will provide:

- an overview of the standard inputs as data tables and their breakdown,
- helping to ensure that the data acquisition process is well-organised,
- using a standardised language for data management and inventory.

Land use categories

In this context, land use categories refer to the classification of land based on its purpose and its relation to ownership status. These categories include (1) encumbered land, which is public land that is already designated for public purposes; (2) unencumbered land, which is land that will be designated for public purposes and required to acquire land from private landholders; and (3) developable, which is land that is available for development. An example of the data table is as below.

id	lu_categ
1	Encumbered Land
2	Unencumbered Land
3	Developable

Land use library

To effectively classify and manage the various land uses within the DCP area, a standard land use library is established. This library contains all unique land use categories and is used to classify the different land uses within the DCP Layer. This is crucial for allowing systems and algorithms to easily retrieve and aggregate data using spatial indexing, which utilises a combination of land use fields. Three hierarchical tiers of land use classification fields are utilised, including Land Use Class, Land Use Type, and Land Use Subtype are described as below.

- Land Use Class field assigns the highest classification order and defines the general purpose of land use, such as transport, open space, or community.
- Land Use Type field assigns the second classification order and defines the specific land use type within its class.
- Land Use Subtype field defines the most detailed classification level and emphasises the specific use of a particular land use class and type.

Hence, for every land use classification, it will be assigned to its corresponding land use category. The definition of land uses in the DCP Layer is an essential input in generating a complete land budget in calculating its area according to their unique combination of land use fields. The deduction of land registered for existing and future public purpose land will compute its total Net Developable Area (NDA), generating the basis and calculation of development charges in a DCP.

The table below illustrates an example of how the land use library is defined, with several rows displaying the different land use classifications and their corresponding categories.

lu_class	lu_type	lu_subtype	lu_categ
Developable Area	Other	NA	Developable
Transport	Existing Private Road	Connector	Encumbered
Community	New Community Centre	NA	Unencumbered
Credited Open Space	New Active	NA	Unencumbered

Project class

The DCP Layer not only displays the physical location and size of infrastructure projects but also aims to identify which projects will require the purchase of land from private property owners. Hence, the project class field is used to differentiate between these types of projects. Each infrastructure item identified in the DCP considers both land acquisition and construction costs, which are separated into three distinct categories: (1) land acquisition costs, (2) construction costs, and (3) both land and construction costs. As example data table is shown as below.

id	proj_class
1	Land
2	Construction
3	Land & Construction

Summary

The fixed inputs defined above provides a common language for defining DCP layers. Each feature in the DCP layer is assigned with a set of fixed inputs as attributes, which serve to standardise, guide, and compute the additional data tables required in a DCP.

DCP Preparation Components – Site Specific Inputs

Every DCP requires specific inputs that are tailored to its location. These inputs is narrowed down into three main components: land value, construction cost estimates, and an indexation method. These components seek to accomodate the specific needs and context of the development site and consider the unique factors that may impact land values and construction design, such as geographical constraints.

Land Valuation

To determine the cost of acquiring public land, a typical DCP uses a "Before and After" land valuation method. This involves calculating the compensation value and acquisition rate of land per property designated for some public land purposes. These calculations should be performed by a registered land valuation organisation and typically presented in a data table format.

prop_no	before_rate_m2	after_rate_m2
1	$100,000	$100,000
2	$100,000	$150,000
3	$100,000	$80,000

Construction Costings

Additionally, the construction cost estimates are determined through input from a quantity surveyor. The surveyor uses information from the DCP, including the scope and design, to ensure that all costs are captured. The calculated costs for each infrastructure are to align with the unique infrastructure project identifier defined in the DCP Layer. The table below presents an example of costings information from a quantity surveyor.

item_id	proj_category	cost_estimate	unit_of_measure	rate	quantity
TH1	Road	$3,500,000	Lm	$200/Lm	800
TH2	Road	$3,500,000	Lm	$200/Lm	800
TH3	Intersection	$2,500,000	m²	$2,000/ m²	30,000
TH4	Sport and Recreation	$3,750,000	m²	Quantity	1
TH5	Community	$14,000,000	m²	Quantity	1

Indexation Schedule

Since a DCP has a typical lifespan of 15 to 20 years, it must account for adjustments in its development charge rates in order to reflect changes in costs due to inflation. This is usually carried out by indexing construction costs annually for each financial year.

There are a wide range of sources local authorities can choose from in retrieving annual index rate such as, the Australian Bureau of Statistics (ABS) or subscriptions to private organisations' databases (for e.g., Rawlinsons Index). In this case, the ABS Price Producer Index - Table 17. Output of the Construction Industries, Subdivision and Class index numbers is used. Thus, an indexation schedule table is created and stored in a data table format to track and update the development charge rate for each financial year. The structure of the data table is illustrated below.

index_year	index_no	rate_change
21/22	115.6	1
22/23	126.3	1.0926
23/24	127	1.0055

DCP Implementation Components – Site Specific Inputs

This section focuses on the strategic and administrative aspects of managing a DCP. Two crucial inputs are required for the effective modelling of development sequencing and delivery of infrastructure: (1) a development schedule and (2) an IPL. These inputs play a crucial role in conducting scenario analysis for negotiations with developers about WIK and evaluating the impact on cash flow and financial risk throughout the lifespan of the DCP.

Development Schedule

As the purpose of a development schedule is already discussed in the aforementioned chapters, it is usually obtained from developers. It gives an estimated timeline for development by breaking it down into multiple stages over time. It is important to note that the schedule is not set in stone and is still subject to change as development progresses. As multiple landholders are involved with varying levels of interest and capacity, it is impossible for council to have a complete schedule for the entire DCP area. Nevertheless, council can make general predictions about when development is likely to occur across the area, giving them insight into incoming revenue and ensuring they have adequate funds to deliver shared infrastructure.

A sample development schedule is shown in the table below illustrating the stages of development it will undergo, its associated NDA per stage and the timing of development activity.

prop_no	name_developer	stage_no	stage_nda	fy
1	Developer A	1	7.67	25/26
1	Developer A	2	3.75	25/26
1	Developer A	3	5.25	27/28
5	Developer E	1	8.67	28/29
5	Developer E	2	4.67	29/30
13	Developer M	1	10.53	25/26
13	Developer M	2	3.56	25/26

IPL

The IPL is a crucial aspect of the ongoing management of a DCP as it outlines the short, medium, and long-term infrastructure projects and their expected delivery timeframes. Similar to the development schedule, the IPL is not fixed and should be used as a flexible framework to prioritize infrastructure projects that align with the timing of development. Collaboration between developers and local authorities is necessary to determine the best development and infrastructure delivery sequencing and coordination to meet the demand at a given time. The IPL also plays a significant role in the overall cash flow model of the council, providing valuable information to make informed decisions when negotiating the delivery of infrastructure with developers.

The table below presents a sample of entries related to the timing and delivery of infrastructure by developers under WIK negotiations recorded in an IPL data table.

proj_id	total_proj_cost	deliver_party	prop_no	wik_apportionment	wik_developer	fy
RD_02	$3,500,000	Developer	13	100%	$3,500,000	22/23
OS_05	$1,889,170	Developer	13	100%	$1,889,170	26/27
RD_09A	$6,440,430	Developer	4	50%	$3,220,215	24/25
IN_04	$1,350,031	Developer	2	100%	$1,350,031	28/29

Summary

In short, a significant portion of DCP inputs is based on data-rich tables that are tied to geographic features. It is essential that the management of DCP data be performed with great care and precision to ensure the accuracy and reliability of the information generated.

Summary of data inputs:

In summary, the table below (refer to Table 3) outlines the data input necessary to be prepared and organised for the development of the IP-PSS

Table 3: Data acquisition list.

Dataset	Format	Data Owner	Source
Spatial Datasets			
Property Layer	ESRI Shapefile	Department of Transport and Planning (DTP)	https://www.land.vic.gov.au/maps-and-spatial/spatial-data/vicmap-catalogue/vicmap-property
Infrastructure Layer	ESRI Shapefile	Local Authority	Digitisation of features
DCP Layer	ESRI Shapefile	Local Authority	Geoprocessing
Fixed DCP Preparation Data Tables			
Land Use Categories	Excel, csv file	General	General
Land Use Library	Excel, csv file	General	Mesh Land Use Library
Project Class	Excel, csv file	General	General
Site Specific DCP Preparation Data Tables			
Land Valuation	Excel, csv file	Local Authority	Engaged registered land valuation organisation
Construction Costings	Excel, csv file	Local Authority	Engage quantity surveyor organisation
Indexation Schedule	Excel, csv file	Local Authority/ ABS	ABS PPI - Table 17. Output of the Construction industries, subdivision and class index numbers
Site Specific DCP Implementation Data Tables			
Development Schedule	Excel, csv file	Local Authority	Local Authority
IPL	Excel, csv file	Local Authority	Local Authority and Developer

Data Processing & Validation

This section discusses the data processing phase where data is transformed, validated, and stored in a format suitable for analysis and programming. It involves a series of checks and procedures to verify that the data meets specific criteria, such as completeness, consistency, and accuracy. This step also includes removing duplicate or incorrect data and correcting errors that may have been introduced during the creation of computed data. Furthermore, this ensures that the data is reliable and can be used to make informed decisions. Hence, the following section below will discuss key processes and validation under three main categories: (1) Data Projection and Transformation, (2) Geoserver, and (3) Spatial Database Management System.

Data Projection & Transformation

The spatial datasets acquired to create a DCP Layer are undertaken under an appropriate Projected Coordinate System (PCS). This is so that geometric calculations such as area and length can be measured accurately. Once the DCP Layer is finalised, every spatial dataset (i.e., property, infrastructure and DCP layer) is transformed and reprojected to a Geographic Coordinate System (GCS), in this case, EPSG:4326 - WGS 84. This is a crucial step as the shapefile must be stored under a GCS to fit the programming requirements of the WebGIS open-sourced framework for visualisation and further analysis.

Geoserver

Spatial data is stored and managed on Geoserver, which is an open-sourced geospatial server hosted on an internet platform that allows for the sharing, processing, and editing of geospatial information. To store the data on the Geoserver, a datastore must be created with the necessary specifications, such as naming, privacy, and boundary details. After the spatial data has been successfully imported, a GeoJSON API key is generated for each layer, which can then be linked and used in programming. The GeoJSON format is ideal for use with the open-source WebGIS framework for further processing and managing spatial information.

Spatial Database Management System

The input data, which includes both spatial and non-spatial information, is stored in a Spatial Database Management System (SDBMS). The SDBMS is a specialised system designed to handle a large volume of data tables, allowing for quick import, manipulation, and retrieval of data through Structured Query Language (SQL). Unlike a regular Database Management System (DBMS), a SDBMS has an added spatial dimension, making it possible to perform spatial queries and operations. Hence, this management system is appropriate to support the development of the IP-PSS. The combination of PostgreSQL and PostGIS is employed to set up the entire functioning SDBMS.

The data tables imported include information and attributes necessary for generating key DCP tables such as the property-specific land budget, infrastructure project list, and summary of development charges. To create these tables, SQL scripts are written based on the attributes from the input data. The use of these scripts provides efficiency and helps avoid errors that could occur with traditional manual methods, such as Microsoft Excel. The scripts are designed to be executed in a systematic manner and automate the process of generating the remaining DCP tables. The output tables are formatted in a way that is easily readable by other programs and have a consistent format, unlike the inconsistent formatting that may occur in Excel.

The output data tables are validated using existing templates and tools, such as Mesh's infrastructure planning suite (refer to Appendix 2). The calculated values generated from SQL are cross-referenced against the templates and any duplication of data or calculation errors are identified and corrected through an interactive process.

Figure 34 displays all the data tables that were generated during this process. These tables are stored in the designated database and schema within the database. Each data table contains information about the fields such as the data type in each field, and its assigned primary key if required.

It is crucial to recognise that the DCP data tables do not operate independently but instead have interconnections. Understanding these connections is crucial for the efficient flow of information in the management and implementation of a DCP. The lack of awareness of these relationships can lead to errors and inefficient data management. An Entity Relationship Diagram (ERD) is prepared to model and depict the relationships between entities in the database to address this issue (see Figure 35). This is achieved by assigning primary and foreign keys to each table using the insights gained from the gap analysis report by Mesh (2022). The property and infrastructure project layers play a pivotal role as the primary connections to the rest of the tables, serving as a crucial reference point for the generation of other tables.

dcp_gis_data

id	BIGINT
geom	geometry
mesh_id	CHARACTER VARYING(100)
prop_no	CHARACTER VARYING(100)
proj_id	CHARACTER VARYING(100)
precinct	CHARACTER VARYING(100)
lu_class	CHARACTER VARYING(100)
lu_type	CHARACTER VARYING(100)
lu_subtype	CHARACTER VARYING(100)
proj_class	CHARACTER VARYING(100)
area_ha	NUMERIC
client_id	CHARACTER VARYING(100)
parcel_pfi	CHARACTER VARYING(100)
parcel_spi	CHARACTER VARYING(100)
parcel_fur	CHARACTER VARYING(100)
parcel_sta	CHARACTER VARYING(100)
ezi_addres	CHARACTER VARYING(100)
dev_class	CHARACTER VARYING(100)
comment	CHARACTER VARYING(100)
lu_categ	CHARACTER VARYING(100)

dcp_gis_project

id	BIGINT
geom	geometry
mesh_id	CHARACTER VARYING(100)
prop_no	CHARACTER VARYING(100)
proj_id	CHARACTER VARYING(100)
precinct	CHARACTER VARYING(100)
lu_class	CHARACTER VARYING(100)
lu_type	CHARACTER VARYING(100)
lu_subtype	CHARACTER VARYING(100)
proj_class	CHARACTER VARYING(100)
area_ha	NUMERIC
client_id	CHARACTER VARYING(100)
parcel_pfi	CHARACTER VARYING(100)
parcel_spi	CHARACTER VARYING(100)
parcel_fur	CHARACTER VARYING(100)
parcel_sta	CHARACTER VARYING(100)
ezi_addres	CHARACTER VARYING(100)
dev_class	CHARACTER VARYING(100)
comment	CHARACTER VARYING(100)
lu_categ	CHARACTER VARYING(100)

dcp_gis_property

MESH_ID	INTEGER
geom	geometry
mesh_id	CHARACTER VARYING(100)
prop_no	CHARACTER VARYING(100)
precinct	CHARACTER VARYING(100)
area_ha	NUMERIC
client_id	CHARACTER VARYING(100)
parcel_pfi	CHARACTER VARYING(100)
parcel_spi	CHARACTER VARYING(100)
parcel_fur	CHARACTER VARYING(100)
parcel_sta	CHARACTER VARYING(100)
ezi_addres	CHARACTER VARYING(100)
id	BIGINT
devyield	NUMERIC
totlia	NUMERIC
no_proj	NUMERIC
perc_ppl	NUMERIC
t_proj_cst	NUMERIC
no_of_wik	NUMERIC
land_value	NUMERIC

costings_ref

source	CHARACTER VARYING(100)
item_id	CHARACTER VARYING(100)
src_proj_cat	CHARACTER VARYING(100)
main_proj_cat	CHARACTER VARYING(100)
proj_type	CHARACTER VARYING(100)
proj_subtype	CHARACTER VARYING(100)
cost_application	CHARACTER VARYING(100)
cost_estimate	NUMERIC(100,2)
unit_measure	CHARACTER VARYING(100)
rate_per_unit_base	NUMERIC(100,2)
quantity	CHARACTER VARYING(100)
unit	CHARACTER VARYING(100)
rate_per_unit	NUMERIC(100,2)
index_type	CHARACTER VARYING(100)
index_year	CHARACTER VARYING(100)
basis_of_costings	CHARACTER VARYING(100)
src_doc	CHARACTER VARYING(100)
date	DATE
proj_id	CHARACTER VARYING(100)

dc_proj_list_2

proj_id	CHARACTER VARYING(100)
proj_cat	CHARACTER VARYING(100)
proj_desc	CHARACTER VARYING(1000)
row_num	NUMERIC
infra_cat	CHARACTER VARYING(100)
proj_area	NUMERIC
proj_constr_area	NUMERIC
total_length_m	NUMERIC
proj_land_cost	NUMERIC
proj_cost	NUMERIC
total_proj_cost	NUMERIC
dcp_apportionment	NUMERIC(100,2)
total_cost_covered	NUMERIC
demand_units	NUMERIC(100,2)
units	CHARACTER VARYING(100)
charge_per_demand_units	NUMERIC

project_costing

proj_id	CHARACTER VARYING(100)
proj_desc	CHARACTER VARYING(1000)
infra_class	CHARACTER VARYING(100)
source	CHARACTER VARYING(100)
src_proj_cat	CHARACTER VARYING(100)
main_proj_cat	CHARACTER VARYING(100)
proj_type	CHARACTER VARYING(100)
proj_subtype	CHARACTER VARYING(100)
item_id	CHARACTER VARYING(100)
quality_factor	NUMERIC(100,2)
unit	CHARACTER VARYING(100)
total_area_m2	CHARACTER VARYING
total_length_m	CHARACTER VARYING
index_year	CHARACTER VARYING(100)
rate_change	NUMERIC(100,6)
proj_cost	NUMERIC

dc_proj_list_final

proj_id	CHARACTER VARYING(100)
proj_cat	CHARACTER VARYING(100)
proj_desc	CHARACTER VARYING(1000)
infra_cat	CHARACTER VARYING(100)
proj_area	NUMERIC
proj_constr_area	NUMERIC
total_length_m	NUMERIC
proj_land_cost	NUMERIC
proj_cost	NUMERIC
total_proj_cost	NUMERIC
dcp_apportionment	NUMERIC(100,2)
total_cost_covered	NUMERIC
demand_units	NUMERIC(100,2)
units	CHARACTER VARYING(100)
charge_per_demand_units	NUMERIC

