VERDANT HOME

Growing Elements of Architecture

By Jenny Babonnick

Figure 1. Libertia ixioides (New Zealand native plant)

Figure 2. Hebe 'Emerald Green' New Zealand native hybrid

Figure 3. Dicksonia fibrosa (endemic New Zealand fern species)

Figure 4. Scleranthus uniflorus (New Zealand native plant)

Figure 5. Robinia pseudoacacia 'LACE LADY'

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Jenny Babonnick

Submitted in partial fulfilment of the Master of Architecture (Professional)
Victoria University of Wellington, School of Architecture and Design
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Figure 6. Pseudowintera colorata, HOROPITO 'PEPPER-TREE' (New Zealand native plant).

Figure 7. Phormium tenax 'PINK PANTHER' (New Zealand native plant)

Figure 8. Libertia ixioides 'TAUPO BLAZE' (New Zealand hybrid plant)

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Finally, to my wonderful friends who have been around throughout the completion of this thesis, thank you for the pleasant discussions and support whenever I needed it.

Figure 9. PLANT GROWING IN BRICK WALL. Karo Drive, Wellington 2011.

"The great design and development fallacy of our time is the presumption that the human built environment can exist independently of the natural environment."

Stephen R. Kellert

(Kellert, 2005, p. 92)

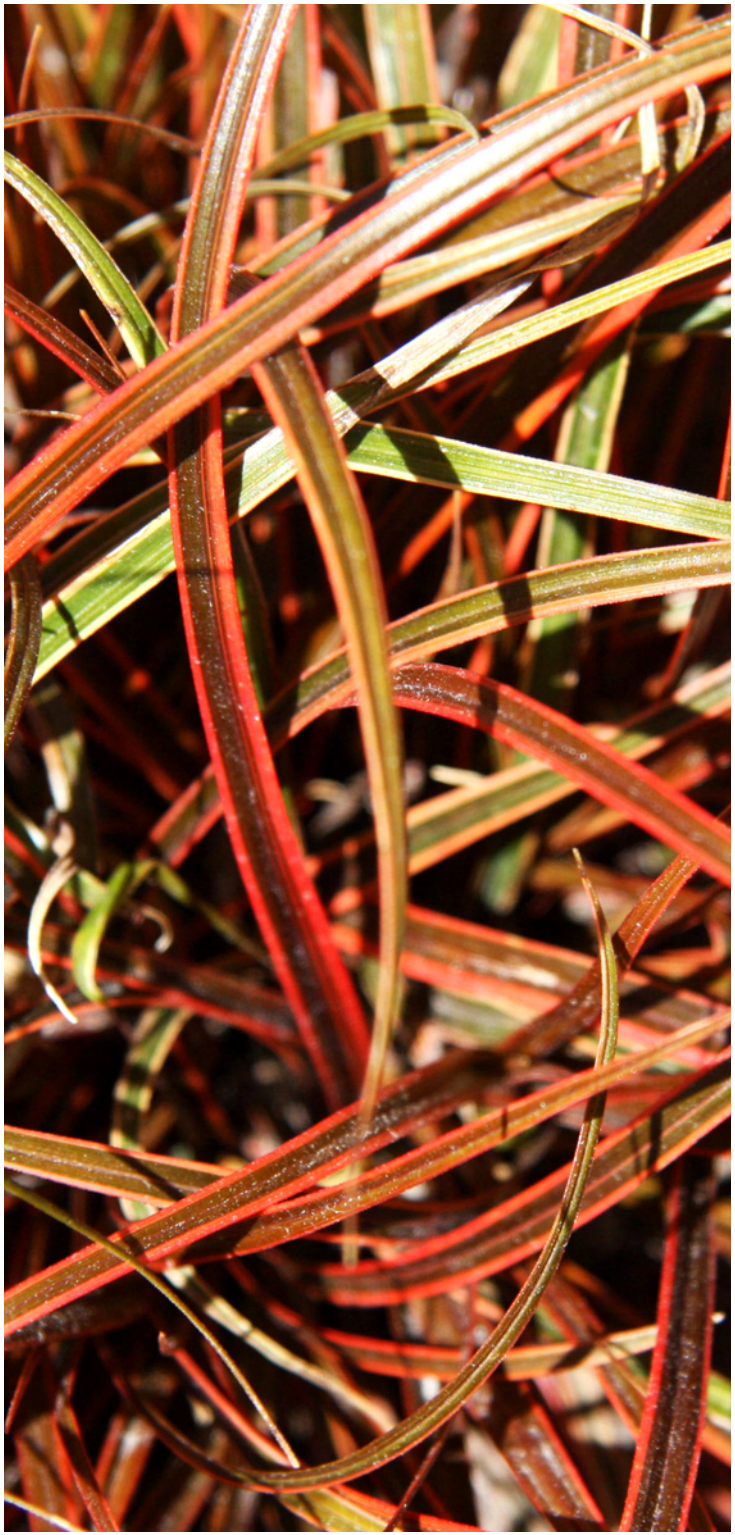


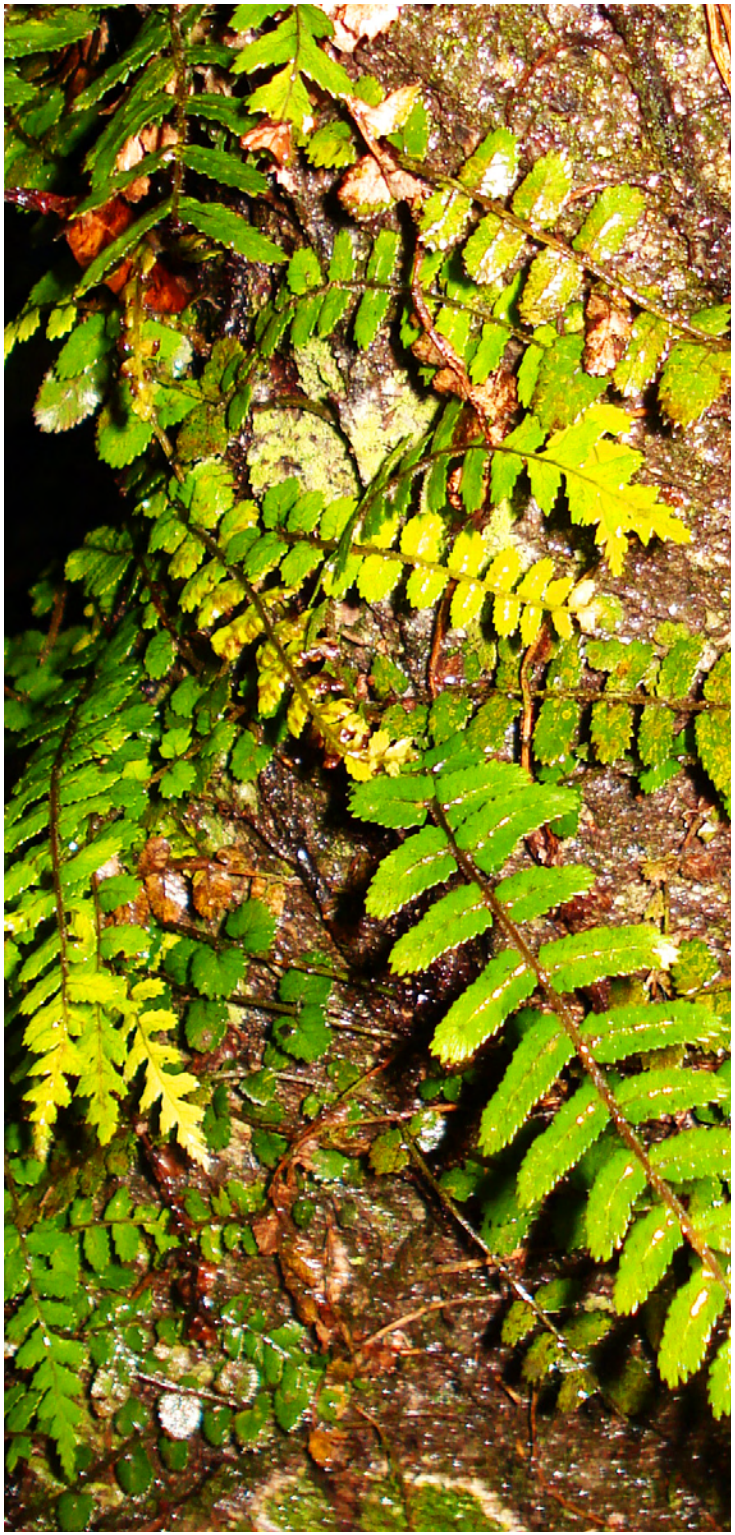
Figure 10. Uncinia rubra 'BELINDA'S FIND' (New Zealand native plant)

ABSTRACT

‘Verdant Home’ explores how the design of residential architecture can evoke the senses through the integration of the garden with the house. This research challenges the use of New Zealand native and exotic plant species as merely *an addition to architecture*; instead creating stimulating and efficacious verdant elements (components) *as part of the architecture.* Two concerns provoked investigations into this subject. Firstly, a concern for the gradually occurring loss of vegetation amongst city residences, and secondly a concern for the way in which green elements are often added to buildings, without consideration of how they could sensually transform and improve the aesthetics of space and context. The final refined solution addresses these concerns by incorporating verdant components in an advantageous way, creating a new typology of residential home for New Zealand.