parcel_budget_final

prop_no	CHARACTER VARYING(100)
total_area	NUMERIC
encum_area	NUMERIC
gda	NUMERIC
unencum_area	NUMERIC
nda	NUMERIC
nda_percent	NUMERIC
ppl_percent	NUMERIC
lu_class	CHARACTER VARYING(100)
lu_type	CHARACTER VARYING(100)
lu_subtype	CHARACTER VARYING(100)
lu_concat	TEXT
lu_categ	CHARACTER VARYING(100)
area	NUMERIC
total_ppl_area	NUMERIC

dev_ipl_input

proj_id	CHARACTER VARYING(100)
proj_desc	CHARACTER VARYING(100)
total_proj_cost	NUMERIC(100,2)
total_cost_covered	NUMERIC(100,2)
total_cost_council	NUMERIC(100,2)
deliver_party	CHARACTER VARYING(100)
prop_no	CHARACTER VARYING(100)
wik_status	CHARACTER VARYING(100)
wik_apportionment	NUMERIC(100,2)
wik_developer	NUMERIC(100,2)
wik_council	NUMERIC(100,2)
fy	CHARACTER VARYING(100)

land_valuation

prop_no	CHARACTER VARYING(100)
total_area	NUMERIC
before_area	NUMERIC
before_rate	NUMERIC(100,2)
before_value	NUMERIC
area_acquired	NUMERIC
total_nda	NUMERIC
after_rate	NUMERIC(100,2)
after_value	NUMERIC
compensation	NUMERIC
acquisition_rate	NUMERIC

dc_proj_list_1

proj_id	CHARACTER VARYING(100)
proj_cat	CHARACTER VARYING(100)
proj_desc	CHARACTER VARYING(1000)
row_num	NUMERIC
infra_cat	CHARACTER VARYING(100)
proj_area	NUMERIC
proj_constr_area	NUMERIC
total_length_m	NUMERIC
proj_land_cost	NUMERIC
proj_cost	NUMERIC

parcel_budget_summary

prop_no	CHARACTER VARYING(100)
total_area	NUMERIC
encum_area	NUMERIC
gda	NUMERIC
unencum_area	NUMERIC
nda	NUMERIC
nda_percent	NUMERIC
ppl_percent	NUMERIC

parcel_budget_lu

prop_no	CHARACTER VARYING(100)
lu_class	CHARACTER VARYING(100)
lu_type	CHARACTER VARYING(100)
lu_subtype	CHARACTER VARYING(100)
lu_concat	TEXT
lu_categ	CHARACTER VARYING(100)
area	NUMERIC
total_ppl_area	NUMERIC

dev_schedule

prop_no	CHARACTER VARYING(100)
name_developer	CHARACTER VARYING(100)
stage_no	CHARACTER VARYING(100)
stage_nda	CHARACTER VARYING(100)
fy	CHARACTER VARYING(100)
dc_rate	NUMERIC
total_levy	NUMERIC

summary_dc

proj_cat	CHARACTER VARYING(100)
proj_land_cost	NUMERIC
proj_cost	NUMERIC
total_proj_cost	NUMERIC
total_cost_covered	NUMERIC
charge_per_demand_units	NUMERIC

dc_proj_list_ext

proj_id	CHARACTER VARYING(100)
dcp_apportionment	NUMERIC(100,2)
demand_units	NUMERIC(100,2)
units	CHARACTER VARYING(100)
proj_cat	CHARACTER VARYING(100)
infra_cat	CHARACTER VARYING(100)

lu_library

lu_id	CHARACTER VARYING(100)
lu_class	CHARACTER VARYING(100)
lu_type	CHARACTER VARYING(100)
lu_subtype	CHARACTER VARYING(100)
lu_concat	CHARACTER VARYING(100)
lu_categ	CHARACTER VARYING(100)

dev_schedule_input

prop_no	CHARACTER VARYING(100)
name_developer	CHARACTER VARYING(100)
stage_no	CHARACTER VARYING(100)
stage_nda	CHARACTER VARYING(100)
fy	CHARACTER VARYING(100)

ss_land_valuation

prop_no	CHARACTER VARYING(100)
before_rate_m2	NUMERIC(100,2)
after_rate_m2	NUMERIC(100,2)
before_rate_ha	NUMERIC(100,2)
after_rate_ha	NUMERIC(100,2)

project_land_cost

prop_no	CHARACTER VARYING(100)
total_area	NUMERIC
proj_id	CHARACTER VARYING(100)
area_ha	NUMERIC
proj_land_cost	NUMERIC

project_costing_ext

item_id	CHARACTER VARYING(100)
proj_desc	CHARACTER VARYING(1000)
infra_class	CHARACTER VARYING(100)
quality_factor	NUMERIC(100,2)

dc_index_rate

index_year	CHARACTER VARYING(100)
index_no	NUMERIC(100,6)
rate_change	NUMERIC(100,6)
dc_rate	NUMERIC

project_land

prop_no	CHARACTER VARYING(100)
total_area	NUMERIC
proj_id	CHARACTER VARYING(100)
area_ha	NUMERIC

index_ref

index_year	CHARACTER VARYING(100)
index_no	NUMERIC(100,6)
rate_change	NUMERIC(100,6)

dc_proj_prop_area

prop_no	CHARACTER VARYING(100)
proj_id	CHARACTER VARYING(100)
total_area	NUMERIC

lu_precinct

id	CHARACTER VARYING(100)
precinct_name	CHARACTER VARYING(100)

lu_proj_class

id	CHARACTER VARYING(100)
proj_class	CHARACTER VARYING(100)

lu_categ

id	CHARACTER VARYING(100)
lu_categ	CHARACTER VARYING(100)

Figure 34: Data tables and their associated attribute fields.

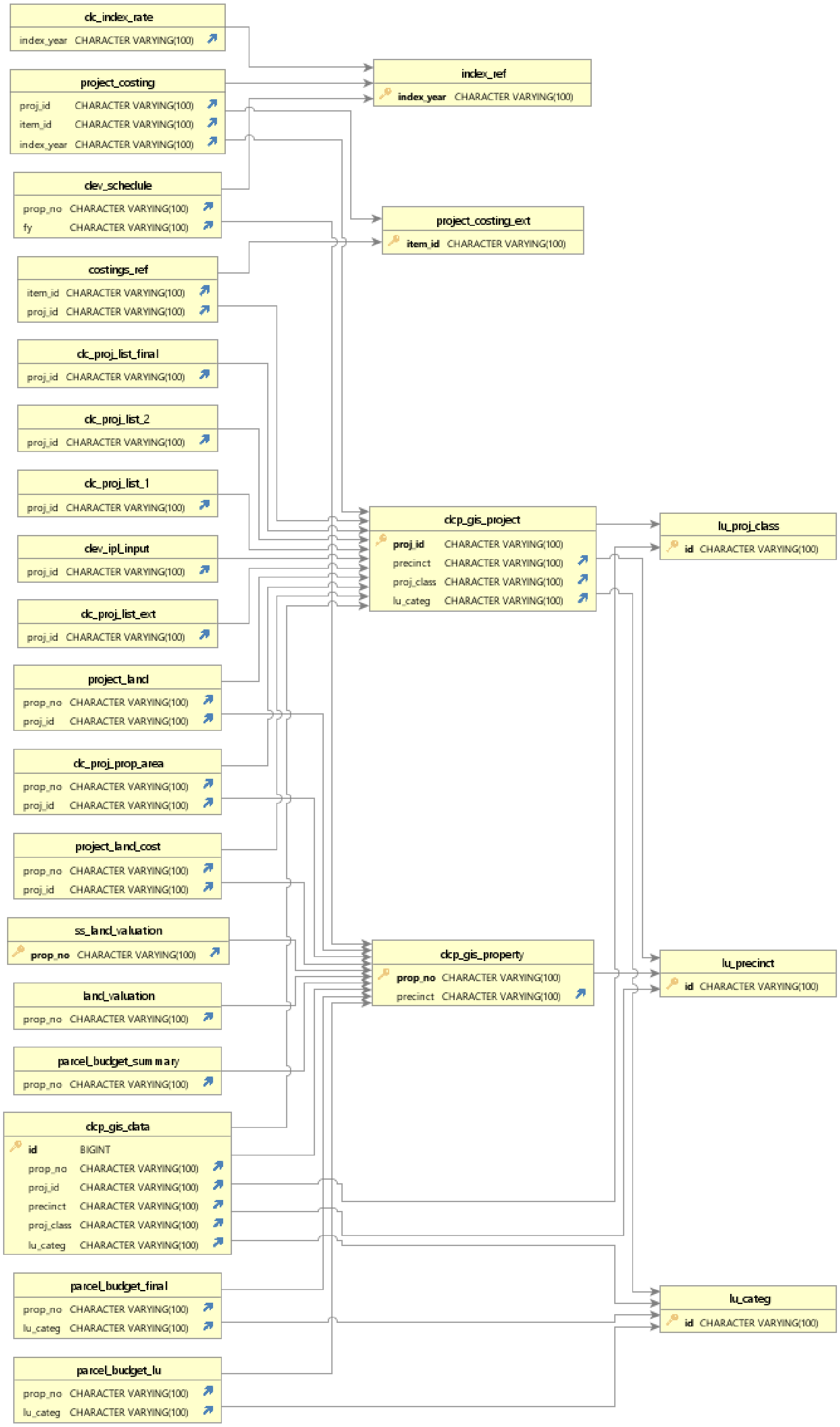


Figure 35: Entity Relationship Diagram of SBDMS.

Development of an IP-PSS

The final part of this chapter will delve into the development of an IP-PSS and its application in addressing the needs and requirements of planning professionals. The IP-PSS is designed to support and guide planners with the tasks in the management of financial contributions for the effective delivery of infrastructure for urban development. Furthermore, the IP-PSS aims to deliver effective and efficient support in establishing a central platform for information gathering and scenario testing.

In the following sections, (1) the type of architectural system used to build the web-based IP-PSS, (2) the core functions of the system, and (3) the system's operational logic for executing user tasks will be discussed in depth, providing an in-depth understanding of the IP-PSS and its role in the infrastructure planning system.

System Architecture

The IP-PSS adopts a system architecture that is depicted in Figure 36. As such, the IP-PSS utilises a client-server technology to allow users to query DCP data and perform development scenario testing. It operates on a multi-tiered architecture that consists of three main parts: (1) the Database Layer, (2) Business Logic Layer, and (3) Presentation Layer. Each tier has its specific components and functions to support the other tiers, and they are connected through secure, compartmentalised sections to enhance the efficiency and security of the system. These building blocks form the basis for developing a web-based IP-PSS, and each tier will be explored in greater detail in subsequent sections.

Database Layer

The database layer mainly consists of the SDBMS, the backbone for storing and retrieving data. The database system acts as an interface with the rest of the system, providing the ability to create, read, update, and delete (CRUD) data. The segmentation into different system tiers protects direct access and modification of the data and can only be accessed through the boundaries and limits enabled by the business logic layer. Furthermore, this layer reduces the risk of losing valuable information and data recovery in the event of system failure.

In this instance, a SQL Schema is created to store all the inputs as data tables specific to a DCP. This schema should be created for every new DCP developed. As described in the earlier sections, The data acquired from various sources are imported and stored into this schema. Within the database system, a series of SQL scripts is implemented to process these data inputs and generate the necessary DCP data tables, establishing a complete DCP SDBMS. The SDBMS is enabled by adding the PostGIS extension to the PostgreSQL database, enabling the querying of information with a spatial dimension and adding more value to the integration of a web-based mapping system.

Business Logic Layer

The business logic layer serves as the middle layer within the IP-PSS system architecture. This layer consists of the core functions and logic of the system, acting as a bridge between the database and presentation layer. Key components in this system tier are the application server, Geoserver, API connection and business rules (i.e., the software function logic and process algorithms). The application server uses Apache Tomcat as a local host web server to enable a web-based IP-PSS. On top of that, Node.js is used to generate API keys to connect DCP data tables from the SDBMS and the GeoJSON WFS link from Geoserver for usage and further processing with the scripting of the business logic and code.

There are four business tabs in the IP-PSS, and each comprises its rules, conditions and actions defined by the business rules. The functions in each tab will be discussed in the next section. Nevertheless, as the layer is designed to be modular, each available tab and its associated components can be developed, activated and tested independently. This can significantly benefit the application's development speed and reduce the risk of errors. Furthermore, the Javascript programming language is dominantly used to develop these business rules, algorithms, mapping and data processing, providing more flexibility to create a more sophisticated solution to the system’s needs and requirements.

Presentation Layer

This layer, also known as the user interface, is the top tier of the multi-tiered architecture system in the development of the IP-PSS. It seeks to provide a user-friendly environment for users to interact with and execute tasks. The feature in this layer allows users to utilise the functionalities under the programmed business logic efficiently, retrieve the required data from the SDBMS and present it back to the user in this presentation layer quickly.

The design of this layer uses HTML and CSS scripting with additional open-sourced frameworks such as Bootstrap and Mapbox GL JS framework to provide a more enhanced user-friendly experience with mapping capabilities that is simple and intuitive.

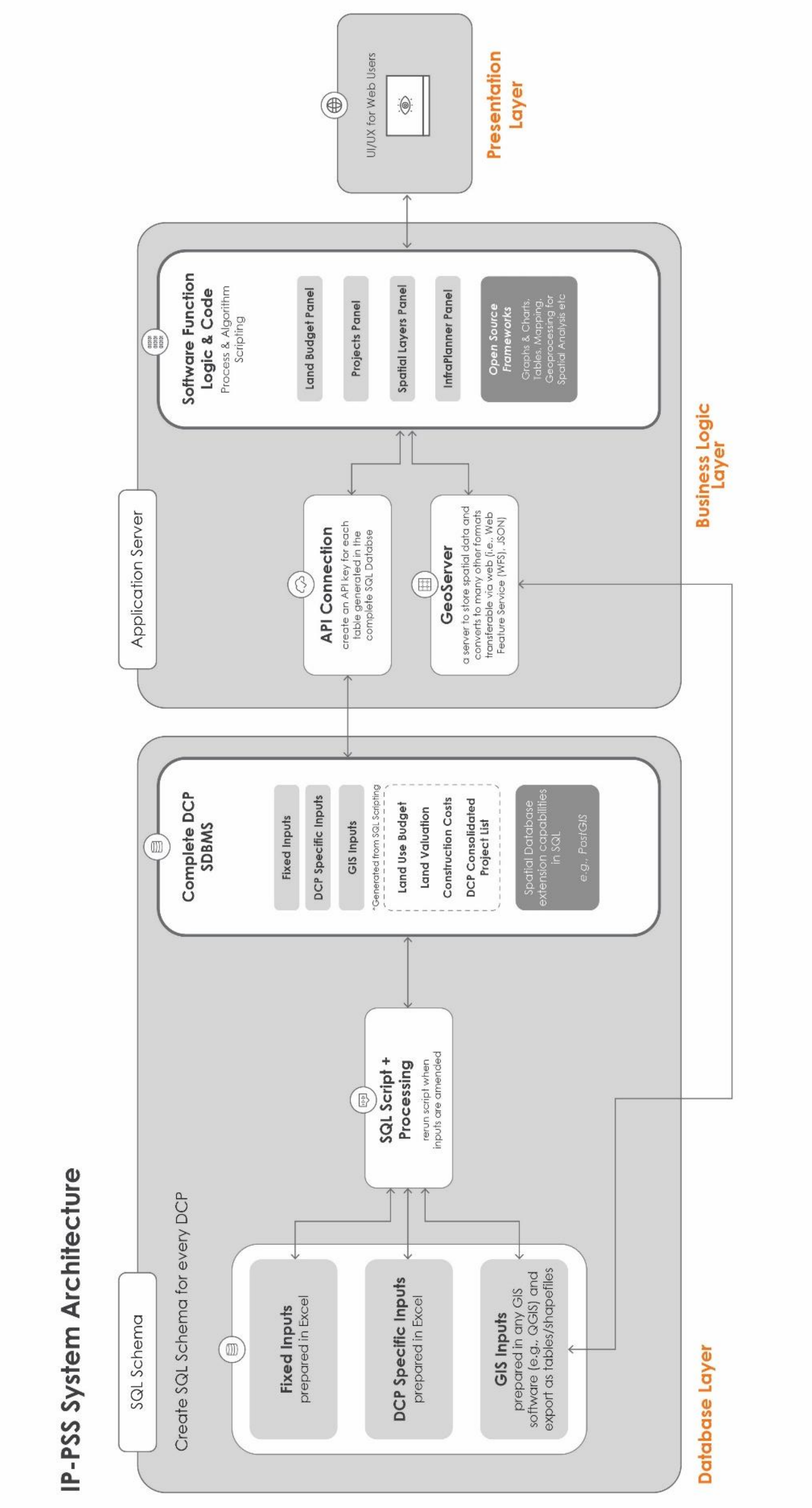


Figure 36: IP-PSS System Architecture.

System Objectives & Functions

The IP-PSS aims to provide practitioners with functions that primarily focus on the strategic tasks of infrastructure planning and some administrative tasks. It is crucial to note that precise inputs derived from the DCP document and strategic tasks are required to perform administrative tasks accurately. Thus, the tool's objective is to digitise the DCP information first and then build the strategic and administrative functions.

The IP-PSS initiates an interactive mapping environment that allows users to interact with the DCP data. Its functions include an interactive map that provides users (1) access to data corresponding to the map, (2) the manipulation of data attributes, (3) data computation and visualisation, and (4) spatial data analytics. The system's purpose is to present static data in a format that is interactive, transparent, and easily accessible that generate insights from the data itself. The following sub-sections describes the each of the objectives and functions in the IP-PSS in terms of its type of tasks, purpose, and required inputs.

Objective 1: Land Use and Infrastructure Project Query

DCP Lifecycle Stage	Preparation
Task Type	Planning process
Task	Structure planning
Function Purpose	To retrieve information about the designated land uses and the locations of infrastructure projects. It intends to generate land budget and infrastructure projects calculations and statistics through graphical representations.
Inputs	Property layer, infrastructure layer, DCP layer, DCP land budget, infrastructure project list

Objective 2: Calculation of Infrastructure Levy

DCP Lifecycle Stage	Implementation (a)
Task Type	Strategic
Task	Calculating a levy

Function Purpose	To calculate the overall levies based on indexed DCP rates and development charge units (e.g., NDA). The levies cover both land acquisition and construction costs.
Inputs	DCP land budget, infrastructure project list, indexation schedule

Objective 3: WIK Project Status

DCP Lifecycle Stage	Recording and Reporting
Task Type	Administrative
Task	Tracking WIK
Function Purpose	To provide a transparent record and the location of infrastructure projects that is under WIK agreements.
Inputs	Infrastructure project list, IPL, Cash flow modelling

Objective 4: WIK and Cash Flow Scenario Planning

DCP Lifecycle Stage	Implementation (a), Implementation (b), Recording and Reporting
Task Type	Strategic and Administrative
Task	Cash flow analysis, IPL, Negotiating WIK, Crediting WIK, Indexation
Function Purpose	To model the timing of likely income in terms of cash contributions (i.e., DCP liability) and incoming assets (i.e., WIK), and expenditure in terms of WIK reimbursements and council direct delivery projects.
Inputs	Property layer, DCP land budget, property specific development schedule, IPL, total of credits entitled per property

Function 5: Analytical Spatial Layers

The objective of this function is to provide a spatial representation of data using various symbology classifications. Users can interact with four main layers, including the (1) DCP layer (i.e., Future Urban Structure), (2) Property Size, (3) Total liability Per Property, and (4) Infrastructure Delivery Type.

Chapter 5: IP-PSS Results & Evaluation

The chapter seeks to present the results of the web-based IP-PSS tool and evaluate its performance. It will demonstrate the implementation of the tool, including its features and functionalities discussed in the PSS design and development phase. Furthermore, it will also exhibit one primary use case to demonstrate further its capability and how it can improve the planner's role in decision-making within the infrastructure planning system.

Following the demonstration of the IP-PSS, the tool will be assessed and evaluated through engagement with practitioners utilising it. Thereby, an evaluation framework, introduced in the later section, will be used to measure the performance and usefulness of the tool.

IP-PSS Tool & Use Case

User Interface

The IP-PSS main interface is presented in Figure 37. It comprises the map canvas as the primary aspect of the tool where the DCP Layer and other spatial data are visualised. In addition, two main side panels are allocated to each corner consisting of a suite of unique functions assigned to each tab. The tabs along the left panel mainly comprise the tool's query and scenario planning functions and subsidiary functions, such as spatial data layers on the right-side panel.

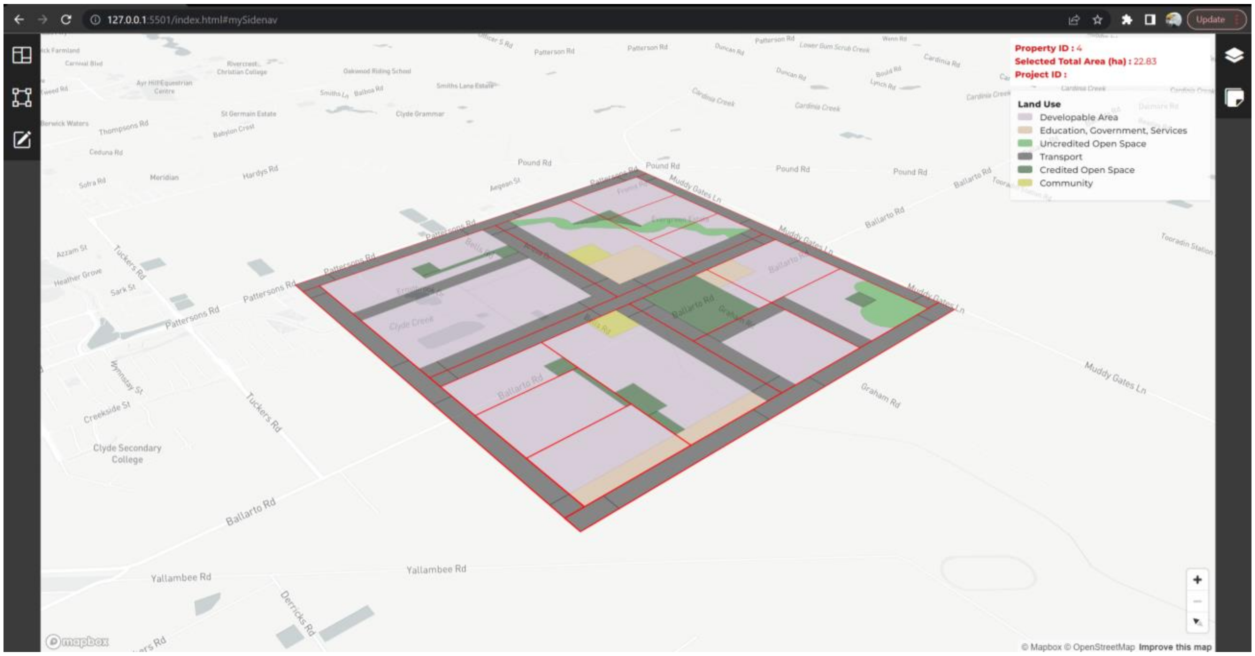

Property ID : 4
Selected Total Area (ha) : 22.83
Project ID :

Figure 37: IP-PSS main user interface.

The tool's functionality is showcased by using hypothetical inputs that have been preloaded into its data and temporal characteristics, with the aim of demonstrating its capability for scenario planning.

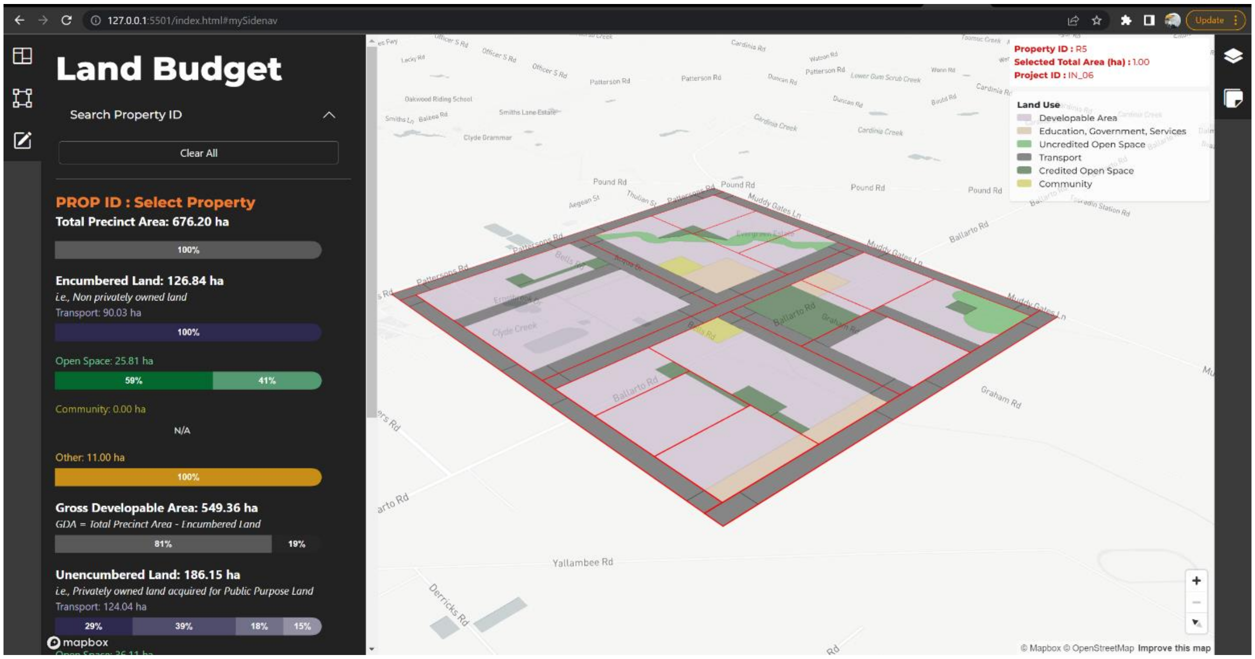
Tab 1: Land Budget and Levy Calculation

Property specific land budget query

The main objective of this tab is to allow users to access land budget information as per the selected property on the map. The reporting graphs are arranged systematically according to the hierarchy shown in the method for spatial planning (i.e., total area, encumbered, unencumbered land etc.) implemented in Victoria's planning system for growth areas (refer to Figure 12).

For each level of land use area calculation, the total statistics of land area and their proportion of land use regarding their subtype classification are generated and represented through interactive charts. A further categorisation for land use classes for encumbered and unencumbered land is implemented and summarised by the three main infrastructure categories: transport, open space, and community. An additional category of 'other' is added to assign the other land uses found in the DCP Layer to account for land uses not captured under the main categories defined.

Since the graphs are interactive and dynamic, it refreshes their information during a user's interaction with information on the map. Refer to Figure 38 and use case.



PROP ID : Select Property
Total Precinct Area: 676.20 ha
100%

Encumbered Land: 126.84 ha
i.e., Non privately owned land
Transport: 90.03 ha
100%
Open Space: 25.81 ha
59% 41%
Community: 0.00 ha
N/A
Other: 11.00 ha
100%

Gross Developable Area: 549.36 ha
GDA = Total Precinct Area - Encumbered Land
81% 19%

Unencumbered Land: 186.15 ha
i.e., Privately owned land acquired for Public Purpose Land
Transport: 124.04 ha
29% 39% 18% 15%

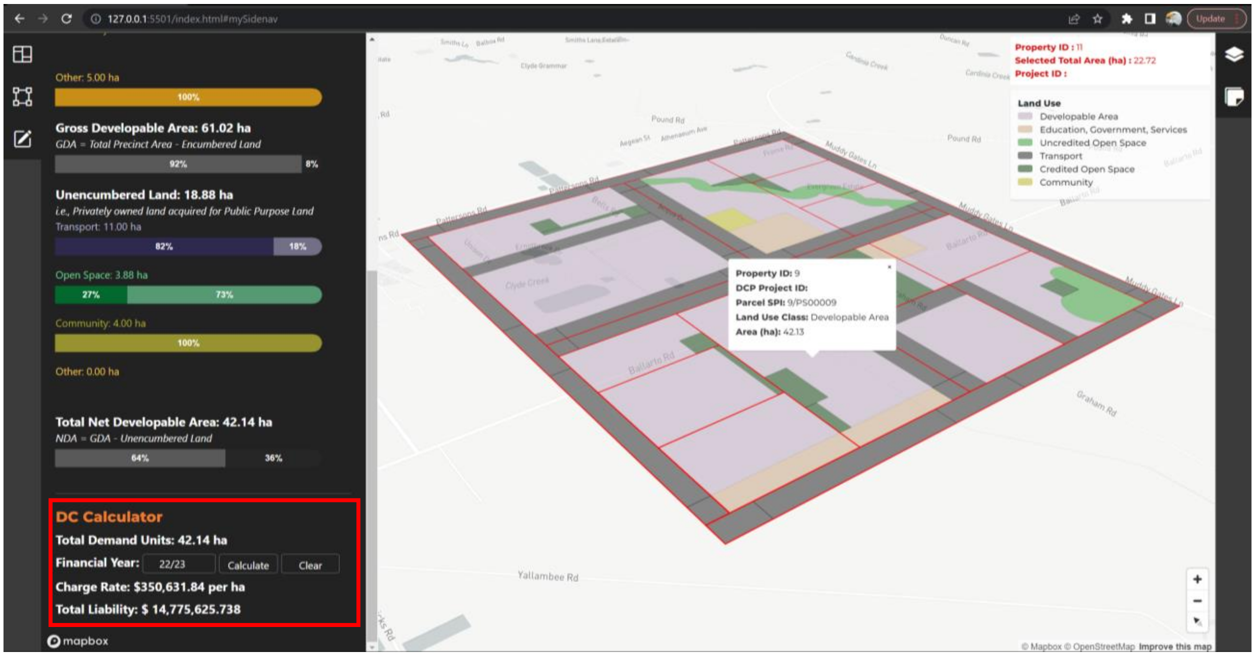
Property ID : R5
Selected Total Area (ha) : 1.00
Project ID : IN_06

Figure 38: Tab 1 – Land Budget tab.

Calculation of levy

Finally, the query about land use information for a particular property of interest computes its total demand units (i.e., the NDA). It provides a logical progression to calculate the total financial liability of the selected property. Therefore, a levy calculator is provided to assist the user in having an idea of the extent of financial obligation as payments to council.

In addition, as infrastructure levy rates are indexed annually to account for inflation, users can select a series of financial year rates to calculate its past, current and projected financial liability. Refer to Figure 39 and the use case.



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Other: 5.00 ha

Gross Developable Area: 61.02 ha
GDA = Total Precinct Area - Encumbered Land

Unencumbered Land: 18.88 ha
i.e., Privately owned land acquired for Public Purpose Land
Transport: 11.00 ha

Open Space: 3.88 ha

Community: 4.00 ha

Other: 0.00 ha

Total Net Developable Area: 42.14 ha
NDA = GDA - Unencumbered Land

DC Calculator
Total Demand Units: 42.14 ha
Financial Year: 22/23
Charge Rate: $350,631.84 per ha
Total Liability: $ 14,775,625.738

Property ID : 11
Selected Total Area (ha) : 22.72
Project ID :

Property ID: 9
DCP Project ID:
Parcel SPI: 9/PS00009
Land Use Class: Developable Area
Area (ha): 42.13

Figure 39: Tab 1 - Levy calculation function.

Tab 2: Infrastructure Projects, WIK Delivery and Spatial Query

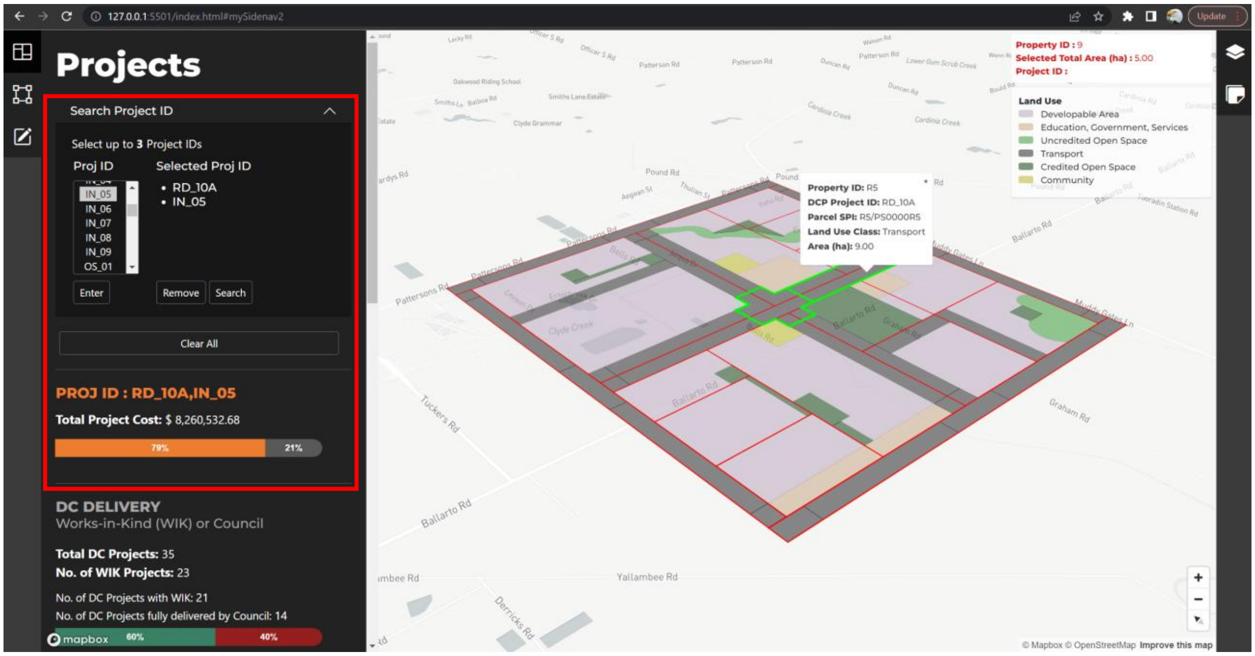
This tab presents a comprehensive overview of all infrastructure-related information contained in the DCP Layer. It is organised into distinct sections containing specific information, which will be discussed in detail in the following section.

Infrastructure project query

The first section of this tab is dedicated to retrieving infrastructure cost information. This includes both the costs of land acquisition and construction. Similar to the functionality shown in the land budget tab, the user can access this information by interacting with spatial data displayed on the map.

Furthermore, the system allows for retrieving multiple infrastructure items, up to three items, and aggregate their costs. This feature aims to assist users in efficiently calculating the total cost of infrastructure that is of interest to them. This is important for developers, who often seek opportunities to undertake WIK projects that are either in close proximity or a particular infrastructure item acting as a catalyst to unlock their development site.

As such, this feature makes it easy for developers and councils to quickly assess the potential infrastructure costs associated with a given list of infrastructure projects. Refer to Figure 40.