Modern architectural technologies allow conventionally separate garden spaces to be integrated with building forms, removing the need for separate garden spaces. These technologies provide humans with the positive environmental benefits of plants within interior spaces. This thesis builds on these benefits, providing ideas for enhancing spatial experiences within the home by merging programmatic use with the pleasurable qualities of gardens. Presented at the outset of the thesis is evidence supporting the physical and mental benefits of everyday human contact with nature. The pursuit for a way in which architecture can encompass verdant elements as integral components of the home is explored through a review of garden history and theory. This review provides specific inspiration for the creation of splendid spaces, spaces which manipulate dimension and materials, sensually practical spaces and statement spaces in the design of a residential home. Following this, buildings from various time periods and locations which innovatively incorporate vegetation are evaluated. An analysis of the New Zealand architectural context and its relationship to gardens is then completed, leading to designs which incorporate all of this research.

This thesis challenges the current use of verdant elements such as: living walls, roofs and facades. Whilst these are beneficial technologies, there is potential for them to have an increased atmospheric effect on the spaces they are part of. New aesthetic possibilities are focused on through the designs, which utilise principles of historical garden design typologies to sensually integrate verdant technologies. This results in the creation of aesthetically engaging verdant home solutions.



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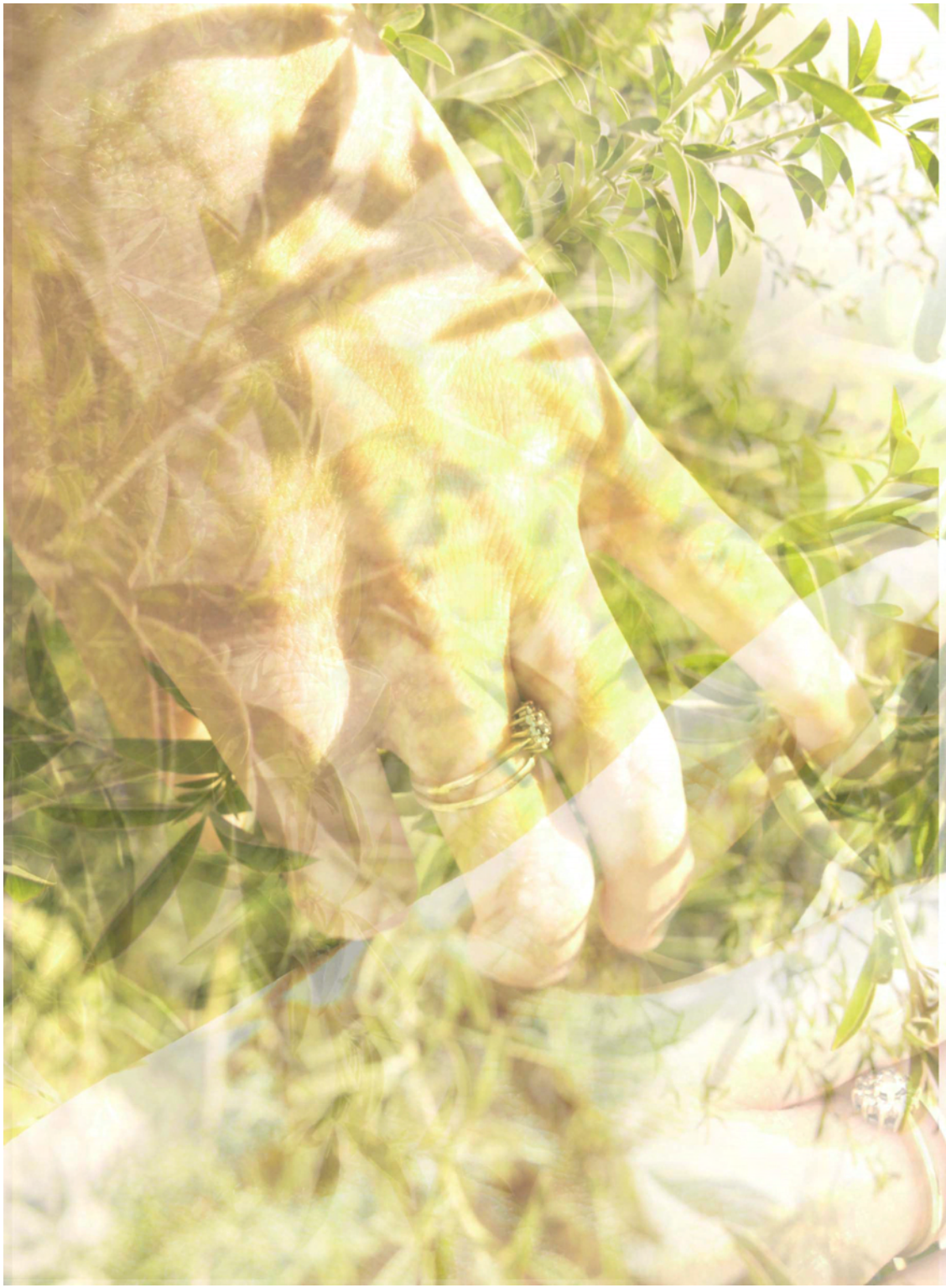


chapter one:
INTRODUCTION

"We depend on our surroundings obliquely to embody the moods and ideas we respect and then to remind us of them."

Alan de Botton

(de Botton, 2006, p. 107)

1.1 THESIS STATEMENT

This thesis explores the expressive spaces that are obtainable when incorporating plants with architecture. New ways of creating internal spaces which exude exteriority are presented through the integration of 'verdant elements'[1] with the design of space. Unique sensual and atmospheric qualities are created in interior spaces that are only possible due to the well thought-out use of plants.

1.2 THE NEED FOR VERDANT ELEMENTS IN RESIDENTIAL HOMES

It is becoming increasingly necessary for verdant elements to be incorporated with architecture. Already densely populated cities are running out of land and demand for inhabitable space around the world continues to increase[2]. As a consequence, many people are living in built-up areas with little access to nature or plants. Correspondingly, as New Zealand's city centres and nearby suburbs intensify, people are often left with "handkerchief" (Barnett, 1995, p. 185) sized suburban gardens, or dwellings with little or no external space. Incorporating plants with residential buildings is a viable way to provide people the positive benefits of plants; requiring less space than providing residences with external amenities such as gardens, parks or views to nature.

1.3 OVERVIEW

Innovative verdant elements[3] are being added to new and existing architecture around the world (see Figure 14), however many of these elements are not integrated with their host space. They exist *as an addition to the architecture*, creating an internal space which would function and exist atmospherically in the same way without the verdant element. Green roofs and external living walls are two verdant typologies (see Figures 15 and 16), where the sensual qualities of adjacent internal spaces more often than

Figure 13. Previous Page. HAND AMONGST PLANTS. *Image by Author.*

1 - Verdant is defined as green with lush vegetation (Oxford English Dictionary Online, 2011).
2 - By 2015, 55 percent of the world's population is expected to live in cities and towns (American Association for the Advancement of Science, 2011).
3 - Innovative verdant elements include green roofs, living walls, green facades. Other ways of providing humans with access to verdant elements include the provision of pot plants, or simply a view to nature outside the window

VIEW TO NATURE

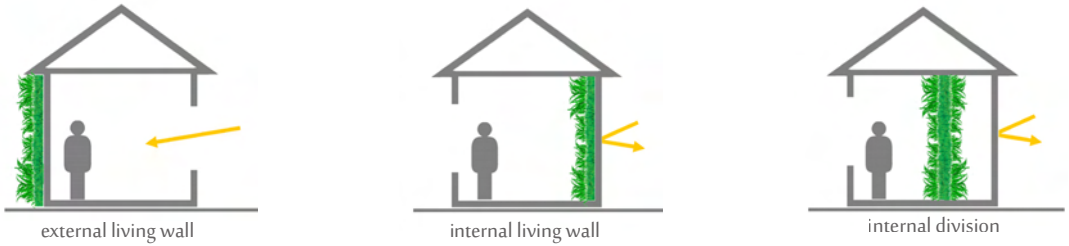
Figure 14.

GREEN ROOFS

Figure 15.

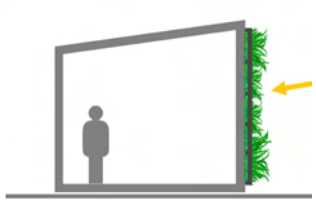
LIVING WALLS

Figure 16.