- RD_10A
- IN_05

PROJ ID : RD_10A,IN_05

Total Project Cost: $ 8,260,532.68

DC DELIVERY
Works-in-Kind (WIK) or Council

Total DC Projects: 35
No. of WIK Projects: 23

No. of DC Projects with WIK: 21
No. of DC Projects fully delivered by Council: 14

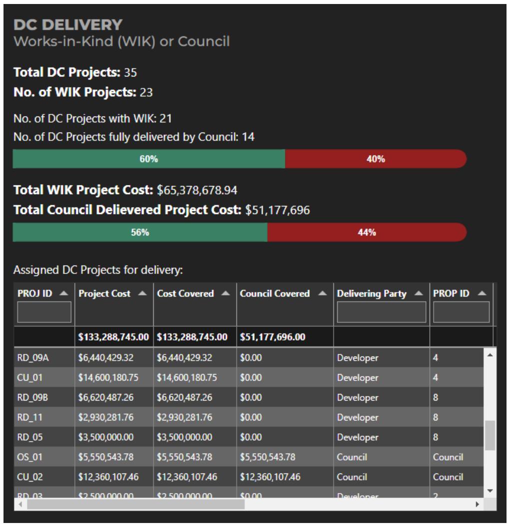
Property ID : 9
Selected Total Area (ha) : 5.00
Project ID :

Property ID: R5
DCP Project ID: RD_10A
Parcel SPI: R5/PS0000R5
Land Use Class: Transport
Area (ha): 9.00

Figure 40: Tab 2 – Infrastructure project query.

Delivery Status
Secondly, this section of the tab aims to provide users with information regarding the summary of infrastructure status in terms of the total number of items and its delivery type breakdown (i.e., council or developer).

The charts assigned to this section display the proportion of infrastructure items in categories according to their delivery type and associated costs. Furthermore, a table containing a list of all registered infrastructure items is generated to provide users with detailed information for each item. Refer to Figure 41.



DC DELIVERY
Works-in-Kind (WIK) or Council

Total DC Projects: 35
No. of WIK Projects: 23

No. of DC Projects with WIK: 21
No. of DC Projects fully delivered by Council: 14

Total WIK Project Cost: $65,378,678.94
Total Council Delievered Project Cost: $51,177,696

Assigned DC Projects for delivery:

PROJ ID	Project Cost	Cost Covered	Council Covered	Delivering Party	PROP ID
	$133,288,745.00	**$133,288,745.00**	**$51,177,696.00**		
RD_09A	$6,440,429.32	$6,440,429.32	$0.00	Developer	4
CU_01	$14,600,180.75	$14,600,180.75	$0.00	Developer	4
RD_09B	$6,620,487.26	$6,620,487.26	$0.00	Developer	8
RD_11	$2,930,281.76	$2,930,281.76	$0.00	Developer	8
RD_05	$3,500,000.00	$3,500,000.00	$0.00	Developer	8
OS_01	$5,550,543.78	$5,550,543.78	$5,550,543.78	Council	Council
CU_02	$12,360,107.46	$12,360,107.46	$12,360,107.46	Council	Council
RD_03	$2,500,000.00	$2,500,000.00	$0.00	Developer	2

Figure 41: Tab 2 – Infrastructure delivery status.

Infrastructure project spatial query

The final section of this tab can be considered as an additional add-on to the infrastructure query function where users can undertake a spatial query action. This function references one of the principles in urban infrastructure finance, nexus. This principle aims to determine the level of connection and proximity of an infrastructure item to a property. The closer an infrastructure is to a property, the more likely it will generate a higher usage demand. The idea being discussed is associated with Tobler's first law, which asserts that the closer things are to each other, the more interconnected they tend to be (Sui, 2004).Hence, the purpose of this function is to showcase a spatial relationship function between a range of distance buffers around the boundaries of the infrastructure item and DCP properties using an intersection predicate.

A distance range slider is provided for users to easily assign their buffer distance range to filter out property that intersects with the selected infrastructure item. The resulting table below corresponds with the filtering criteria for every submission entry, which has a range of attribute fields, such as the proportion of the area of the infrastructure item overlapping the surrounding properties. This information can assist developers and the council in determining the justification of proportioning fully or a segment of an infrastructure cost to the developer.

Furthermore, this query function can help in determining the servicing catchment of an infrastructure item and how much area of the surrounding property is within it. Refer to Figure 42 and use case.

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RD_07	$3,000,000.00	$3,000,000.00	$3,000,000.00
RD_10A	$5,600,334.55	$5,600,334.55	$5,600,334.55
RD_10B	$4,590,026.58	$4,590,026.58	$4,590,026.58
IN_06	$1,260,002.92	$1,260,002.92	$1,260,002.92
IN_07	$800,000.00	$800,000.00	$800,000.00
IN_09	$800,000.00	$800,000.00	$800,000.00

Project Nexus to Properties

Select Project ID: RD_11

Distance (m) from Project Extent:

PROJ ID	PROP ID	Precinct	Infra Category	Total A
Roads (5 items)				
RD_11	6		Roads	6.00182
RD_11	5		Roads	
RD_11	R2		Roads	
RD_11	8		Roads	5.00151
RD_11	7		Roads	

Property ID : R2
Selected Total Area (ha) : 9.00
Project ID : RD_05

Property ID: 6
DCP Project ID: RD_11
Parcel SPI: 6/PS00006
Land Use Class: Transport
Area (ha): 6.00

Figure 42: Tab 2 – Spatial query function at 100m buffer from RD-11.

Tab 3: InfraPlanner – Development sequencing, WIK, and cash flow scenario planning

The first two tabs presented above provide an interactive spatial environment for users to explore a spatially enabled DCP and its associated land use and infrastructure attributes.

The InfraPlanner tab discussed in this section relates to the scenario planning or 'What If' aspect of the IP-PSS. It comprises several segments that allow users to manipulate data, obtain insights related to the impact on the cash flow, and acquire a solid financial oversight management of the DCP.

Thus, the knowledge gained from utilising the land budget and infrastructure tabs will be crucial to undertake scenario planning tasks successfully. This is because they will give the user an understanding of the baseline obligation for funding infrastructure delivery. Then, the user will be more equipped to make informed adjustments to specific inputs and parameters to test the impact of those actions.

The development of InfraPlanner brings together the principles of PSS and key issues of urban infrastructure finance, particularly in the implementation aspects discovered in the literature review and gap analysis. Below is a short description of each functional component. Every single component described below integrates to formulate the final income and expense summary and cash flow analysis output – which provide planners with an understanding of the implications of the changes in development activity and delivery types for managing financial contributions.

Development Infrastructure Levy (DIL) and Development Staging

The purpose of this function is to supply information regarding the breakdown of incoming DIL revenue over time. This information is based on the inputs regarding the amount of land to be developed according to development stages and can be manipulated in the provided table. The entered amount of land (i.e., NDA per stage) will then determine the total DIL liability for that particular stage based on the relative financial development charge rate. Besides that, users can also access the flow of development activity and revenue of a specific property through the query function.

Project Delivery

This function examines the infrastructure delivery type (i.e., by a developer or council). The core component is built around information sourcing from the IPL table. Hence, an interactive IPL table is provided for users to adjust the inputs to assign the appropriate delivery type it seeks to undertake for each infrastructure item. It is important to reiterate that the IPL is a highly dynamic table and not fixed and should be constantly reviewed through the ongoing partnership between council and developers in practice.

Moreover, the preparation and implementation of the IPL table have the most significant role and impact on the overall cash flow because it acts as the central management in terms of the prioritisation and sequencing of infrastructure delivery. Users can access the flow of the total cost of WIK assets anticipated to be delivered by developers per property and direct delivery assets by council over time through the query function.

Incoming WIK & DIL Income

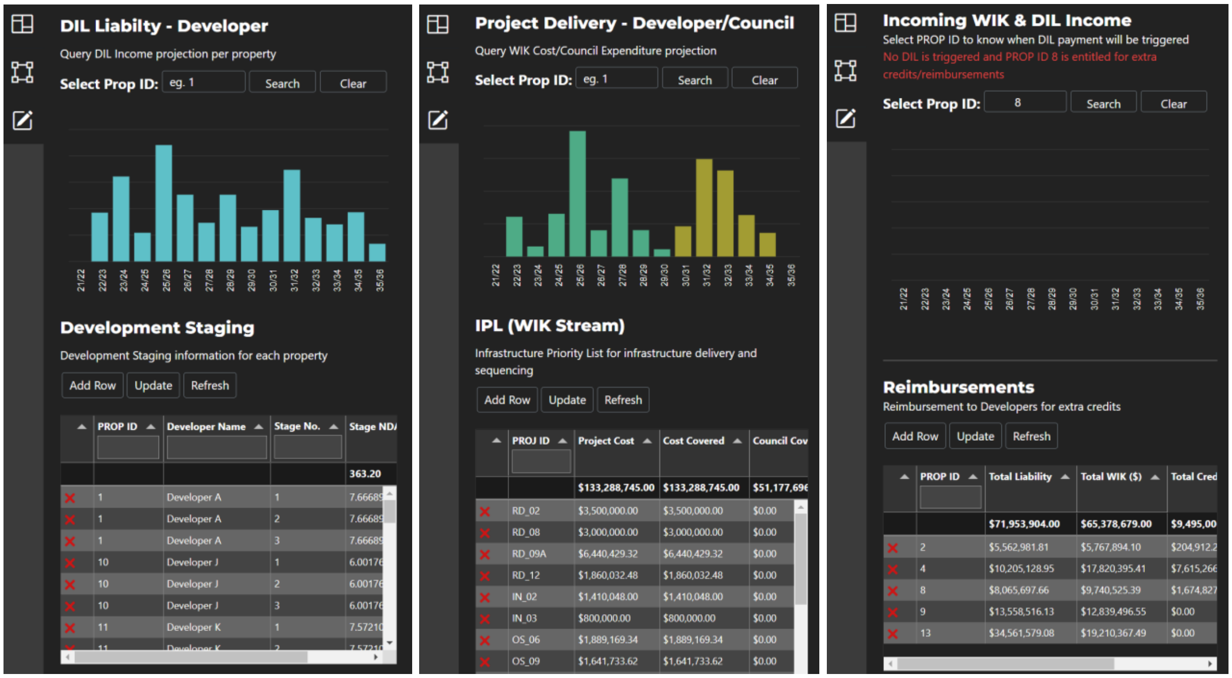
Once the knowledge of how much land is anticipated to be developed and who will be delivering the infrastructure, this function processes inputs from the projected DIL liability to be paid by the developer and the total cost of WIK assets that a developer may be undertaking in order to account for credits. It seeks to calculate and determine when the developer would start triggering DIL payments after they have finished offsetting credits from delivering WIK projects in lieu of their initial cash payments. It also seeks to determine if the developer is over-contributing above their overall infrastructure liability and calculate the total amount entitled for reimbursements by council.

Users can query the flow of DIL payments per property and assess the remaining cash payments they have to pay on top of WIK projects or if they do not trigger any DIL payments and are entitled to reimbursements.

Reimbursements

Based on the inputs from all the above three components, this component automatically calculates the total amount of reimbursements council has to account for in their overall cash flow for landowners/developers who are contributing beyond their financial obligation. The reimbursement table is generated as a result of the above inputs. It is then the user's preference to assign an appropriate financial year when council can make those reimbursements back to the developers.

Figure 43 below presents the components of InfraPlanner as discussed above.



DIL Liabilty - Developer

Query DIL Income projection per property

Select Prop ID: eg. 1

Development Staging

Development Staging information for each property

	PROP ID	Developer Name	Stage No.	Stage ND/
				363.20
✕	1	Developer A	1	7.66689
✕	1	Developer A	2	7.66689
✕	1	Developer A	3	7.66689
✕	10	Developer J	1	6.00176
✕	10	Developer J	2	6.00176
✕	10	Developer J	3	6.00176
✕	11	Developer K	1	7.57210
✕	11	Developer K	2	7.57210

Project Delivery - Developer/Council

Query WIK Cost/Council Expenditure projection

Select Prop ID: eg. 1

IPL (WIK Stream)

Infrastructure Priority List for infrastructure delivery and sequencing

	PROJ ID	Project Cost	Cost Covered	Council Cov
		$133,288,745.00	$133,288,745.00	$51,177,696
✕	RD_02	$3,500,000.00	$3,500,000.00	$0.00
✕	RD_08	$3,000,000.00	$3,000,000.00	$0.00
✕	RD_09A	$6,440,429.32	$6,440,429.32	$0.00
✕	RD_12	$1,860,032.48	$1,860,032.48	$0.00
✕	IN_02	$1,410,048.00	$1,410,048.00	$0.00
✕	IN_03	$800,000.00	$800,000.00	$0.00
✕	OS_06	$1,889,169.34	$1,889,169.34	$0.00
✕	OS_09	$1,641,733.62	$1,641,733.62	$0.00

Incoming WIK & DIL Income

Select PROP ID to know when DIL payment will be triggered

No DIL is triggered and PROP ID 8 is entitled for extra credits/reimbursements

Select Prop ID: 8

Reimbursements

Reimbursement to Developers for extra credits

	PROP ID	Total Liability	Total WIK ($)	Total Cred
		$71,953,904.00	$65,378,679.00	$9,495,00
✕	2	$5,562,981.81	$5,767,894.10	$204,912.2
✕	4	$10,205,128.95	$17,820,395.41	$7,615,266
✕	8	$8,065,697.66	$9,740,525.39	$1,674,827
✕	9	$13,558,516.13	$12,839,496.55	$0.00
✕	13	$34,561,579.08	$19,210,367.49	$0.00

Figure 43: InfraPlanner components.

Income and Expense Summary

Figure 44 below presents the income and summary time series chart that visualises the data inputs and manipulation during the scenario planning process. Since a DCP typically has a lifespan of around fifteen to twenty years, the series chart provides a visual summary regarding the magnitude of financing infrastructure. This allows users to identify peak and off-peak development activities and income quickly.

Each component is represented by its own distinctive category as shown in the symbology key.

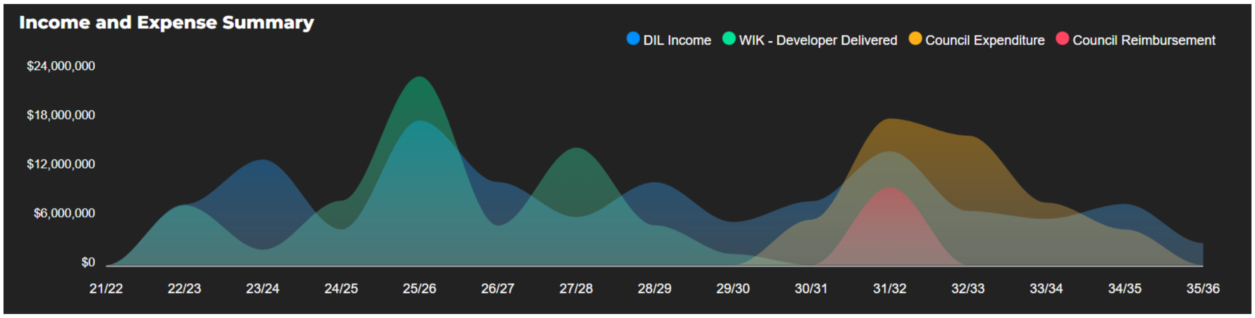


Figure 44: InfraPlanner – income and expense summary.

Cash Flow Analysis

The four categories of financial aspects, DIL income, WIK assets, council expenditure and council reimbursements, can be further translated into cash inflows, outflows and balanced, hence modelling a complete cash flow analysis.

It is important to note that WIK assets are not included in the cash flow analysis as they are incoming assets and not in terms of cash. Therefore, the cash inflows are sourced from DIL income and cash outflows from both council's expenditure and reimbursements. The cash balance is the difference between the inflows and outflows of cash, providing an additional layer of insight into determining the funding gap in managing this DCP.

Figure 45 below presents the cash flow analysis as an integral part of InfraPlanner.