GREEN FACADE

Figure 17.

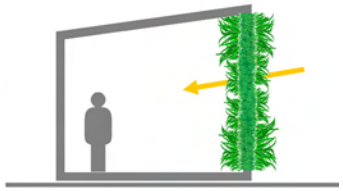


not remain unaffected by their planted external coverings. External green elements provide benefits such as insulation for the building, a reduction of urban heat island effects, and storm water-run off. However the aesthetic benefits of plants themselves cannot be experienced from inside these spaces (see Figure 17). Intelligent design can integrate green roofs with architecture so they provide unique sensual qualities for internal space as well as functional benefits.

In contrast, internal living walls (see Figure 16) are enjoyed within buildings; not only for their beautiful colours and textures, but also the mental and physical health benefits they provide for the inhabitants. While internal living walls inherently change the feel of a space, they sometimes appear to be no more than a wallpaper in a conventionally shaped room. Designs that allow a living wall to become part of a space, rather than an addition, can drastically change the sensual qualities. Similarly, the way in which a living wall interacts with the outdoors can change how the adjoining internal space is used. Often internal living walls could be more expressively designed to privilege changing light levels and temperatures, providing unique and varied spaces at different times of day and year.

SEMI TRANSPARENT LIVING WALL / FACADE

Figure 18.



To fully exploit the obtainable benefits of verdant architecture, the related technologies need to be explored with regard to their functional benefits, as well as their mood-making possibilities. An element such as a semi transparent living wall / facade (see Figure 18) is one verdant element which is easily capable of both. It provides a permeable green screen allowing changing light levels to be experienced throughout the day. By ensuring the spaces contained by this edge are designed to work collectively with the green facade, the spaces become interesting to inhabit.

When incorporating verdant elements with architecture there should be a strong consideration of place. New Zealand, the setting of this thesis has a strong cultural affiliation towards the preservation of its native ecosystems and landscape (see Section 6.1). Unfortunately these were negatively affected by European colonisation (see Section 6.3) With architectural allowances, native plants can be re-integrated.

Plants can be used as an architectural material to change the qualities and forms of current residential space in New Zealand. It is imperative that predominately externally functioning elements such as living walls and green roofs are further integrated with building skins and interiors, so that plants are able to influence interior spatial qualities. People benefit when surrounded by natural elements in their everyday lives; whether in the workplace or at home, plants in close proximity to internal living spaces or views to nature are beneficial for human beings.

The health benefits of having plants visible to humans have been proven in a number of studies (see Section 2.2). These studies show that plants are sometimes incorporated as aesthetic or visual elements to increase productivity, or help patients heal faster in hospitals or health centres. In consideration of these benefits, a strong argument exists that vegetation should be made present in residential environments; where the prevalence of plants and nature is not widely seen.

1.4 RESEARCH APPROACH

This research has defined four ways in which nature can be combined with built form (see Figure 19). These four typologies have been discussed throughout this thesis, each providing valuable information relevant to the creation of verdant architecture. The design concepts focus on creating architecture that utilises verdant elements *as an addition to structure* and *an element of architecture.*

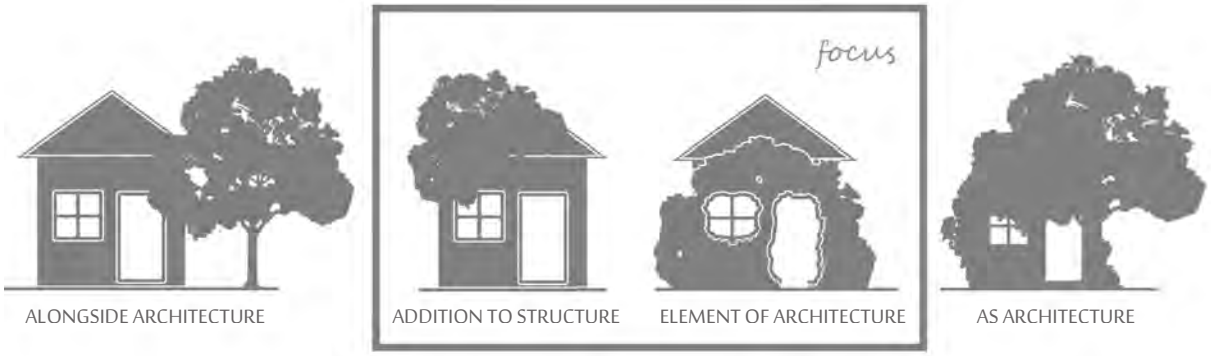


Figure 19. VERDANT ARCHITECTURE TYPOLOGIES.

In *Part A*, biophilia theory provides justification of the need for residential buildings to incorporate nature.

Part B explores research on the history of gardens, the historical use of planting and the formal spatial qualities of gardens throughout history. The review includes, the splendid space qualities of Egyptian and Persian gardens; the manipulated dimensions and materials of Chinese and Japanese gardens; the sensual practicality of Greek, Roman and Medieval gardens; and the formal statement of Italian Renaissance, and French Baroque gardens. These typologies provide a range of spatial principles which are used in the design of verdant house concepts in Chapter 8.

Part C explains and critiques current examples of verdant architecture, such as living walls, roofs, and pot plants (which are often merely an addition to architectural spaces). Typically the vegetation is not incorporated into the design of the architectural spaces, rather it is merely a facade, skin or feature. For example, air purifying green walls are positive features to a space; however they are generally an addition to an existing wall. Case study precedents from around the world are critically analysed to comprehend how they innovatively combine vegetation as more than an 'add on'. This study proposes that we should utilise these technologies as integral components of the architecture itself. If buildings were to integrate the vegetation with functioning elements such as walls, roofs, floors, divisions, drainage, and light filters, efficient as well as comfortable and unique spaces would be created. Case studies include: Patrick Blanc's living walls, Jun Yasumoto's Phyto-Purification Bathroom, Tryptique architects' Harmonia 57, Mitchell Jocachim's Fab Tree Hab, Michael Van Valkenburg and Associates Regis Gardens, Raderschall's MFO park and Atelier Kempe Thill's Hedge building. These each provide precedent techniques and examples for the creation of living elements within architecture.

Part D looks to the New Zealand context, where the design element of the thesis is sited. It examines the country's strong but constantly changing relationship to private gardens and the importance of these spaces for the New Zealand context. It also examines the climatic conditions of Wellington, New Zealand; the site for the design exploration.

Part E utilises historic garden qualities, to inform four different domestic house designs; designed for the same site in suburban Newtown, Wellington, New Zealand. Each of the four conceptual house designs integrate qualities and principles of selected garden types creating different spatial aesthetics for each. A refined design is then presented, this design is a culmination of ideas from all four concepts, with strong influence from the Manipulation of space and materials concept. In creating the designs, consideration was given to garden theory, verdant technologies and modern construction methods, cultural influences and societal living ideals, and native plants. Such consideration has created designs appropriate for the New Zealand context.

1.5 AIMS AND OBJECTIVES

This thesis aims to utilise the structural form and properties of plants as integral building elements in residential architecture. Design approaches considered in this thesis endeavor to provide possibilities for integrating planting and nature into New Zealand's domestic residences.

The objectives of this project are to:

- Create sensual residential space through the adaptation of historical garden principles to contemporary verdant architecture.
- Critically review precedents of living roofs / walls / structure and adapt this understanding into building design concepts.
- Challenge the notion of vegetation as a spatially unconsidered *addition to architecture* by designing functional vegetated elements as *part of the architecture.*
- Explore how verdant architecture can be designed as psychologically comfortable, sensual and provocative space; unable to be replicated without vegetation.

1.6 KEY TERMS

verdant - lush and green with vegetation

verdant element - living plants which grow on man-made structure to form components of architecture which include green roofs, living walls, green facades and semi transparent living wall-facades.

green facade - A man-made vertical building surface covered in vegetation

living wall - A man-made system which attaches to a vertical building surface and supports the growth of vegetation

semi-transparent living wall-facade - A man-made system which supports the growth of vegetation forming a two sided vertical wall. The *semi-transparent living wall* typology refers to internal use, while the *semi-transparent living facade* typology functions as an interior / exterior wall; as it is both the external facade, and the internal wall lining.

1.7 RESEARCH SCOPE

This thesis questions how a residential home can become a series of engaging and sense provoking spaces, through the use of verdant architectural elements. It synthesises functional technology with spatial theory, allowing particular aesthetics to be created within interior spaces. This thesis does not complete a technical analysis of physical comfort levels within the internal spaces of the building design concepts. Of the many environmental conditions that effect the design of a home, light has received the most consideration. Due to research constraints acoustics, ventilation, humidity and temperature are beyond full analysis in this thesis. As a possible advancement of the project; technical heating, cooling and ventilation systems could be further incorporated to regulate comfort levels for inhabitants. The plants used in the design concepts have been deliberately selected to provide the desired light, texture and spatial effects within the design. However as this research is architecturally focussed and my knowledge of planting design is minimal, further work would need to be done to ensure that the plants suit their placement and would thrive as intended.