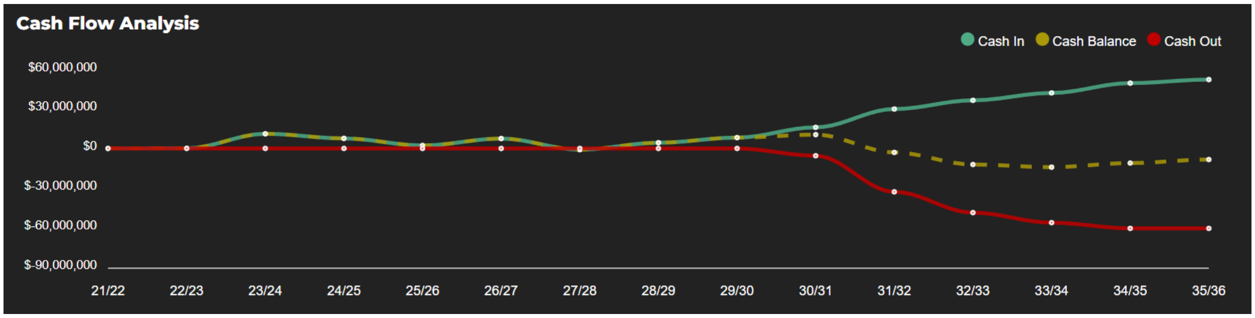
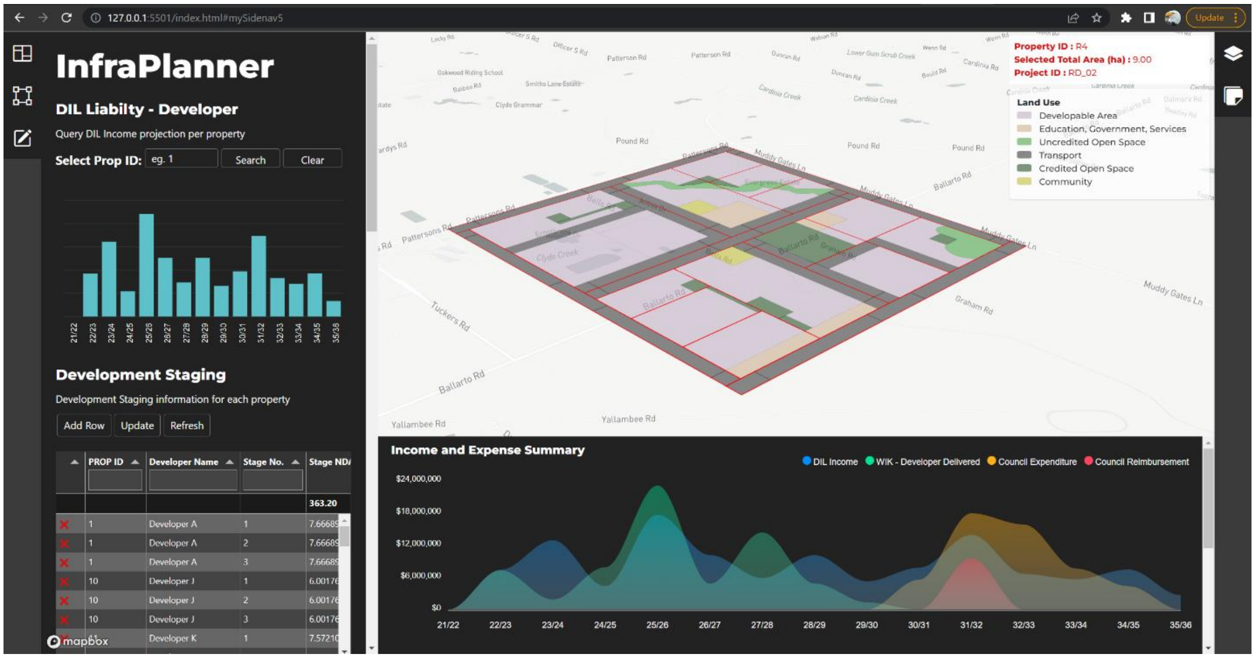


Figure 45: InfraPlanner – cash flow analysis.

The full InfraPlanner tab is shown in Figure 46 below, whereby development scenario testing is undertaken.



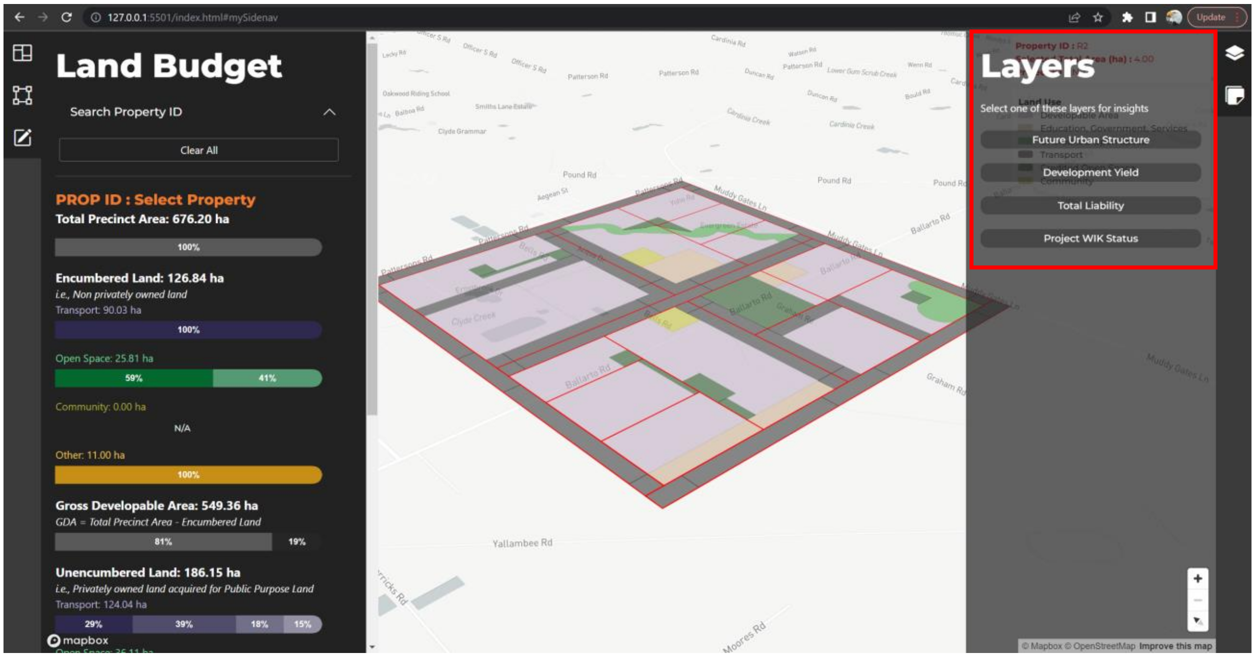
Property ID : R4
Selected Total Area (ha) : 9.00
Project ID : RD_02

	PROP ID	Developer Name	Stage No.	Stage NDA
				363.20
✕	1	Developer A	1	7.66689
✕	1	Developer A	2	7.66689
✕	1	Developer A	3	7.66689
✕	10	Developer J	1	6.00176
✕	10	Developer J	2	6.00176
✕	10	Developer J	3	6.00176
✕	11	Developer K	1	7.57210

Figure 46: InfraPlanner.

Tab 4: Analytical Spatial Layers

Figure 47 shows the tab that allows users to switch to a range of spatial layers that enable data visualisation through maps for better communication and highlight spatial patterns.

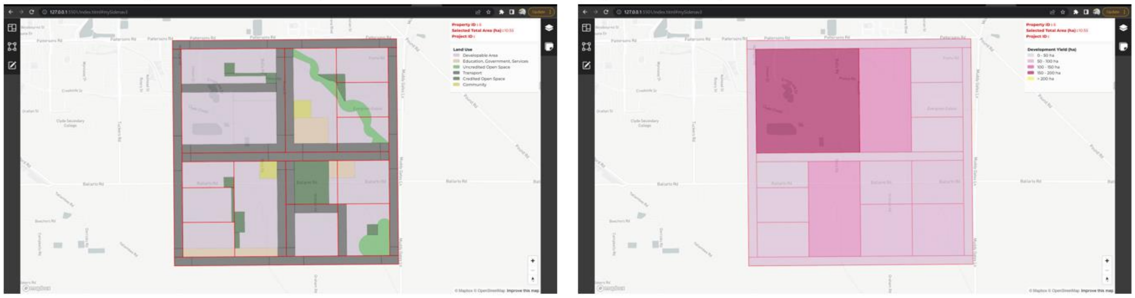


PROP ID : Select Property
Total Precinct Area: 676.20 ha
Encumbered Land: 126.84 ha
i.e., Non privately owned land
Transport: 90.03 ha
Open Space: 25.81 ha
Community: 0.00 ha
Other: 11.00 ha
Gross Developable Area: 549.36 ha
GDA = Total Precinct Area - Encumbered Land
Unencumbered Land: 186.15 ha
i.e., Privately owned land acquired for Public Purpose Land
Transport: 124.04 ha

Figure 47: Analytical Spatial Layers tab.

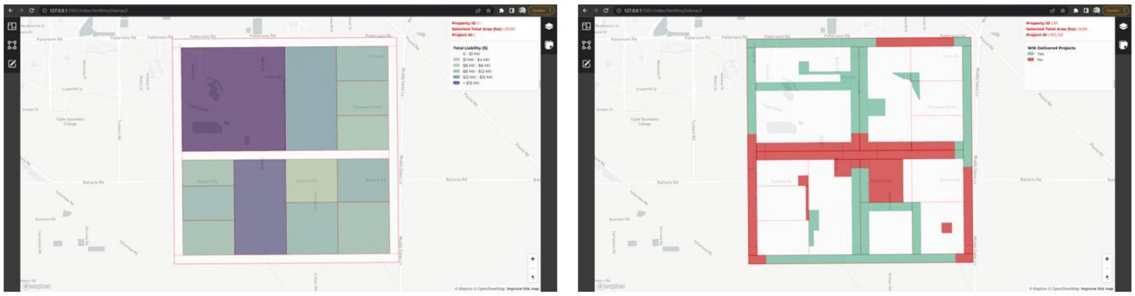
Spatial layers

The list of spatial layers is presented in Figure 48 comprises of their own unique attribute properties and symbology.



Layer 1 : Property + Infrastructure Projects

Layer 2 : Property Size



Layer 3 : Total Liability per Property

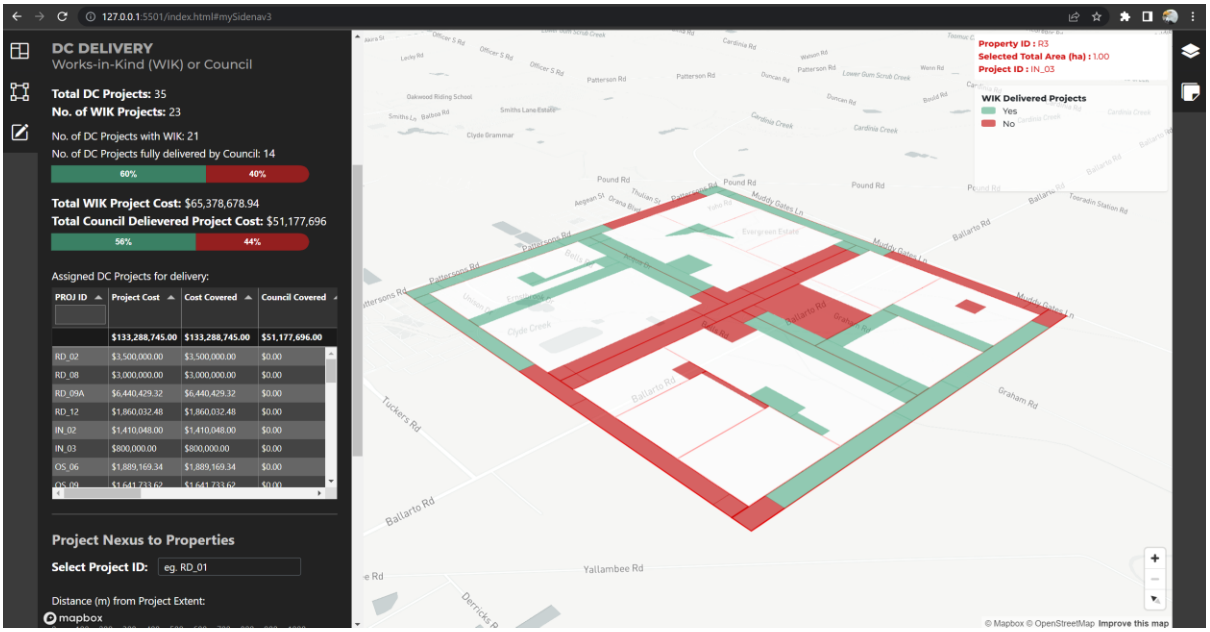
Layer 4 : Infrastructure Delivery Type (Developer or Council)

Figure 48: Analytical spatial layers offered within the IP-PSS.

IP-PSS Analytics

The objective of this section is to demonstrate how the scenario planning and analysis undertaken in the IP-PSS can further assist planners in managing financial contributions within the infrastructure planning system. The analytics presented uses a hypothetical development scenario to illustrate the influence of the varying degree of development activities and the impact on the overall financial flow in delivering infrastructure.

The following scenario proposes that 21 infrastructure items (60%) be delivered as WIK (i.e., by developers) and the remaining (40%) to be delivered directly by council. The estimated value of the incoming asset is ~ $65 Million, and the remaining ~ $51 Million must be collected from developers. The location of infrastructure to be delivered by developers (green) and council (red) is shown in Figure 49 below. Additionally, the assignment of delivery type for each infrastructure item is determined while preparing the IPL table with the necessary inputs.



DC DELIVERY
Works-in-Kind (WIK) or Council

Total DC Projects: 35
No. of WIK Projects: 23

No. of DC Projects with WIK: 21
No. of DC Projects fully delivered by Council: 14

Total WIK Project Cost: $65,378,678.94
Total Council Delievered Project Cost: $51,177,696

Assigned DC Projects for delivery:

PROJ ID	Project Cost	Cost Covered	Council Covered
	$133,288,745.00	$133,288,745.00	$51,177,696.00
RD_02	$3,500,000.00	$3,500,000.00	$0.00
RD_08	$3,000,000.00	$3,000,000.00	$0.00
RD_09A	$6,440,429.32	$6,440,429.32	$0.00
RD_12	$1,860,032.48	$1,860,032.48	$0.00
IN_02	$1,410,048.00	$1,410,048.00	$0.00
IN_03	$800,000.00	$800,000.00	$0.00
OS_06	$1,889,169.34	$1,889,169.34	$0.00
OS_09	$1,641,733.62	$1,641,733.62	$0.00

Project Nexus to Properties

Select Project ID: eg. RD_01

Distance (m) from Project Extent:

Property ID : R3
Selected Total Area (ha) : 1.00
Project ID : IN_03

WIK Delivered Projects
🟩 Yes
🟥 No

Figure 49: WIK status for infrastructure delivery.

The IPL also seeks to assign the timing of infrastructure delivery that matches the interests of both developers and council. The submission of the IPL table in the system generates and updates two time series charts (income and expense, and cash flow) as illustrated in the above sections, informing the expectant flow of incoming and expenditure of revenue.

In this scenario, the quadrants found in the Infrastructure Delivery Matrix as discussed in Chapter 3, can be mapped onto both the time series charts. For instance, two distinctive spectrum of infrastructure delivery approach can be observed whereby a Developer Led Delivery is more prominent during the first ten years and then taken over by council (see Figure 50).

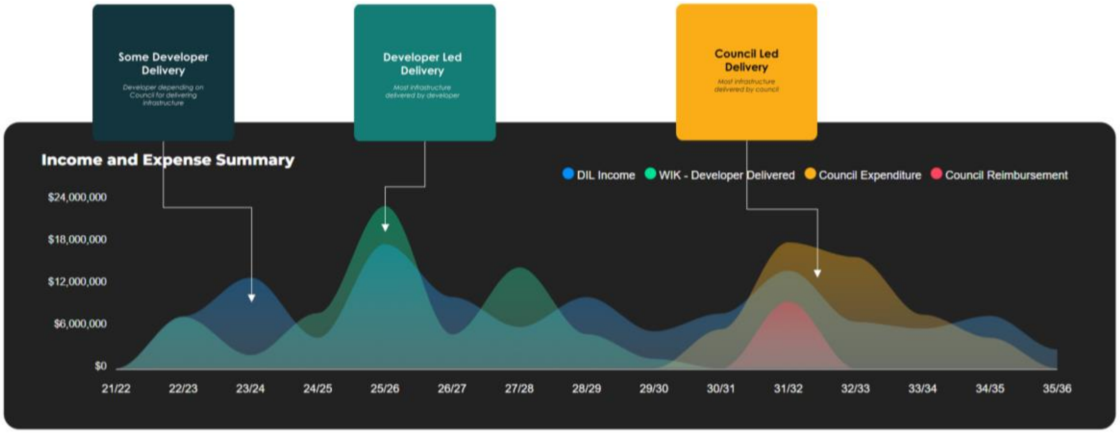


Figure 50: Quadrants in the infrastructure delivery matrix mapped to the income and expense summary chart.

Furthermore, Figure 51 shows that a developer-led delivery method generates a smaller funding gap and accumulates income gradually. On the other hand, when the council takes charge of infrastructure delivery, it heavily relies on developers' payments, which enable them to have the financial capacity to deliver infrastructure. Consequently, the cash balance begins to experience fluctuations, resulting in a funding gap at the end of the DCP lifespan.

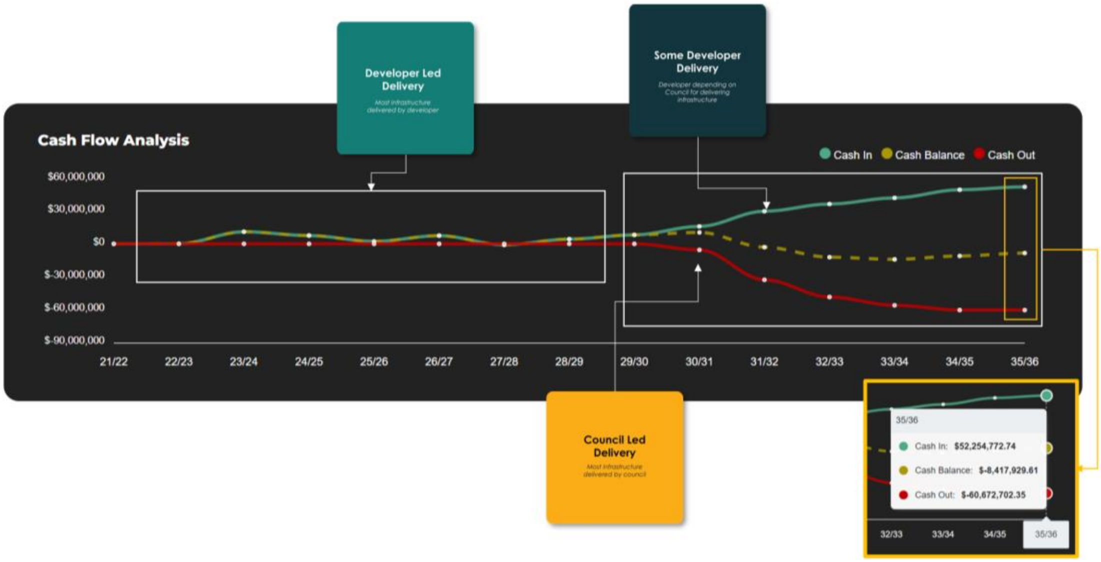


Figure 51: Quadrants in the infrastructure delivery matrix mapped to cash flow analysis chart.

Key Findings & Summary

The results and functionalities presented in the section above illustrates the financial implications of undertaking different delivery types of infrastructure. The two distinctive delivery types impact the overall cash flow differently, along with their associated risks and funding gap. Therefore, based on the inputs and scenarios performed by the user, these are the general trends in the financial flow at two different extremes.

It is important to note that a DCP is not a full recovery model and is imprecise due to the fluctuation of development charge rates because of inflation, and the land value changes as development increases over time (DELWP, 2007). Therefore, a funding gap at the end of the DCP lifespan is inevitable. However, council can reduce the gap by managing it with the knowledge of foresight in their projected cash flow and have more opportunities to negotiate WIK with developers using this tool.

IP-PSS Tool Evaluation

We have learned that PSS is not widely used today for many reasons, mainly because of failing to meet users' needs, lack collaboration with practitioners and poor interfaces. Therefore, an evaluation process is undertaken to assess the "usefulness" of the tool based on Zhang, Geertman, Hooimeijer, and Lin (2019) evaluation method and performance criteria. The evaluation framework is centred on the theoretical concept of human-computer interaction (HCI), which evaluates two aspects of usefulness: utility and usability. Utility refers to the system's ability to deliver the required functionality, while usability assesses the ease with which users can utilise that functionality to complete tasks (Nielsen, 1994).

Utility

To determine the utility of the IP-PSS, semi-structured interviews were carried out with three highly experienced planning practitioners holding director and managing director positions who are experts in infrastructure planning within the Victorian Planning System. The IP-PSS tasks and capabilities were only presented to the interviewees. During the interview, five crucial questions were posed:

1. *How likely is it that you would adopt this tool into your day-to-day role?*
2. *What part of the tool matched your goal?*
3. *What functionality in the tool you think is good?*
4. *What functionality in the tool you think is unnecessary?*
5. *What functions need improvements?*

To summarise the conversation and discourse that took place during the interview sessions, it is evident that the primary goal of the tool has been achieved and satisfied the requirements of planners. In addition to the spatially enabled DCP on a web-based platform, the simple and appealing user interface makes it very likely for planners and even within the broader government organisation to adopt this tool regularly.

Furthermore, the map-corresponding data query function and spatial visualisation of infrastructure projects are highly valued and attractive to the user, making their tasks more efficient and time-saving. Therefore, this tool aspect aligns well with planners' objectives when seeking information about financial obligations during the development evaluation phase for developers.

The discussion around what functionality of the tool is unnecessary is steered differently to what functionalities the user should have access to, depending on the level of engagement they need within the infrastructure planning system. For example, some users only need to view data on the platform, while others require more advanced capabilities, such as viewing and performing scenario testing.

In terms of potential improvements to the tool, the following considerations have been identified: incorporating manual input for calculating the total financial liability for infrastructure, adding the infrastructure category of drainage into the land budget calculations, implementing a spatial query using the "touching" spatial predicate to determine adjacent properties rather than those within a catchment, and including a validation land calculation when filling in development staging information to prevent errors and ensure compliance with the total demand units calculated in the DCP. These suggestions aim to enhance the tool's effectiveness and accuracy for infrastructure planning.

Usability

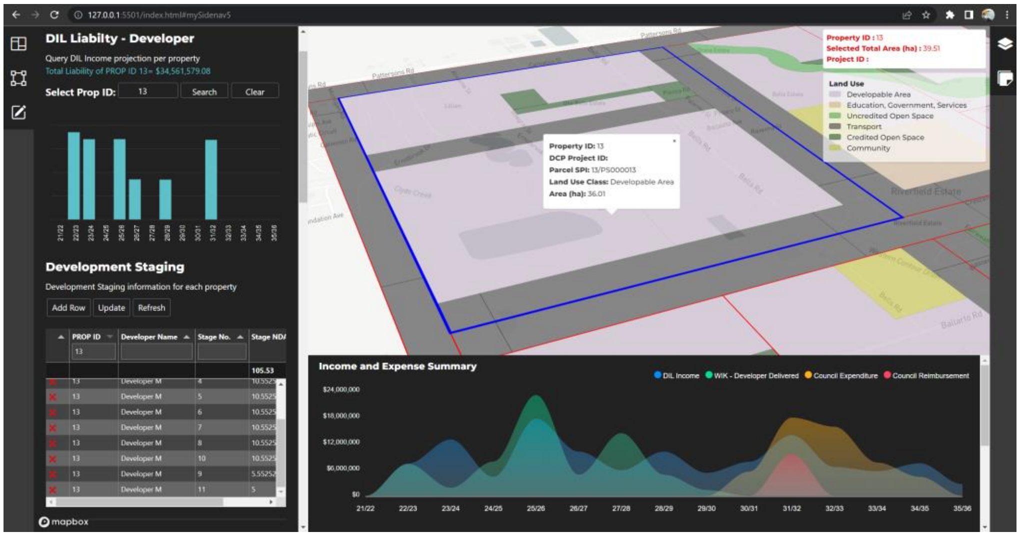
A personal one-to-one session was held with five participants, including managers, professionals, urban designers, and junior staff, to assess the tool's usability. The users were allowed to use and explore the tool and were encouraged to undertake and complete several defined scenario planning tasks of their choice. The choice of three main tasks is provided to the participants to complete, which are:

1. *Add, remove, or update development staging information in terms of the number of stages, development area, and year anticipated for the development.*
2. *Reassign information related to the infrastructure delivery type for the delivery of infrastructure of a property or across the DCP area.*
3. *For properties entitled to some credits due to the costs of delivering infrastructure beyond their initial liability, reallocate the year to which council will reimburse the developer.*

For instance, during the session, the actions of the participants were observed as they performed scenario tasks 1 and 2. Below is an explanation of how the participants used the tool to complete these tasks, including their general approach and ideas.

Task No. 1 – Add, remove, or update development staging information in terms of the number of stages, development area, and year anticipated for the development.

The property of interest is first queried using the drop-down list in the 'DIL Liability' section to view the property boundary on the map and its current development staging and the amount of financial liability triggered for each year (see Figure 52).



DIL Liabilty - Developer

Query DIL Income projection per property

Total Liability of PROP ID 13= $34,561,579.08

Select Prop ID: 13

Development Staging

Development Staging information for each property

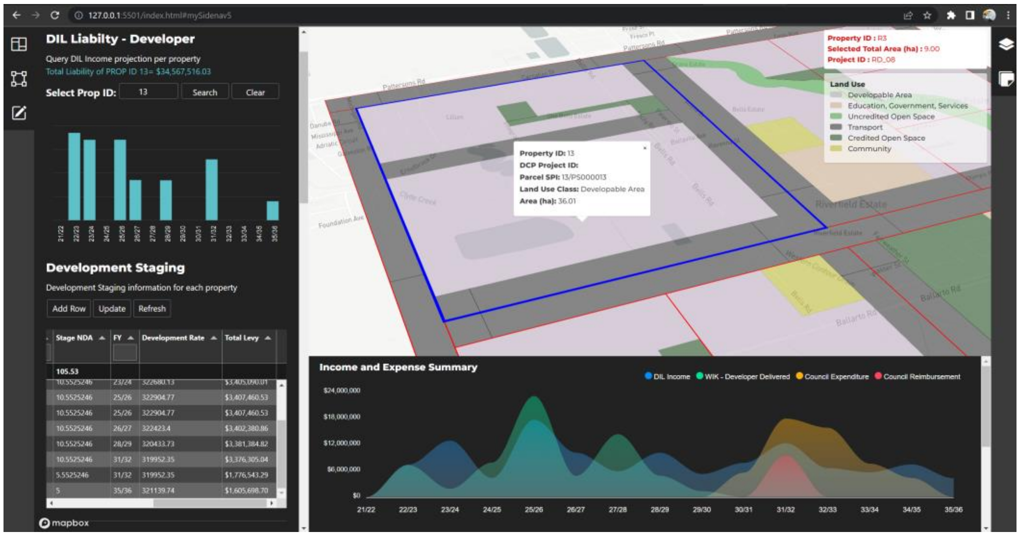
	PROP ID	Developer Name	Stage No.	Stage NDA
	13			
				105.53
✖	13	Developer M	4	10.5525
✖	13	Developer M	5	10.5525
✖	13	Developer M	6	10.5525
✖	13	Developer M	7	10.5525
✖	13	Developer M	8	10.5525
✖	13	Developer M	10	10.5525
✖	13	Developer M	9	5.55252
✖	13	Developer M	11	5

Property ID : 13
Selected Total Area (ha) : 39.51
Project ID :

Property ID: 13
DCP Project ID:
Parcel SPI: 13/PS000013
Land Use Class: Developable Area
Area (ha): 36.01

Figure 52: Current development staging and financial liability information per stage.

The table provided under this tab is used to add, remove, or update the fields of the corresponding stages related to the property of interest. In this case, a new development stage is added and has been assigned to the year it is forecast to be developed. The result of the updated chart and cash flow summary is shown in Figure 53.



DIL Liabilty - Developer

Query DIL Income projection per property

Total Liability of PROP ID 13= $34,567,516.03

Select Prop ID: 13

Development Staging

Development Staging information for each property

Stage NDA	FY	Development Rate	Total Levy
105.53			
10.5525246	23/24	322680.13	$3,405,090.01
10.5525246	25/26	322904.77	$3,407,460.53
10.5525246	25/26	322904.77	$3,407,460.53
10.5525246	26/27	322423.4	$3,402,380.86
10.5525246	28/29	320433.73	$3,381,384.82
10.5525246	31/32	319952.35	$3,376,305.04
5.5525246	31/32	319952.35	$1,776,543.29
5	35/36	321139.74	$1,605,698.70

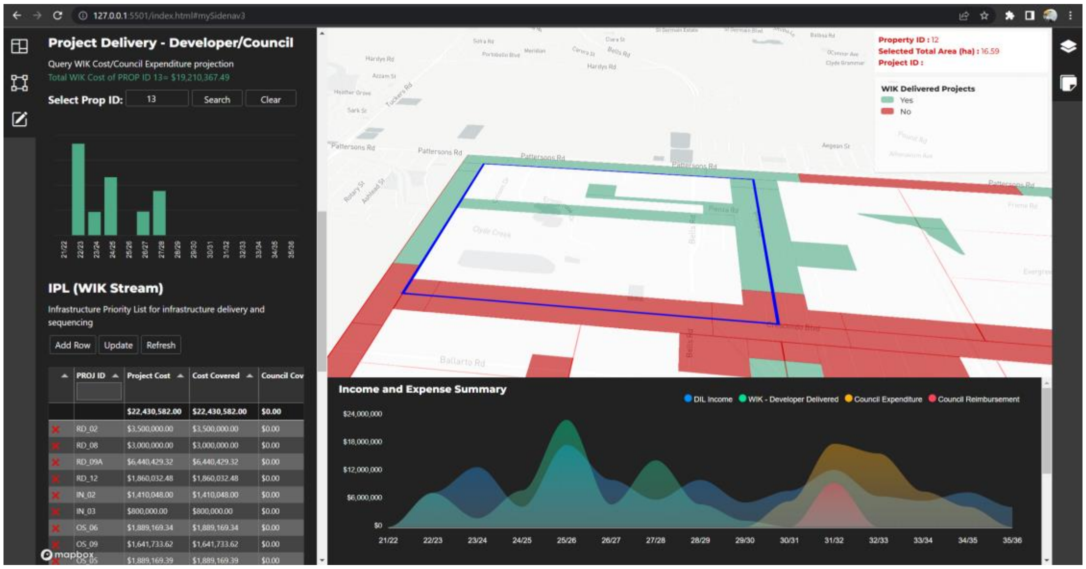
Property ID : R3
Selected Total Area (ha) : 9.00
Project ID : RD_08

Property ID: 13
DCP Project ID:
Parcel SPI: 13/PS000013
Land Use Class: Developable Area
Area (ha): 36.01

Figure 53: Modified development staging and liability information.

Task No. 2a - Reassign information related to the infrastructure delivery type for the delivery of infrastructure of a property.

To examine the necessary infrastructure and associated costs for the property in question, the 'Project Delivery' section is first approached to query the property of interest. The resulting chart will display the required infrastructure costs according to the assigned plan specified in the underlining table (i.e., the IPL) and activate the spatial layer to view the projects to be delivered by the developer or council. See Figure 54.



Project Delivery - Developer/Council

Query WIK Cost/Council Expenditure projection

Total WIK Cost of PROP ID 13= $19,210,367.49

Select Prop ID: 13

IPL (WIK Stream)

Infrastructure Priority List for infrastructure delivery and sequencing

	PROJ ID	Project Cost	Cost Covered	Council Cov
		$22,430,582.00	**$22,430,582.00**	**$0.00**
✕	RD_02	$3,500,000.00	$3,500,000.00	$0.00
✕	RD_08	$3,000,000.00	$3,000,000.00	$0.00
✕	RD_09A	$6,440,429.32	$6,440,429.32	$0.00
✕	RD_12	$1,860,032.48	$1,860,032.48	$0.00
✕	IN_02	$1,410,048.00	$1,410,048.00	$0.00
✕	IN_03	$800,000.00	$800,000.00	$0.00
✕	OS_06	$1,889,169.34	$1,889,169.34	$0.00
✕	OS_09	$1,641,733.62	$1,641,733.62	$0.00
✕	OS_05	$1,889,169.39	$1,889,169.39	$0.00

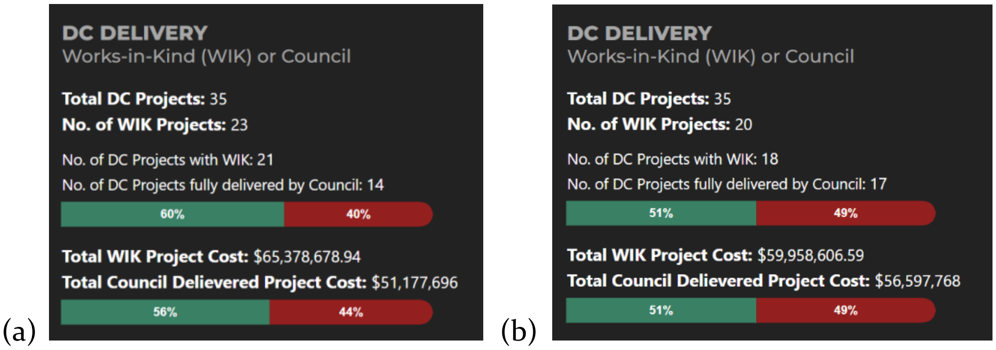
Property ID : 12
Selected Total Area (ha) : 16.59
Project ID :

Income and Expense Summary

Figure 54: Current infrastructure delivery type and WIK information.

The interactive IPL table located below the chart is used to modify the attributes and reassign the agency responsible for delivering the infrastructure. Once the necessary changes have been made, the 'refresh' button is clicked to reload the updated information into the charts. See Figure 56.

The updated breakdown and distribution of infrastructure item and costs can be view by reopening the 'Projects' tab (i.e., second icon along the left side panel) (see Figure 55).


(a)

DC DELIVERY
Works-in-Kind (WIK) or Council

Total DC Projects: 35
No. of WIK Projects: 23

No. of DC Projects with WIK: 21
No. of DC Projects fully delivered by Council: 14

60% 40%

Total WIK Project Cost: $65,378,678.94
Total Council Delievered Project Cost: $51,177,696

56% 44%

(b)

DC DELIVERY
Works-in-Kind (WIK) or Council

Total DC Projects: 35
No. of WIK Projects: 20

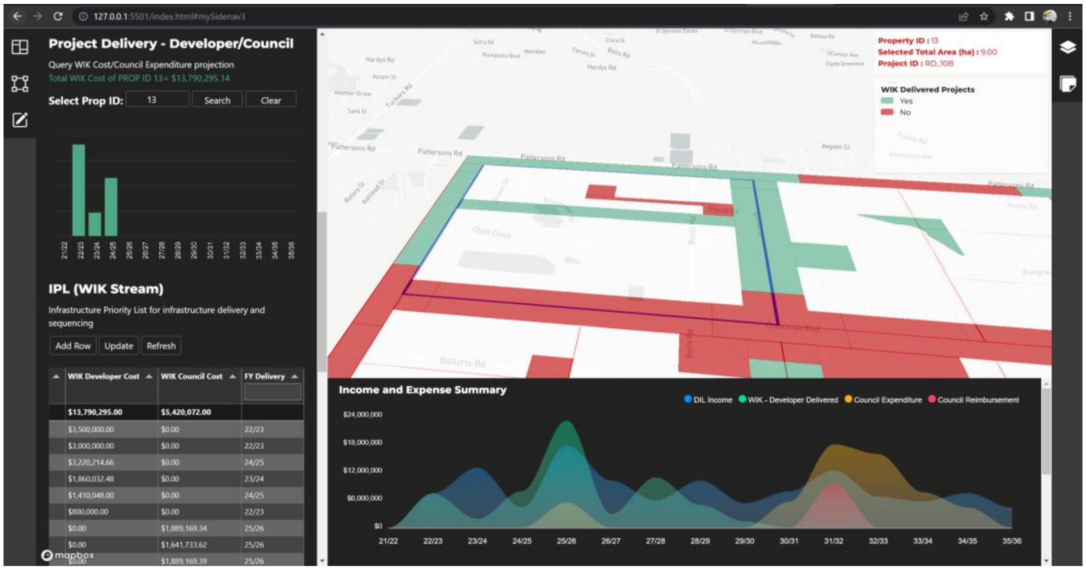
No. of DC Projects with WIK: 18
No. of DC Projects fully delivered by Council: 17

51% 49%

Total WIK Project Cost: $59,958,606.59
Total Council Delievered Project Cost: $56,597,768

51% 49%

Figure 55: Distribution of infrastructure delivery type - (a) initial (b) modified.