1.8 CONTRIBUTION OF STUDY TO BODY OF KNOWLEDGE

This research is significant as it offers an alternative to many examples of verdant architecture. Firstly the research provides a way of defining a well considered verdant component, which needs to consider both its internal and external functionality, as well as its internal and external aesthetic appeal and sensual qualities. The solutions utilise existing technologies and functions of living walls, roofs and structures; translating these into efficacious elements which create sensually evocative domestic architecture. Secondly this research focuses on the integration of residential buildings with verdant components. This type of design with the exclusion of green roofs (which are readily used on residential buildings), is often limited to commercial or public architecture, due to the fact that the technologies are reasonably new. Verdant private residences of a smaller scale are beneficial for everyday people and smaller scale interventions of green architecture are important contributors to the wider environmental conditions of an area. The solution results in the integrated culmination of function and pleasure and proposes that both internal and external space can be enhanced aesthetically through the use of verdant elements.

chapter two:
THE NEED FOR GREEN: CURRENT THEORY

"Interaction with nature is critically important to human well-being and development, but sadly has become compromised and diminished in modern times. Through deliberate design, this connection can be repaired and restored."

Stephen Kellert

(Kellert, 2005, p. 1)

2.1 INTRODUCTION: SIGNIFICANCE OF THE PROBLEM

This chapter evidences the common knowledge that people need to be surrounded by natural elements in their everyday lives. Whether in the workplace or at home, plants in close proximity to internal living spaces, and views to nature, provide psychological benefits for human beings; as well as improving the physical internal environment (see Figure 21).

2.2 THE PSYCHOLOGICAL BENEFITS OF PLANTS

A view of nature is known to improve human mood and well-being. The sight, as well as the smells and sounds of natural elements such as trees, plants and water are positive psychological stimulants (Ulrich, 1991, p. 102). Research through many studies has shown that indoor vegetation enhances human rest, relaxation and creativity. It also increases productivity, self-confidence and alertness, reduces stress, and lowers aggression (Kellert, 2005, p. 15). Combining planting with buildings changes human perception of these buildings and the spaces within them. People perceive buildings with interior planting to be more relaxed, expensive and welcoming (Gilhooley, 2002). A study completed in the UK found that buildings integrated with vegetation are more liked and aesthetically pleasing than those without vegetation (Gatersleben & White, 2010, p. 97). The attraction of humans to nature is intrinsic and is a widely acknowledged actuality. The psychological benefits indicate that residential houses where people spend a lot of their time, should incorporate vegetation.

2.3 THE PHYSICAL BENEFITS OF PLANTS IN THE INTERNAL ENVIRONMENT

When plants are utilised indoors they provide an effective method of improving and regulating the internal environment. Such aspects include: temperature, light, sound, static electricity, relative air humidity and air quality (van der Voordt & Bakker, 2010, p. 418). Internal temperatures can be regulated through use of plants, as they insulate against the extremes of heat and

Figure 20. Previous Page. FLOWER AND SMILE.
Image by Author.

cold (Dunnett & Kingsbury, 2004, p. 7). Fundamental evidence of plants improving air quality was first produced in the 1980's (Smith & Pitt, Healthy workplaces: plantscaping for indoor environmental quality, 2011), however more recent investigations into these benefits are producing more quantifiable results. Positive air quality effects include an improvement in relative humidity (since plants release moisture into the air (Lohr V. , 1992), the reduction of volatile organic compounds (VOCs), the production of oxygen, the removal of carbon dioxide (Smith & Pitt, 2009) and airborne particles such as dust from the air (Lohr & Pearson-Mims, 1996, p. 2566). For these reasons, the New Zealand Green Star rating tool for interiors, grants credits for the use of plants inside New Zealand buildings. It also offers credits for external views connecting inhabitants to the outdoors (New Zealand Green Building Council, 2010). These benefits suggest there is a need for better integration of plants within internal spaces, not only as environmental regulators but as functioning building elements.

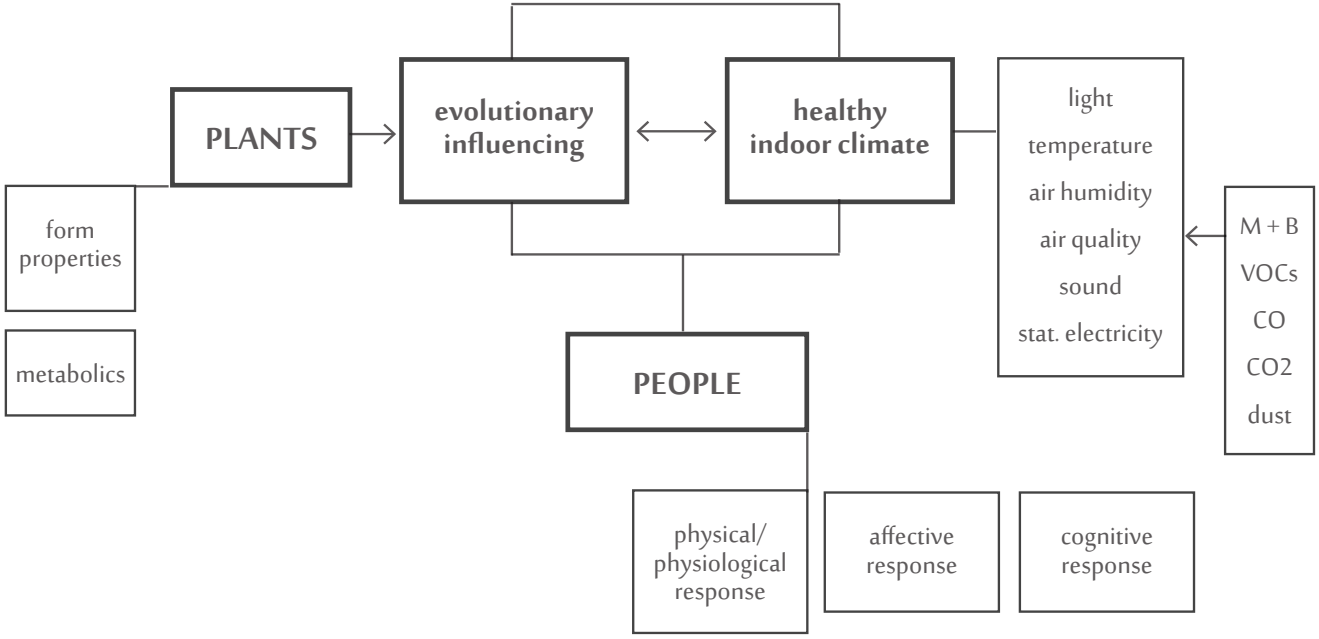


Figure 21. DIAGRAM OF THE IMPACT OF PLANTS ON PEOPLE.

2.4 NEGATIVE IMPACTS OF PLANTS

There are few negative effects of plants for humans, they include allergies, the attraction of bugs, unpleasant smells or being lost in nature. Humans respond with anxiety to literary portrayals of natural settings and are often terrified at the thought of being left in places of open wilderness (Kellert, Heerwagen, & Mador, 2008, p. 265). This scenario is unrelated to this research, which is concentrating on the incorporation of cultivated verdant elements within a suburban house. Design solutions which consider the effects of allergies and pleasant scents are outside the scope of this thesis. The many positive effects of plants largely outweigh the negative impacts, proving that plants should be incorporated with architecture as often as possible.

2.5 CONCLUSION

Plants positively affect humans when they are used in architecture; irrespective of the way in which the verdant element is incorporated. The psychological and physical benefits of plants are interconnected. An interior houseplant, primarily used to improve the air quality, will also provide aesthetic and psychological benefits for the humans who interact within the space. Similarly a green wall used for the functional purpose of reducing storm water runoff is also an attractive visual element. Often only one of these benefits is fully contemplated; leaving the other not entirely explored. While this thesis explores both the functional and aesthetic benefits of verdant elements, it focuses on how the inherent qualities of plants can be customised to enhance psychological benefits for humans.

part B: REVIEW

chapter three:
HISTORICAL PLEASURE GARDENS AND THEIR SPATIAL QUALITIES

There are " Two kinds of garden ... the truly utilitarian one of fruits and vegetables meant to provide food for a man's family and the restful pleasure garden designed to nourish a man's soul."

Julia S. Berrall

(Berrall, 1996, p. 7)

3.1 INTRODUCTION

Various cultures throughout history have created gardens as pleasure spaces. In order to create a desirable sensual atmosphere or mood, these historical garden typologies embodied the attributes of society, climate, and geography unique to their context. To their detriment, New Zealand's modern residential gardens lack distinctive spatial principles that respond perceptively to the New Zealand context. In order to create distinctive spaces in the design of a verdant New Zealand home, the principles of numerous historical pleasure gardens from around the world are explored.