Project Delivery - Developer/Council

Query WIK Cost/Council Expenditure projection

Total WIK Cost of PROP ID 13= $13,790,295.14

Select Prop ID: 13 Search Clear

IPL (WIK Stream)

Infrastructure Priority List for infrastructure delivery and sequencing

Add Row Update Refresh

WIK Developer Cost	WIK Council Cost	FY Delivery
$13,790,295.00	$5,420,072.00	
$3,500,000.00	$0.00	22/23
$3,000,000.00	$0.00	22/23
$3,220,214.66	$0.00	24/25
$1,860,032.48	$0.00	23/24
$1,410,048.00	$0.00	24/25
$800,000.00	$0.00	22/23
$0.00	$1,889,169.34	25/26
$0.00	$1,641,733.62	25/26
$0.00	$1,889,169.39	25/26

Property ID : 13
Selected Total Area (ha) : 9.00
Project ID : RD_10B

Figure 56: Modified infrastructure delivery type and WIK information.

Furthermore, the resulting cash flow analysis can be observed to be updated to reflect the changes made to the IPL instantly. See Figure 57 below.

It is noticeable that the cash inflow and outflow status has been altered and adapted for the 2026/2027 financial year, and its effects on the following years.

Figure 57: Initial cash flow vs modified cash flow.

Task No. 2b - Reassign information related to the infrastructure delivery type for the delivery of infrastructure of across the DCP area.

An alternative way to carry out this scenario and task is to reposition all infrastructure projects to be handled by council. Under this proposed method, the council would act as both the collecting and delivery agency and the developer would only be required to make cash contributions during the DCP's lifespan. This approach aims to evaluate the potential effects of the council taking on the responsibility of delivering infrastructure projects.

The IPL table is modified so that every infrastructure entry only pertains to council and does not have any WIK status associated with it. The result of this scenario is shown in Figure 58 which displays a cash flow analysis of the scenario. The analysis indicates a divergence between income and expenses: as the income increases, so do the expenses. This trend allows the council to accumulate adequate financial resources to support and execute the necessary infrastructure projects.

Property ID : 4
Selected Total Area (ha) : 22.83
Project ID :

ncil Covered	Delivering Party	PROP ID	WIK Status
	Developer		
00			
0	Council	13	No
0	Council	13	No
0	Council	13	No
0	Council	13	No
0	Council	13	No
0	Council	13	No
0	Council	9	No
0	Council	9	No
0	Council	9	No
0	Council	9	No

Figure 58: Fully modified infrastructure delivery type to council only and resulting income, expenses, and cash flow analysis.

Usability Evaluation and Results

Once the participants finished their exploration and attempted the proposed tasks, they were provided with a questionnaire to assess their experience. The questionnaire asked about the users' views on 20 performance criteria (see Appendix 1) based on Zhang et al. (2019) seven design criteria in their user-design fit model. The tabulated score is measured for each criterion and ranks them according to their level of importance.

The questionnaire results are summarised in Table 4, which includes the mean (M) score calculated for each performance criterion, arranged according to the ranking of importance to assess the usability of IP-PSS. The M performance criteria ranged from 2.33 to 5.00 (on a 1-5 scale), suggesting that the participants considered the application usable but believed there was room for improvement for each criterion. The detailed response measures can be found in Appendix 1.

Table 4: Results of respondents on the relative importance for each performance criteria.

Performance criteria	Score (Mean)	Ranking
Effectiveness	5.00	1
Satisfaction	4.67	2
Interactivity	4.50	3
Ease of use	4.30	4
Efficiency	4.20	5
Learnability	2.93	6
Error Rate	2.33	7

Note. For ranking 1 – extremely important, 8 – extremely not important

The performance criterion deemed the most significant in evaluating the usability of IP-PSS is “effectiveness”, with closely ranked criteria including "satisfaction", "interactivity", "ease of use", and "efficiency". Although the participants noted that the tool is not error-free and not always straightforward to use at the start, especially concerning functions within the ‘InfraPlanner’ tab, they expressed general satisfaction with the technology for effectively supporting their tasks due to its comprehensiveness and ease of use.

The performance criteria ranked as the least significant in evaluating the usability of the tool were "learnability" and "error rate," suggesting that the participants did not see these factors as crucial. This aligns with the primary goal of the tool, which was to provide an effective method for managing financial contributions rather than being quickly learned or having low error rates.

In conclusion, the web-based IP-PSS tool was viewed as generally usable, with users placing varying importance on different performance criteria. While the intrinsic planning issue did not initially draw some users, they were intrigued by its presentation and the potential of the IP-PSS.

Key Findings & Summary

The key findings of the IP-PSS evaluation process are described in below:

- The utility of the tool was assessed by three experts in the field of urban infrastructure finance with director and managerial roles.
- According to these experts, the tool has provided and achieve some of the key tasks to enable an effective management and tracking of financial contributions for infrastructure delivery.
- Participants completed with the exploration and attempted tasks using the IP-PSS tool were given a questionnaire to evaluate its usability according to a series of performance criteria based on Zhang et al.'s (2019) user-design fit model.
- The top criteria for assessing the tool's usability were "effectiveness," "satisfaction," "interactivity," "ease of use," and "efficiency."
- Some functions within the "InfraPlanner" tab were not always easy to use, but overall, the tool was deemed effective in supporting their tasks.
- The tool was generally viewed as usable, with participants expressing satisfaction with its comprehensiveness and ease of use.

Chapter 6: Conclusion & Next Steps

Overview of Results

The key results and findings of this research are as follows:

- The utilisation of PSS in the planning industry is limited due to factors such as the gap between researchers and practitioners, a lack of awareness and successful applications, and unsatisfactory quality of PSS.
- The current approach to financing urban infrastructure is fragmented and lacks a cohesive system for monitoring and managing financial contributions from developers. This was demonstrated through the complexities of the planning process, high resource requirements, managing multiple stakeholders with differing interests and financial capacities, and the lack of strategic planning tools available to practitioners for informed decision-making.
- PSS offers a framework that leverages geospatial technologies to represent, analyse, visualise, and predict implications or solutions based on certain decisions to specific planning challenges.
- The principles of PSS assisted in the design and development of the IP-PSS to support planners in managing financial contributions and predicting the impact on council's cash flow based on various infrastructure delivery options and development sequences.
- The IP-PSS has established a foundational framework for infrastructure planning to be implemented in an interactive spatial environment. This comprises the spatial integration with static information.
- An automated and efficient database processing for reading and integrating spatial and non-spatial datasets.
- The IP-PSS offers user-friendly functionalities that end-users can easily navigate without technical expertise.
- The IP-PSS is web-based, offering improved communication, accessibility, and efficiency. This web-based platform has the potential for future integration with other systems.
- Industry specialists believe the IP-PSS is headed in the right direction and has a reasonable chance of being adopted by planners due to its spatial integration and straightforward functionality.

- Planning practitioners who tested the tool were generally pleased with its functionality and the support it provides to their role.
- The methodology adopted in this study was successful in two ways. Firstly, it created a spatial decision support system to enhance urban infrastructure financing. Secondly, it demonstrated that a successful PSS could be achieved through strong industry collaboration, a clear understanding of the planning problem, and a system design that meets the needs of planners, showcasing the PSS's benefits and relevance to the daily tasks of planners.

Limitations and recommendations for further research

The research has successfully demonstrated the implementation of a PSS to address a planning problem specific to its context, and it has mostly met the needs of planners. However, this research has four limitations: technical, data, function, and user limitations. These limitations are described in detail below, along with recommendations for future research.

Technical Limitations: The current IP-PSS retrieves most of its data from a backend database system, making it challenging for users to edit and save new data from the front-end user interface. Future research should consider re-evaluating the system architecture to allow for a more integrated two-way transaction for data acquisition and updating.

Data Limitations: The current IP-PSS can only handle one DCP layer in a single deployment, limiting the amount of data it can process without compromising efficiency in system architecture and data structures. Future research should investigate the system's capacity and speed of data processing for varying scales of DCPs and integration with different amounts of non-spatial attributes.

Function Limitations: The scenario testing module of the IP-PSS lack spatial integration and is still highly manual and inefficient, leading to user errors in inputs and calculations. The system should investigate validation functions to ensure inputs reflect the development profile of specific properties and DCPs.

User Limitations: The IP-PSS has only been tested by a small group of specialists and practitioners. It is insufficient to conclude with a high confidence level in determining its success rate. Future research should include more participants from various sectors during the testing phase to gather a more comprehensive understanding of the system's success.

In addition, a 3D spatial aspect of the IP-PSS should be further explored as an extension of this research. This includes the investigation of using 3D spatial datasets and visualisation that accounts for vertical or underground infrastructures and multi-level development scenarios.

Concluding Remarks

This research aimed to explore an innovative solution for managing financial contributions through spatial technologies and concepts to increase access and transparency and facilitate better decision-making.

This was demonstrated by applying the principles and concept of PSS to develop a tailored PSS tool to undertake specific planning-associated tasks in the space of urban infrastructure finance and planning, such as determining infrastructure liability per property, identification of infrastructure delivery type, testing different development scenarios and infrastructure delivery sequencing.

Implementing a spatial system to integrate with non-spatial components and attributes through a multi-tiered system architecture brings great value to the infrastructure planning system in Victoria. It enables the IP-PSS to be web-based, making it even more accessible and interoperable with other systems for further integration.

Although the IP-PSS still has room for improvement, the practitioners who trialled the tool expressed positive opinions about its functionality and recognised its potential for growth.

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Appendix 1

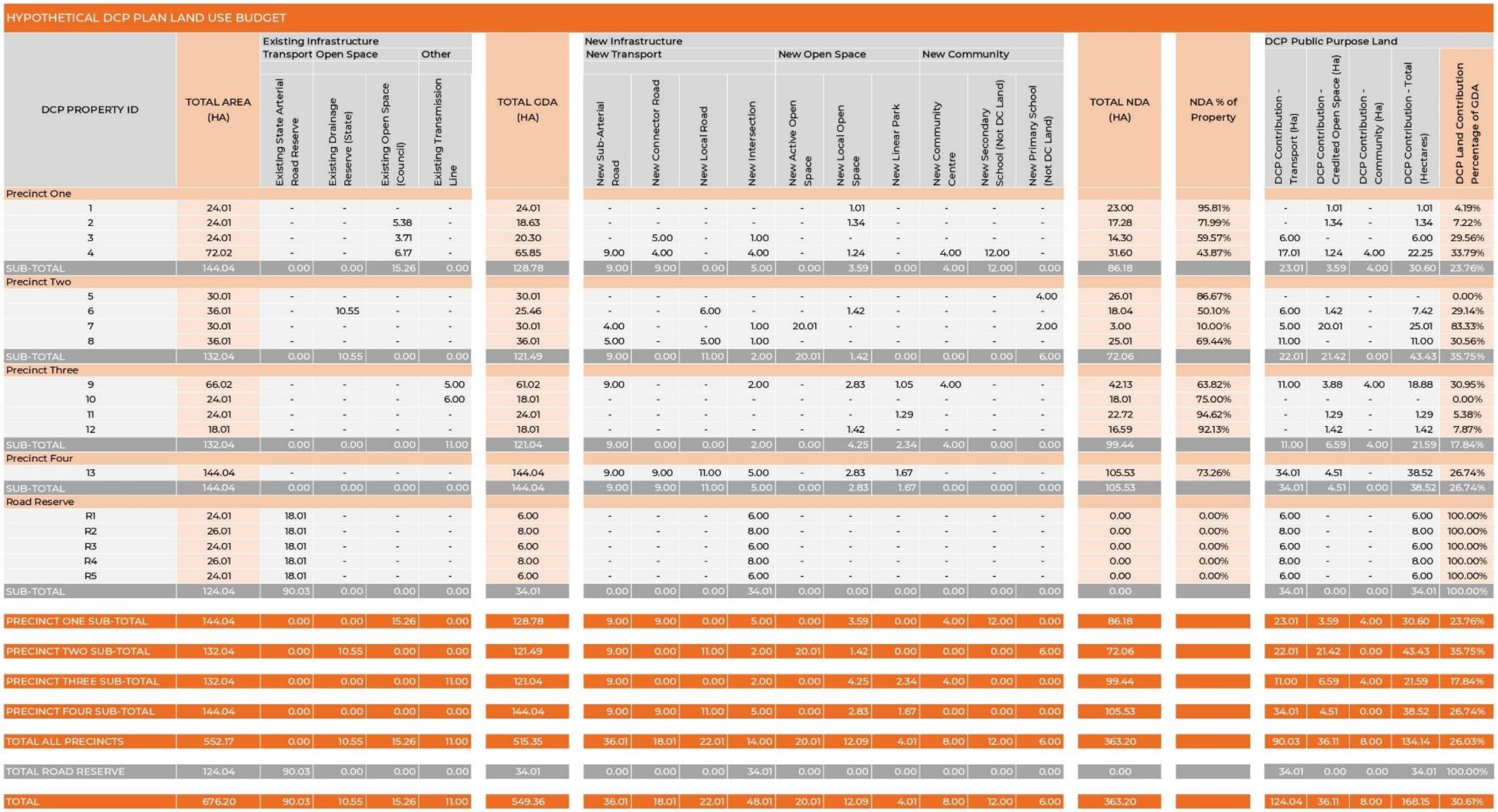
Survey results on the usability of the web-based IP-PSS application (N = 5).

Performance criteria	Mean (M)
Error Rate	
Did I make an error in adding a new entry to the number of development stages for a property in the InfraPlanner tab?*	2.20
Did I make an error when modifying the IPL table in the InfraPlanner tab?	2.40
Did I make an error with the manipulation of the timing of reimbursement in the InfraPlanner tab?*	2.40
Learnability	
I find the functions of this application easy to understand.	4.80
I require assistance when using this application*	1.60
I have to spend time exploring to become familiar with the application*	2.40
Ease of use	
I find it simple to retrieve land budget information.	5.00
I find it simple to retrieve infrastructure project information.	5.00
I find the spatial component of the tool helpful.	5.00
I find the graphs and data presented easy to understand.	4.20
I find it easy to manipulate data in the InfraPlanner tab	4.00
I find it easy to undertake different scenarios.	2.60
Interactivity	
I was satisfied with the function for interacting with the map.	4.60
I was satisfied with the overall interactive features of the application.	4.40
Effectiveness	
This application helped me to achieve my goals better than referring to a DCP document	5.00
Efficiency	
Compared to traditional spatial and calculation methods, this application enabled me to complete my tasks in less time.	4.40
Compared to traditional spatial and calculation methods, this application enabled me to complete my tasks with less effort.	4.00
Satisfaction	
I was satisfied with the overall user interface and experience of this application.	4.60
I was satisfied with the amount of time it took to achieve my goal in this application.	5.00
The application was friendly to use.	4.40

Note. 1 – strongly disagree, 2 – disagree, 3 – neutral, 4 – agree, 5 – strongly agree, * scores have been reversed in this table.

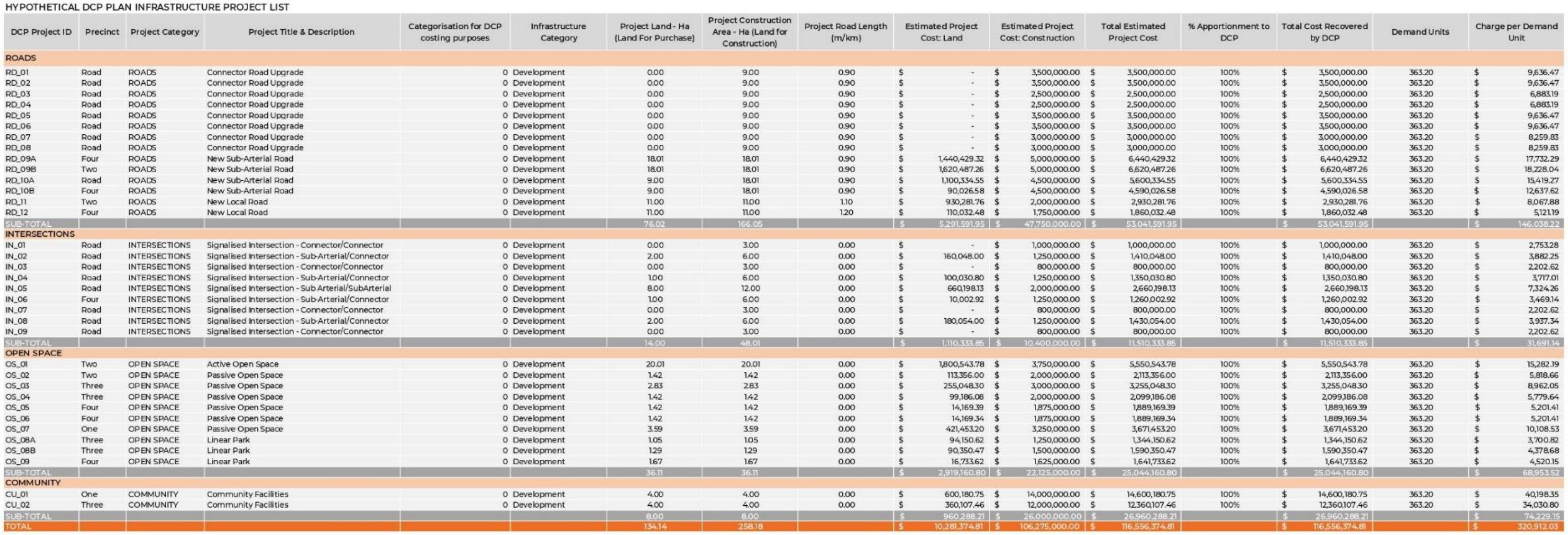
Appendix 2

Land Use Budget of the hypothetical DCP scenario



HYPOTHETICAL DCP PLAN LAND USE BUDGET																							
		Existing Infrastructure					New Infrastructure												DCP Public Purpose Land				
		Transport	Open Space		Other		New Transport				New Open Space			New Community									
DCP PROPERTY ID	TOTAL AREA (HA)	Existing State Arterial Road Reserve	Existing Drainage Reserve (State)	Existing Open Space (Council)	Existing Transmission Line	TOTAL GDA (HA)	New Sub-Arterial Road	New Connector Road	New Local Road	New Intersection	New Active Open Space	New Local Open Space	New Linear Park	New Community Centre	New Secondary School (Not DC Land)	New Primary School (Not DC Land)	TOTAL NDA (HA)	NDA % of Property	DCP Contribution - Transport (Ha)	DCP Contribution - Credited Open Space (Ha)	DCP Contribution - Community (Ha)	DCP Contribution - Total (Hectares)	DCP Land Contribution Percentage of GDA
Precinct One																							
1	24.01	-	-	-	-	24.01	-	-	-	-	-	1.01	-	-	-	-	23.00	95.81%	-	1.01	-	1.01	4.19%
2	24.01	-	-	5.38	-	18.63	-	-	-	-	-	1.34	-	-	-	-	17.28	71.99%	-	1.34	-	1.34	7.22%
3	24.01	-	-	3.71	-	20.30	-	5.00	-	1.00	-	-	-	-	-	-	14.30	59.57%	6.00	-	-	6.00	29.56%
4	72.02	-	-	6.17	-	65.85	9.00	4.00	-	4.00	-	1.24	-	4.00	12.00	-	31.60	43.87%	17.01	1.24	4.00	22.25	33.79%
SUB-TOTAL	144.04	0.00	0.00	15.26	0.00	128.78	9.00	9.00	0.00	5.00	0.00	3.59	0.00	4.00	12.00	0.00	86.18		23.01	3.59	4.00	30.60	23.76%
Precinct Two																							
5	30.01	-	-	-	-	30.01	-	-	-	-	-	-	-	-	-	4.00	26.01	86.67%	-	-	-	-	0.00%
6	36.01	-	10.55	-	-	25.46	-	-	6.00	-	-	1.42	-	-	-	-	18.04	50.10%	6.00	1.42	-	7.42	29.14%
7	30.01	-	-	-	-	30.01	4.00	-	-	1.00	20.01	-	-	-	-	2.00	3.00	10.00%	5.00	20.01	-	25.01	83.33%
8	36.01	-	-	-	-	36.01	5.00	-	5.00	1.00	-	-	-	-	-	-	25.01	69.44%	11.00	-	-	11.00	30.56%
SUB-TOTAL	132.04	0.00	10.55	0.00	0.00	121.49	9.00	0.00	11.00	2.00	20.01	1.42	0.00	0.00	0.00	6.00	72.06		22.01	21.42	0.00	43.43	35.75%
Precinct Three																							
9	66.02	-	-	-	5.00	61.02	9.00	-	-	2.00	-	2.83	1.05	4.00	-	-	42.13	63.82%	11.00	3.88	4.00	18.88	30.95%
10	24.01	-	-	-	6.00	18.01	-	-	-	-	-	-	-	-	-	-	18.01	75.00%	-	-	-	-	0.00%
11	24.01	-	-	-	-	24.01	-	-	-	-	-	-	1.29	-	-	-	22.72	94.62%	-	1.29	-	1.29	5.38%
12	18.01	-	-	-	-	18.01	-	-	-	-	-	1.42	-	-	-	-	16.59	92.13%	-	1.42	-	1.42	7.87%
SUB-TOTAL	132.04	0.00	0.00	0.00	11.00	121.04	9.00	0.00	0.00	2.00	0.00	4.25	2.34	4.00	0.00	0.00	99.44		11.00	6.59	4.00	21.59	17.84%
Precinct Four																							
13	144.04	-	-	-	-	144.04	9.00	9.00	11.00	5.00	-	2.83	1.67	-	-	-	105.53	73.26%	34.01	4.51	-	38.52	26.74%
SUB-TOTAL	144.04	0.00	0.00	0.00	0.00	144.04	9.00	9.00	11.00	5.00	0.00	2.83	1.67	0.00	0.00	0.00	105.53		34.01	4.51	0.00	38.52	26.74%
Road Reserve																							
R1	24.01	18.01	-	-	-	6.00	-	-	-	6.00	-	-	-	-	-	-	0.00	0.00%	6.00	-	-	6.00	100.00%
R2	26.01	18.01	-	-	-	8.00	-	-	-	8.00	-	-	-	-	-	-	0.00	0.00%	8.00	-	-	8.00	100.00%
R3	24.01	18.01	-	-	-	6.00	-	-	-	6.00	-	-	-	-	-	-	0.00	0.00%	6.00	-	-	6.00	100.00%
R4	26.01	18.01	-	-	-	8.00	-	-	-	8.00	-	-	-	-	-	-	0.00	0.00%	8.00	-	-	8.00	100.00%
R5	24.01	18.01	-	-	-	6.00	-	-	-	6.00	-	-	-	-	-	-	0.00	0.00%	6.00	-	-	6.00	100.00%
SUB-TOTAL	124.04	90.03	0.00	0.00	0.00	34.01	0.00	0.00	0.00	34.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00		34.01	0.00	0.00	34.01	100.00%
PRECINCT ONE SUB-TOTAL	144.04	0.00	0.00	15.26	0.00	128.78	9.00	9.00	0.00	5.00	0.00	3.59	0.00	4.00	12.00	0.00	86.18		23.01	3.59	4.00	30.60	23.76%
PRECINCT TWO SUB-TOTAL	132.04	0.00	10.55	0.00	0.00	121.49	9.00	0.00	11.00	2.00	20.01	1.42	0.00	0.00	0.00	6.00	72.06		22.01	21.42	0.00	43.43	35.75%
PRECINCT THREE SUB-TOTAL	132.04	0.00	0.00	0.00	11.00	121.04	9.00	0.00	0.00	2.00	0.00	4.25	2.34	4.00	0.00	0.00	99.44		11.00	6.59	4.00	21.59	17.84%
PRECINCT FOUR SUB-TOTAL	144.04	0.00	0.00	0.00	0.00	144.04	9.00	9.00	11.00	5.00	0.00	2.83	1.67	0.00	0.00	0.00	105.53		34.01	4.51	0.00	38.52	26.74%
TOTAL ALL PRECINCTS	552.17	0.00	10.55	15.26	11.00	515.35	36.01	18.01	22.01	14.00	20.01	12.09	4.01	8.00	12.00	6.00	363.20		90.03	36.11	8.00	134.14	26.03%
TOTAL ROAD RESERVE	124.04	90.03	0.00	0.00	0.00	34.01	0.00	0.00	0.00	34.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00		34.01	0.00	0.00	34.01	100.00%
TOTAL	676.20	90.03	10.55	15.26	11.00	549.36	36.01	18.01	22.01	48.01	20.01	12.09	4.01	8.00	12.00	6.00	363.20		124.04	36.11	8.00	168.15	30.61%

Infrastructure Project List of the hypothetical DCP scenario



HYPOTHETICAL DCP PLAN INFRASTRUCTURE PROJECT LIST

DCP Project ID	Precinct	Project Category	Project Title & Description	Categorisation for DCP costing purposes	Infrastructure Category	Project Land - Ha (Land For Purchase)	Project Construction Area - Ha (Land for Construction)	Project Road Length (m/km)	Estimated Project Cost: Land	Estimated Project Cost: Construction	Total Estimated Project Cost	% Apportionment to DCP	Total Cost Recovered by DCP	Demand Units	Charge per Demand Unit
ROADS															
RD_01	Road	ROADS	Connector Road Upgrade	0	Development	0.00	9.00	0.90	$ -	$ 3,500,000.00	$ 3,500,000.00	100%	$ 3,500,000.00	363.20	$ 9,636.47
RD_02	Road	ROADS	Connector Road Upgrade	0	Development	0.00	9.00	0.90	$ -	$ 3,500,000.00	$ 3,500,000.00	100%	$ 3,500,000.00	363.20	$ 9,636.47
RD_03	Road	ROADS	Connector Road Upgrade	0	Development	0.00	9.00	0.90	$ -	$ 2,500,000.00	$ 2,500,000.00	100%	$ 2,500,000.00	363.20	$ 6,883.19
RD_04	Road	ROADS	Connector Road Upgrade	0	Development	0.00	9.00	0.90	$ -	$ 2,500,000.00	$ 2,500,000.00	100%	$ 2,500,000.00	363.20	$ 6,883.19
RD_05	Road	ROADS	Connector Road Upgrade	0	Development	0.00	9.00	0.90	$ -	$ 3,500,000.00	$ 3,500,000.00	100%	$ 3,500,000.00	363.20	$ 9,636.47
RD_06	Road	ROADS	Connector Road Upgrade	0	Development	0.00	9.00	0.90	$ -	$ 3,500,000.00	$ 3,500,000.00	100%	$ 3,500,000.00	363.20	$ 9,636.47
RD_07	Road	ROADS	Connector Road Upgrade	0	Development	0.00	9.00	0.90	$ -	$ 3,000,000.00	$ 3,000,000.00	100%	$ 3,000,000.00	363.20	$ 8,259.83
RD_08	Road	ROADS	Connector Road Upgrade	0	Development	0.00	9.00	0.90	$ -	$ 3,000,000.00	$ 3,000,000.00	100%	$ 3,000,000.00	363.20	$ 8,259.83
RD_09A	Four	ROADS	New Sub-Arterial Road	0	Development	18.01	18.01	0.90	$ 1,440,429.32	$ 5,000,000.00	$ 6,440,429.32	100%	$ 6,440,429.32	363.20	$ 17,732.29
RD_09B	Two	ROADS	New Sub-Arterial Road	0	Development	18.01	18.01	0.90	$ 1,620,487.26	$ 5,000,000.00	$ 6,620,487.26	100%	$ 6,620,487.26	363.20	$ 18,228.04
RD_10A	Road	ROADS	New Sub-Arterial Road	0	Development	9.00	18.01	0.90	$ 1,100,334.55	$ 4,500,000.00	$ 5,600,334.55	100%	$ 5,600,334.55	363.20	$ 15,419.27
RD_10B	Four	ROADS	New Sub-Arterial Road	0	Development	9.00	18.01	0.90	$ 90,026.58	$ 4,500,000.00	$ 4,590,026.58	100%	$ 4,590,026.58	363.20	$ 12,637.62
RD_11	Two	ROADS	New Local Road	0	Development	11.00	11.00	1.10	$ 930,281.76	$ 2,000,000.00	$ 2,930,281.76	100%	$ 2,930,281.76	363.20	$ 8,067.88
RD_12	Four	ROADS	New Local Road	0	Development	11.00	11.00	1.20	$ 110,032.48	$ 1,750,000.00	$ 1,860,032.48	100%	$ 1,860,032.48	363.20	$ 5,121.19
SUB-TOTAL						76.02	166.05		$ 5,291,591.95	$ 47,750,000.00	$ 53,041,591.95		$ 53,041,591.95		$ 146,038.22
INTERSECTIONS															
IN_01	Road	INTERSECTIONS	Signalised Intersection - Connector/Connector	0	Development	0.00	3.00	0.00	$ -	$ 1,000,000.00	$ 1,000,000.00	100%	$ 1,000,000.00	363.20	$ 2,753.28
IN_02	Road	INTERSECTIONS	Signalised Intersection - Sub-Arterial/Connector	0	Development	2.00	6.00	0.00	$ 160,048.00	$ 1,250,000.00	$ 1,410,048.00	100%	$ 1,410,048.00	363.20	$ 3,882.25
IN_03	Road	INTERSECTIONS	Signalised Intersection - Connector/Connector	0	Development	0.00	3.00	0.00	$ -	$ 800,000.00	$ 800,000.00	100%	$ 800,000.00	363.20	$ 2,202.62
IN_04	Road	INTERSECTIONS	Signalised Intersection - Sub-Arterial/Connector	0	Development	1.00	6.00	0.00	$ 100,030.80	$ 1,250,000.00	$ 1,350,030.80	100%	$ 1,350,030.80	363.20	$ 3,717.01
IN_05	Road	INTERSECTIONS	Signalised Intersection - Sub Arterial/SubArterial	0	Development	8.00	12.00	0.00	$ 660,198.13	$ 2,000,000.00	$ 2,660,198.13	100%	$ 2,660,198.13	363.20	$ 7,324.26
IN_06	Four	INTERSECTIONS	Signalised Intersection - Sub-Arterial/Connector	0	Development	1.00	6.00	0.00	$ 10,002.92	$ 1,250,000.00	$ 1,260,002.92	100%	$ 1,260,002.92	363.20	$ 3,469.14
IN_07	Road	INTERSECTIONS	Signalised Intersection - Connector/Connector	0	Development	0.00	3.00	0.00	$ -	$ 800,000.00	$ 800,000.00	100%	$ 800,000.00	363.20	$ 2,202.62
IN_08	Road	INTERSECTIONS	Signalised Intersection - Sub-Arterial/Connector	0	Development	2.00	6.00	0.00	$ 180,054.00	$ 1,250,000.00	$ 1,430,054.00	100%	$ 1,430,054.00	363.20	$ 3,937.34
IN_09	Road	INTERSECTIONS	Signalised Intersection - Connector/Connector	0	Development	0.00	3.00	0.00	$ -	$ 800,000.00	$ 800,000.00	100%	$ 800,000.00	363.20	$ 2,202.62
SUB-TOTAL						14.00	48.01		$ 1,110,333.85	$ 10,400,000.00	$ 11,510,333.85		$ 11,510,333.85		$ 31,691.14
OPEN SPACE															
OS_01	Two	OPEN SPACE	Active Open Space	0	Development	20.01	20.01	0.00	$ 1,800,543.78	$ 3,750,000.00	$ 5,550,543.78	100%	$ 5,550,543.78	363.20	$ 15,282.19
OS_02	Two	OPEN SPACE	Passive Open Space	0	Development	1.42	1.42	0.00	$ 113,356.00	$ 2,000,000.00	$ 2,113,356.00	100%	$ 2,113,356.00	363.20	$ 5,818.66
OS_03	Three	OPEN SPACE	Passive Open Space	0	Development	2.83	2.83	0.00	$ 255,048.30	$ 3,000,000.00	$ 3,255,048.30	100%	$ 3,255,048.30	363.20	$ 8,962.05
OS_04	Three	OPEN SPACE	Passive Open Space	0	Development	1.42	1.42	0.00	$ 99,186.08	$ 2,000,000.00	$ 2,099,186.08	100%	$ 2,099,186.08	363.20	$ 5,779.64
OS_05	Four	OPEN SPACE	Passive Open Space	0	Development	1.42	1.42	0.00	$ 14,169.39	$ 1,875,000.00	$ 1,889,169.39	100%	$ 1,889,169.39	363.20	$ 5,201.41
OS_06	Four	OPEN SPACE	Passive Open Space	0	Development	1.42	1.42	0.00	$ 14,169.34	$ 1,875,000.00	$ 1,889,169.34	100%	$ 1,889,169.34	363.20	$ 5,201.41
OS_07	One	OPEN SPACE	Passive Open Space	0	Development	3.59	3.59	0.00	$ 421,453.20	$ 3,250,000.00	$ 3,671,453.20	100%	$ 3,671,453.20	363.20	$ 10,108.53
OS_08A	Three	OPEN SPACE	Linear Park	0	Development	1.05	1.05	0.00	$ 94,150.62	$ 1,250,000.00	$ 1,344,150.62	100%	$ 1,344,150.62	363.20	$ 3,700.82
OS_08B	Three	OPEN SPACE	Linear Park	0	Development	1.29	1.29	0.00	$ 90,350.47	$ 1,500,000.00	$ 1,590,350.47	100%	$ 1,590,350.47	363.20	$ 4,378.68
OS_09	Four	OPEN SPACE	Linear Park	0	Development	1.67	1.67	0.00	$ 16,733.62	$ 1,625,000.00	$ 1,641,733.62	100%	$ 1,641,733.62	363.20	$ 4,520.15
SUB-TOTAL						36.11	36.11		$ 2,919,160.80	$ 22,125,000.00	$ 25,044,160.80		$ 25,044,160.80		$ 68,953.52
COMMUNITY															
CU_01	One	COMMUNITY	Community Facilities	0	Development	4.00	4.00	0.00	$ 600,180.75	$ 14,000,000.00	$ 14,600,180.75	100%	$ 14,600,180.75	363.20	$ 40,198.35
CU_02	Three	COMMUNITY	Community Facilities	0	Development	4.00	4.00	0.00	$ 360,107.46	$ 12,000,000.00	$ 12,360,107.46	100%	$ 12,360,107.46	363.20	$ 34,030.80
SUB-TOTAL						8.00	8.00		$ 960,288.21	$ 26,000,000.00	$ 26,960,288.21		$ 26,960,288.21		$ 74,229.15
TOTAL						134.14	258.18		$ 10,281,374.81	$ 106,275,000.00	$ 116,556,374.81		$ 116,556,374.81		$ 320,912.03