In this chapter an overview of the distinctive spatial virtues and theoretical principles used in the creation of nine pleasure garden typologies have been analysed. Arranged into four sections, the analysis concentrates predominately on the methods used to create sensual garden space; rather than on the utilitarian uses of these gardens. The chapter explores the splendid space qualities of Egyptian and Persian gardens; the manipulated dimensions and materials of Chinese and Japanese gardens; the sensual practicality of Greek, Roman and Medieval gardens; and the formal statement of Italian Renaissance, and French Baroque gardens. This analysis established what gave these pleasure gardens their spatial virtues and how similar spaces and feelings can be recreated in the context of a house design in Part E.

3.2 SPLENDID SPACE

3.2.1 INTRODUCTION

The earliest cultures in the world developed in the Middle East alongside the Nile, Tigris, and Euphrates rivers. It was in this arid climate that such water enabled the first gardens to grow; both naturally near these rivers, and locally through the catchment and channelling of water to man-made gardens (Berrall, 1996, p. 11). The Old Testament describes the lush green Garden of Eden, set within this context. This Garden represented paradise, (Dunnett & Clayden, 2007, p. 9) symbolising the long established

Figure 22. Previous Page. OVERGROWN PLANTS IN DOORWAY. *Image by Author.*

notion of gardens as space purely for the experience of pleasure. Egyptian, Persian and later Indian cultures desired similar atmospheric qualities in their spaces and accordingly constructed splendid and lush gardens. Such gardens provided a pleasant environment, contrasting the unpleasant scorched landscapes.

3.2.2 ANCIENT EGYPTIAN GARDENS

Egypt lies in the African desert belt and consequently has a hot and dry bi-seasonal climate where in the summer (March to November) temperatures reach 33 - 50 degrees Celsius. The highest annual rainfall is 19cm[4] with some areas receiving no rain whatsoever for many years (Lonely Planet Publications Pty Ltd, 2011). The pictorial hieroglyphics on the walls of Egyptian tombs provide the earliest evidence of how gardens were created (Berrall, 1996, p. 12); these drawings express the formal function and geometrical forms of Egyptian gardens (Loxton, 1991, p. 12). The following sections describe the three main types of Egyptian garden: the domestic garden, the palace garden and the temple garden (Turner, 2005, p. 25).

The Domestic Garden

The small residences of middle to lower class Egyptian families were located in the populated towns and cities of Egypt. The houses were made of mud-brick and varied in height from one to three storeys. Placed at end of rectangular plots the houses provided outdoor spaces with desirable shade from the harsh sun and cooled indoor spaces (Turner, 2005, p. 27). Small outdoor living spaces which accompanied the dwellings (see Figure 23), on the ground, as well as on inhabitable flat roofs, utilised trees, vines and planted mats to block the sun's rays (Turner, 2005, p. 28). Rows of lush trees edged the small outdoor space, providing pleasurable shade and textured light to residents. Some colourful flowers such as red poppies or blue cornflowers may have been grown for visual pleasure in these spaces (Berrall, 1996, p. 13). Water was a necessity in these gardens as it was in all of Egypt; small storage pools of water cooled the surrounding air and provided irrigation for plants. The beautiful environment of the tree shaded outdoor space would have been a comfortable haven for cleaning, cooking and relaxation; in stark contrast to outdoor space in Egypt without any plants.

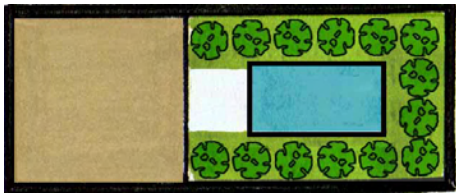
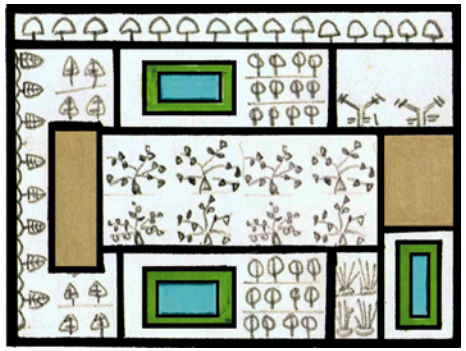


Figure 23. EGYPTIAN DOMESTIC GARDEN.
Diagram by Author.

4 - There is 19cm of rain annually in Alexandria in Northern Egypt. Aswan in the far south receives an average of 2mm of rain a year.



The Palace Garden

Beneath the luxuriant dimness light flickers through a textured screen of leaves

Cool air sweeps upwards from the swirling pool of golden specks

Beyond this, a view to the endless rows of vines and fig trees

Within this fertile enclosure

The scorched unrelenting world does not exist

Poem by Author

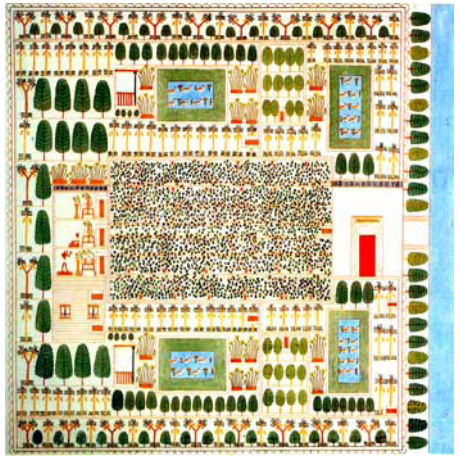


Figure 24. EGYPTIAN PALACE GARDEN. *Diagram by Author.*

Figure 25. SENNUFER'S GARDEN. 19th century copy of the original painting of Sennufer's Garden found in the funerary chapel of Sennufer, this garden is thought to have been in Eastern Thebes, Egypt (Turner, 2009).

The more elaborate domestic residences of the wealthy; provided sensual palace garden spaces for enjoyment and delight (see Figure 24). These large gardens and buildings were often rurally located (Turner, 2005, p. 23), as a sanctuary within the unrelenting desert. High boundary walls enclosed these spaces blocking the strong[5], hot desert winds whilst also providing shade and security (Berrall, 1996, p. 12). Water for irrigation was transported to estates in canals dug from the Nile; the layout of these water channels then divided the ground geometrically (Loxton, 1991, p. 13). These gardens utilised pergolas to create shade and divide space attractively, using supportive structure to privilege the growth and beauty of nature. Pergolas can be described as verdant architectural elements; as they affect the space around them both physically and aesthetically. The built frame structures provide a framework for twining and tendril-climbing plants to grow on, and are similar to those used in facade greening which is discussed in section 4.4.2.

From an examination of palace garden images (see Figure 25) it can be understood that the entrances to these estates were accessed from the sun exposed Nile. Arriving at a grand entrance under the full exposure of the sun, one would have been impressed by both the scale and by the protection from the sun provided by the pallid but impenetrable stone material. Upon entering the enclosure a varied range of formal planting was arranged from the boundary walls inwards. Plants alongside linear paths provided changing levels of cooling shade, and evenly placed pools dampened the air. The geometrically arranged spaces were divided into multiple courts, pavilions, orchards, vineyards, flowerbeds, vegetable gardens, pools and storage reservoirs

5 - Hot dry winds (khamsin) of up to 150km/h can blow in from the parched Western Desert, which encompasses the area between Libya and the banks of the Nile (Lonely Planet Publications Pty Ltd, 2011).

(Turner, 2005, p. 24). Seen through the colours and textures of the many plants at the far side of the enclosure the lightly coloured building mass would have been visible but not dominant; perceived as one of the many spaces within the enclosure. The similarly sized but differing solidity of pergola post spacing and plant densities provided constantly changing concentrations of shade and light.

Pleasure and experience were central to these gardens, which were an ideal design for the harsh Egyptian environment. Whilst they provided food; the symmetrical layout, and the design of spaces in which to sit and meander amongst the shade, suggest that these contained spaces were well used for leisure. Incorporating the principles of this outdoor garden into the design of interior spaces would create a strong connection to the environment and would vary the spatial qualities depending on the time of day or season of the year. The boundaries and divisions that were created in these spaces are particularly interesting; they were both used for functionality and visual pleasure. These qualities can also be seen in Persian gardens which are written about in Section 3.2.3.

The Temple Garden

Encircled by the unrelenting heat of the Egyptian desert
The row of splendid shade stretches onwards
Escaping the smouldering sun under the encompassing shadow of a sphinx
Feeling the gentle projection of leaves softening light while banishing the heat of the sun
Pausing for a second before proceeding further
Continuing the journey to a final paradox of endless internal shade

Poem By Author

The temple garden (see Figure 26) was the largest of the Egyptian garden typologies; it accompanied the vast temples, at an equally large scale. Berrall explains that sacred groves of highly appreciated trees were often planted around temple forecourts

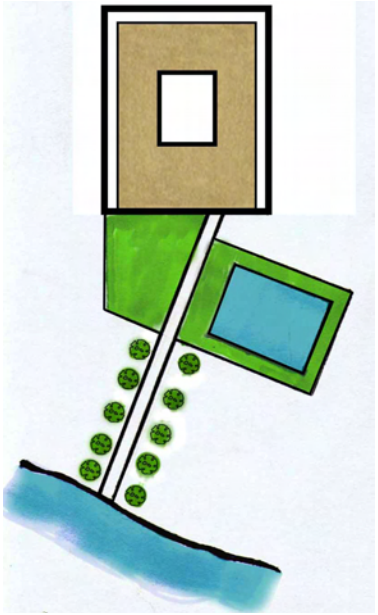


Figure 26. EGYPTIAN TEMPLE GARDEN.
Diagram by Author.

while colourful flowers and scented herbs were most likely grown within the temple gardens (Berrall, 1996, p. 15). Trees lining the road towards and around the temple, in a land where trees were scarce and difficult to grow, would have proven the great authority of the high priest or king. The sheer number lining through the city to the temple, would have created a feeling of anticipation; as well as providing direction up to the site of the temple, where the building is at the pinnacle of the axial route.

In an arid land such as Egypt, the magnificence of these verdant spaces and elements would have supplied pleasure as well as utility. The linear procession of avenue elements through city spaces provided stark contrasts between light and dark, hot and cold, bright colour and uniform desert. As the environmental conditions in Wellington do not create these extreme contrasts in comfort levels, Section 8.8 contrasts verdant spaces which were designed to explore how sensual experience within a domestic house can be enhanced.

3.2.3 THE DEVELOPMENT OF PERSIAN GARDENS

Persian gardens were designed to provide luxurious tranquillity and sensory delight for visitors (see Figure 29). The Persians were indisputably influenced by the geometrically arranged spaces of Egyptian gardens (Berrall, 1996, p. 30). These gardens, which may have existed since 1100BC (Bosser, 2006, p. 11), appeared as impossibilities amongst their harsh desert landscape. Scarce water was brought by deep underground channels from the mountains to fill four equal rectangular reserves; these channels represented the four rivers of life and the source of abundance (Hobhouse, 2003). The essence of the Persian garden was a place of protected leisure where internal and external boundaries were blurred through the use of internal courtyards, which opened onto external gardens (see Figures 27 and 28). Shade provided by walls was variable; changing through the placement of permeable trellis structures and patterned walls, which were used to control sunlight. The patterned walls of Persian gardens delivered filtered light into spaces delicately (see Figure 30). Similar effects could be replicated with verdant walls; that integrate the varied sizes and structure of trunks, stems, leaves and flowers as the pattern creating forms.

Figure 27. ALHAMBRA, GRENADA, SPAIN. Constructed in the mid 14th century

Figure 28. ALHAMBRA SUMMER GARDEN.

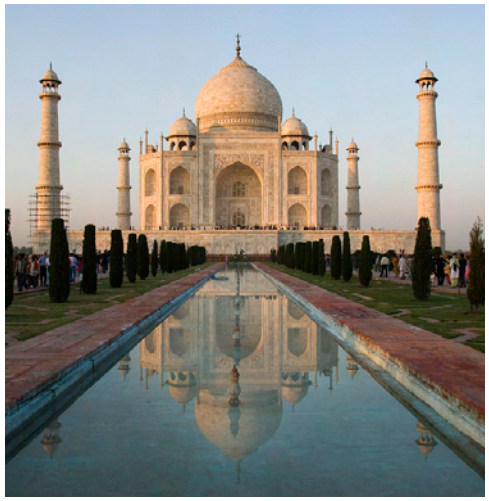


Figure 29. THE GARDEN AT THE TAJ MAHAL[6]

6 - The garden at the Taj Mahal (1592-1666) in Uttar Pradesh, India is one of the most well known gardens to have been influenced by the Persian garden tradition (Beckwirh & Gilsrer, 1997, p. 7).

Figure 30. Light effects inside the Alhambra, Grenada, Spain

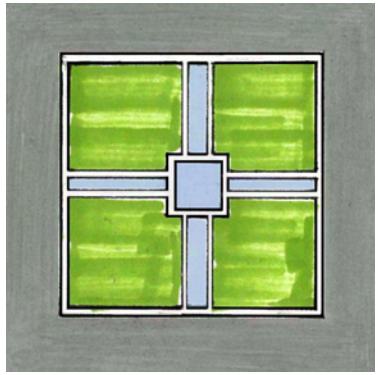


Figure 31. ISLAMIC COURTYARD GARDEN.
Diagram by Author.

Islamic Gardens

Within Islamic garden spaces (see Figure 31) the distinction between the material world and the poetic world is said to have dissolved (Barlow Rogers, 2001). These gardens provided inhabitants with calm, pleasurable serenity; opposing the arid desert landscape just as their Persian predecessors did. Islamic garden space was formally geometrical, and enclosed by the walls of adjacent areas. Upon entering the garden, linear tree-lined channels of shallow water led to a central pool or pavilion. Loxton explains that sensual pleasure was enhanced through the use of colourful fragrant plants and flowers including narcissi, tulips, lilac, jasmine, and orange trees, which were allowed to flourish freely against the gridded layout (Loxton, 1991, p. 19) (Bosser, 2006, p. 19).

Persian gardens were associated with everlasting beauty and well-being (Beckwirh & Gilsrer, 1997, p. 7). The considered treatment of the gardens' enclosing edges provided spaces with exquisitely varied levels of shade and patterning. The densities and strength of light and heat in these magnificent internal and enclosed external spaces created comfortable paradoxical spaces amongst a harsh climate. In contrast, people in New Zealand do not need to escape the country's temperate climate; the outdoor environment can instead be treated as an equivalent of the comfortable courtyard space. This suggests that the boundaries between indoor and outdoor spaces should to be treated as sensually significant elements.

The Persian garden tradition has spread to places such as North Africa and Spain and has influenced the Mughal gardens of India and Kashmir (Beckwirh & Gilsrer, 1997, p. 7). The Mughal gardens of Northern India were influenced by the enclosed form and layout of Persian gardens; however, they differ in their inclusion of more decorative elements and spaces. A typical Mughal garden (see Figures 32 and 33) can be envisioned in plan as a quartered enclosed space divided by a central water axis and central platform for structures such as palaces / pavilions. A mixture of vineyard, orchard and flowers surrounds this (Barlow Rogers, 2001).

Figure 32 and 33. AMBER FORT IN JAIPUR, INDIA. Example of Indian Mogul garden. Raised platforms, water channels and garden patterns.

3.2.6 DISCUSSION: THE EDGES OF SPLENDID SPACES

Egyptian and Persian gardens provided comfortable shade and water for irrigation creating splendid spaces within a barren environment. The gardens innovatively produced extrinsic conditions which possessed a natural feeling. This creation of paradoxical space against the adjacent desert conditions influenced my decision to design the splendid space concept using the "edge" typology of verdant architecture. This typology allowed me to focus on the splendid space creation methods taken from this research when designing in Section 8.8. The resulting concept focuses on the design of spatial boundaries which would create changeable spaces and contradictory conditions to those of neighbouring spaces.

3.3 DIMENSION AND MATERIAL MANIPULATION

3.3.1 INTRODUCTION

Unlike Egyptian and Persian gardens where the creation of splendid space relied on creating a comfortable haven to escape from the unpleasant barren surroundings, Chinese and Japanese gardens appreciated the attractive wilderness of landscapes and endeavoured to express such beauty in the design of garden spaces. Despite the fact that the high summer temperatures in parts of China were also often unbearable, due to the high humidity of many areas, much of the natural landscape was lush and fertile. This wilderness was celebrated, as were elements of nature. Through the careful incorporation of natural elements, Chinese and Japanese gardens utilised techniques to change perception in the creation of their gardens creating beautiful scenes, seen as a series of spaces in China, and as a complete picture in Japan (Berrall, 1996, p. 327). Chinese Courtyard and Scholar gardens and Japanese gardens and their relationship to architecture are discussed in this section.

3.3.2 CHINESE GARDENS

The picturesque quality which defines Chinese gardens is derived from the landscape paintings of poets, monks and scholars whose sensitive feelings were expressed through the art of painting. The sensitised thinking behind these artworks was then used to create garden spaces (Berrall, 1996, p. 327). Chinese garden typologies reflect the Taoist and Buddhist philosophies of oneness and the contemplation of nature (Loxton, 1991, p. 26). Even in small domestic residences the Chinese would utilise materials and layout to make the dimensions of the space appear much larger. Ancient Chinese gardens were constructed as early as 2000 BC; the traditional Chinese garden aimed to recreate nature within enclosed boundary walls (Loxton, 1991, p. 26). These elements were all meant to represent the natural world and buildings and views were arranged to enhance the experience of the recreated nature.

Chinese Courtyard Gardens

From my window I gaze out to the mountains

They seem so far away

But I know the beautiful forms are close

I glance out the window

All that is there are oddly shaped rocks

Poem by Author, Chinese contentment of the garden compared to the Westerners dissatisfaction

The late eighteenth century scholar Sheng Fu suggested that to make a successful garden, the feeling of large needed to be created in the small, and the feeling of small in the large (Stuart, 2010, p. 69). This suggests that whatever one lacks in constructed surroundings can be psychologically created through the design of the garden and the relationship with the architecture. Thus Chinese courtyard gardens (see Figure 34) were treated as places to represent the natural world, utilising the Chinese philosophies of equilibrium; yin and yang; to balance opposites (Loxton, 1991, p. 26). These opposites included dark and light, faint and bright and soft and hard, however utilising these opposites always lead to the creation of natural space which was never symmetrical (Berrall, 1996, p. 342).

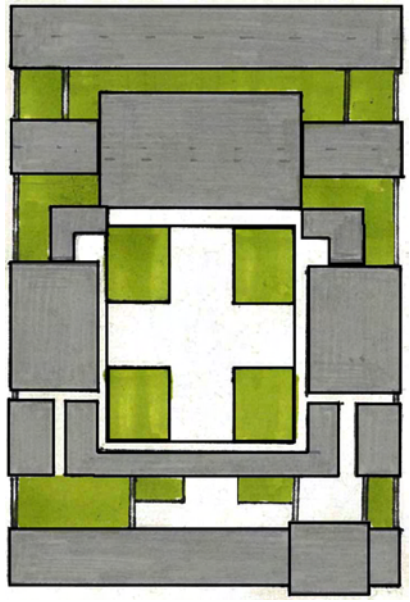


Figure 34. CHINESE FOUR SIDED COURTYARD RESIDENCE. *Diagram by Author.*

The buildings amongst these gardens were representative of Chinese ethics, morals, and politics (Loxton, 1991, p. 26). The south facing building was deemed the most desirable and therefore was occupied by the head of the family, east and west buildings were occupied by elders and the oldest children. The north facing building near the entry was occupied by servants, it was separated from the main residence by patterned screens which were believed to have prevented demons from entering (Stuart, 2010, p. 59). Courtyard spaces adjacent to each building provided external areas complementary to the buildings internal uses (see Figure 35). For example a bedroom would have had a relaxing a pleasurable garden and an internal living area would have had an external cooking space.

These gardens which were carefully constructed spaces, used meticulously selected rocks, plants and water, to create intimate views for their inhabitants (Berrall, 1996, p. 342). The purpose was not to be monumental but to create sensitised spaces where one's mind could imagine and be delighted.

Figure 35. EXAMPLE OF CHINESE COURTYARD RESIDENCE. Showing raised platforms and screens which prevented demons from entering the space.

Chinese Scholar Gardens

Every turn seems to be a world of its own

The dim light is reminiscent of dawn

Within the flickering forest of bamboo

And then bright like noon

As sunlight streams through the circular void ahead

It masks what is beyond

Stopping under the textured shadows of a maple tree

I will draw

Poem by Author

Chinese scholar gardens (see Figure 36) were designed to be experienced slowly; the meandering trails lead one through the gardens series of scenes, with a sense of anticipation for what will be next. Liu writes that Chinese gardens either directly imitated nature or represented indirect suggestions from traditional landscape paintings (Liu, 1993). The Chinese garden is the most intellectually and emotionally challenging of all the garden typologies (Stuart, 2010, p. 59). Rory Stuart explains that there is an absolute lack of any symmetry, leaving the inhabitant disorientated; an experience familiar to visitors of the garden (Stuart, 2010, p. 59). The garden was a succession of elements, including precisely designed structures, water, ground works, lakes, pools, manmade rivers, bridges, pavilions, islands and tombs (Bosser, 2006, p. 35). Paths, fences and walls were never constructed in straight lines, in order to offer continuously changing views. These gardens were used for spiritual self improvement: meditating, writing, painting, practicing calligraphy or for social experiences such as drinking and flirting (Stuart, 2010, p. 69). The beautiful spaces which could be viewed as scenes individually (see Figure 37) or as a series, were meant for enjoyment and the many private areas were an ideal setting for courtship and intimacy.

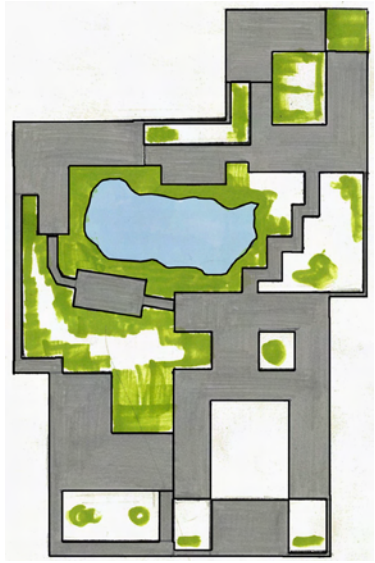


Figure 36. CHINESE SCHOLAR GARDEN. *Diagram by Author.*

The Chinese garden typology poses a problem for the westerner, who may not look past the literal into the metaphorical meanings behind elements used in the Chinese garden. For example to the westerner, the prised rocks used within the gardens may appear grotesque; but to the Chinese they were an important necessity which created a pleasant scene in one's mind (Berrall, 1996, p. 342). The Chinese garden required the smallest details, and elements which are usually taken for granted, to be celebrated. However to those who do not know the meanings behind a garden's design the Chinese scholar garden would still exude a sense of meaning and purpose. In Section 8.2, the consideration and manipulation of spatial depth and materials has been used to influence the design of typical internal external boundaries used in a residential Wellington home.

Figure 37. SCENE IN CHINESE SCHOLAR GARDEN. water, trees and rocks.

3.3.3 JAPANESE GARDENS AND ARCHITECTURE

Traditional Japanese gardens were largely influenced by the garden creation techniques used in China. Similarly to the Chinese the Japanese have cultivated a unique harmony between the natural surroundings and their way of life. More so than China this responsiveness was supported by the mostly temperate climate of Japan, which allowed the house and garden to be integrated (Itoh, 1978, p. 33). Below a summarised time line of the Japanese Garden is shown:

Asuka period (538-710) - gardens express Buddhism and Taoism by replicating China's mountainous regions
Heian period (794-1184) - gardens became a place for ceremonies, amusement and contemplation
Kamakura and Muromachi periods (1185-1573) - Zen beliefs and enjoyment of gardens
Tea Ceremonies Edo period (1603-1868) - reflected power, the tastes and style of shogun ruler

Japanese gardens were designed to privilege the imperfect and changeable state of nature; the objects used in their designs expressed this in their unsymmetrical layout and varied forms. These gardens were arranged to be viewed from designated points, rather than to be physically walked through (Stuart, 2010, p. 91) as is seen in Chinese scholar gardens. One such view could be described from the muted frame of a door way to outside; a lush lawn and moss covered rocks fill the foreground of the view, a snaked path leads through the garden disappearing out of sight behind a number of trees, and behind these a glimpse of a distant hill can be seen in the background. The principles behind Japanese gardens were based on an observation of how things are in nature. In their designs elements of nature such as: rocks and stones, sand, earth, water, trees and plants are all of equal importance (Spooner, 1983, p. 67). Often these elements were used in isolation in order to accentuate the character of an individual element against a contrasting background texture or colour (Spooner, 1983, p. 69). The garden was never thought of as a luxury or symbol of material wealth. The gardens were modest in size and were appropriate for private and intimate human interaction (Spooner, 1983, p. 67). This scale is dissimilar to the extravagant formal gardens of Europe, which are discussed in Section 3.5.

Japanese gardens were carefully integrated with the surrounding architecture; no Japanese house was considered complete without a surrounding garden and architecture which allowed intimate views to the peaceful garden (Berrall, 1996, p. 345). The sukiya variation (tea house style) became the most influential architectural style in Japan; it can still be seen in modern work (Daniell, 2010, p. 17). Previous shinden-zukuri (palace style) and shoin- zukuri (study style) styles were used to symbolically express social and religious status, whilst combining a variety of rooms beneath a single roof shape (Itoh, 1978, p. 46). Initial sukiya style designs had a freer ground plan and as the style developed the garden began to permeate the entire building complex (Nitschke, 2003, p. 157) with tranquil verdant areas, lush leaves and mossy ground. Features of the architectural spaces include small spaces, thin elements, untreated materials and broad eaves (Daniell, 2010, p. 17). Elements such as sliding panels and lightweight walls enabled interior spaces to be muted while large outdoor verandas, lattices and screens blurred the boundary of inside and outside (Daniell, 2010, p. 17). The asperity of natural materials used in these spaces was enhanced by the light and shadow effects created by the architecture.

3.3.4 DISCUSSION: DIVISIONS WHICH MANIPULATE DIMENSIONS AND MATERIALS

All Chinese and Japanese gardens were created to reference the beauty of nature and its desirable landscapes, even within dense cities where the gardens were created on small sections of land and enclosed by high solid walls. The peaceful spaces these cultures created within any environment lead me to explore the manipulation of dimensions and materials using the “division” typology of creating verdant architecture. These gardens can be used to create differing scenes in different spaces of the house by creating, varied sensitised views and physically dividing interior spaces and interior / exterior space in unique ways. Creating a house which is changeable and which can be treated as a series of divided scenes would be an experiential environment to live within; it would allow details and features to be discovered throughout a resident’s stay.

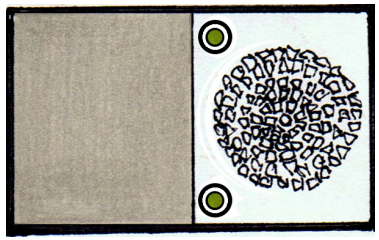


Figure 38. GREEK COURT GARDEN.
Diagram by Author.

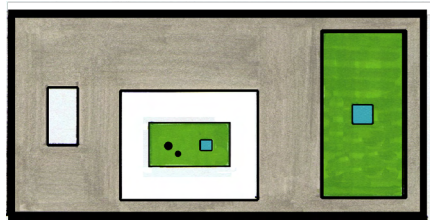


Figure 39. ROMAN COURT GARDEN.
Diagram by Author.

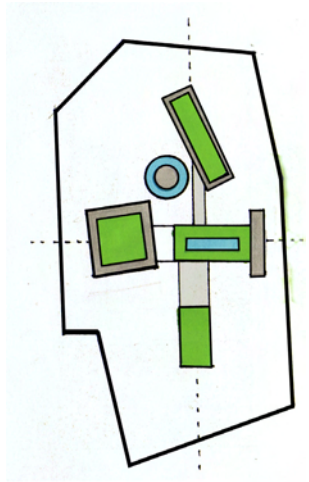


Figure 40. ROMAN VILLA GARDEN.
Diagram by Author.

3.4 SENSUAL PRACTICALITY

3.4.1 INTRODUCTION

The gardens discussed in this section provided herbs, vegetables and fruit for their people as well as creating attractive and private sensual spaces. The gardens discussed here were initially concerned with growing plants for their utilitarian purposes, but as cultural conditions and circumstances changed gardens began to develop this use of edible plants into a designed creation of pleasurable space.

3.4.2 GREEK AND ROMAN GARDENS

Greek Gardens

Alexandrian culture brought ideas of ancient Egyptian and Middle Eastern gardens to Greece. These ideas then spread to Rome and the rest of Europe (Vercelloni & Vercelloni, 2010, p. 15). In a land where rural space prevailed, Greek gardens (see Figure 38) were initially used for the practical cultivation of fruit trees, vines, and ornamental trees. However due to the limited amount of space available within the cities, smaller residences on strictly rectangular plots were limited to having a small central court within their house; in which to grow vegetables, herbs and other fast growing plants in pots (Loxton, 1991, p. 15).

Roman Gardens

Roman gardens (see Figure 39) were influenced by Hellenistic culture (Alexandrian Civilisation), and Eastern cultures. Similarly to Greek houses, residential gardens in densely populated Roman towns were generally created within this courtyard typology as internal atrium spaces (Stuart, 2010, p. 119). However sometimes a second space to the rear of the house would provide more extravagant private gardens which could be glimpsed at from the atrium space (Stuart, 2010, p. 119). When space was limited the Romans used wall paintings of garden scenes to create the illusion of a larger garden (Loxton, 1991, p. 15). The Greeks and Romans used edible herbs and plants in the creation of these small court gardens within their houses for both the attractive nature

of these plants and the fact that they were suitable for eating. The larger Roman villa garden (see Figure 40) was not governed by principles of controlling or representing nature instead aiming to please the senses. The garden was dictated by the buildings it served, the topography, and the availability of water (Bosser, 2006, p. 79). The greatest contribution of the Roman garden to garden history is the appreciation of ornamental planting and the connection of the garden as an inseparable extension of the house (Berrall, 1996, p. 39).

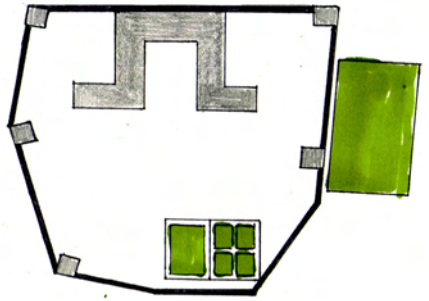


Figure 41. MEDIEVAL CASTLE GARDEN. *Diagram by Author.*

3.4.3 MEDIEVAL GARDENS

Medieval Castle Gardens

The paradise garden is the origin of the medieval garden; 14th century medieval gardens were characteristically, enclosed spaces where the creation of beauty was restored (Pizzoni, 1997, p. 22). Typically organised and complex, enclosed castle gardens (see Figure 41) provided space for private contemplation away from the wider agrarian context (Vercelloni & Vercelloni, 2010, p. 23). Outside the walls of medieval gardens, produce was grown in its own organised area to be used for the complete community inside the castles enclosure (see Figure 42). After 1000 AD, the use of botanical plants began to increase due to the importation and exchange of botanical plants and knowledge throughout Europe. Monks began to grow and process medicinal plants within the medieval castle walls, in small garden spaces (Loxton, 1991, p. 23). These plants were grown predominantly for utilitarian purposes, but also for their decorative qualities (Pizzoni, 1997, p. 20).

Figure 42. CASTLE GARDEN. Month of September in The Très Riches Heures by Limbourg brothers, Barthélémy d'Eyck and Jean Colombe. Painting depicts the harvest of the grapes in the foreground, in the background is the Château de Saumur.

Medieval Cloister Gardens

The use of decorative colours and pleasant scents near to living spaces led to the development of the Medieval Cloister garden (see Figure 43), which intended to engage all of the senses. The utilisation of scented herbs, coloured flowers, soft touchable plants, pergolas and fruit trees came later. The scents, colours and gentle murmurings enclosed in the garden were to be enjoyed away from the dwelling place, and were to be meandered in for recreation and entertainment (Pizzoni, 1997, pp. 22-23). Spaces within were subdivided according to function and often included a central pool with a fountain, flower beds at the entrance

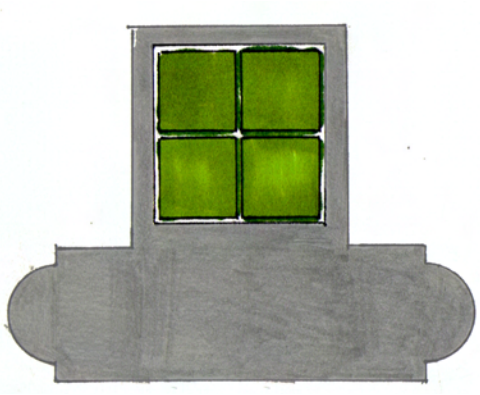


Figure 43. MEDIEVAL CLOISTER GARDEN. *Diagram by Author.*

to the garden and lawns containing seats, labyrinths, pergolas and a bathing pavilion (Vercelloni & Vercelloni, 2010, p. 23). Other sectors within the garden included a fish pond, orchard, viridarium (garden of evergreen trees) and a kitchen or aromatic and medicinal herb garden (Vercelloni & Vercelloni, 2010, p. 23). Cloister gardens were places of sensory pleasure the smells colours and textures of the plants in these spaces were used for both their utilitarian purposes and to create beautiful spaces.

The late-medieval garden was seen as a pleasant distraction from the fatigues of everyday life and was the ideal environment for the composition of poems, relaxation, courtship, and a place where refined feelings could be displayed (see Figure 44). These gardens had special significance due to their siting within a walled courtyard and then a further enclosing internal trellis (Vercelloni & Vercelloni, 2010, p. 26). Trellis structures were particularly popular in the medieval garden and have continued to be used throughout history. They are currently used in the creation of verdant screens, facade greening, semi transparent living wall / facades, and pergola structures. These techniques are further discussed in Section 4.4 and 4.5.

Figure 44. THE MAJOLICA CLOISTER. Convent of Santa Chiara, Naples, Italy.

3.4.4 DISCUSSION: A SENSUALLY PRACTICAL HOME IN NEW ZEALAND

Greek, Roman and Medieval gardens were cherished places of enjoyment when there was little private outdoor space available. The limited space required gardens to be highly interconnected with architecture, resulting in buildings which enclosed and integrated gardens. The gardens made use of all outdoor space by utilising plants for inhabitants to gain pleasure from, many of which the inhabitants could also eat. In New Zealand issues related to increasing population density are a recent development. In the past most houses had a large garden, where the building and garden were related but not integrated areas. As plot sizes in high density areas are reduced, gardens are made smaller or removed. In New Zealand the principles of sensually practical gardens could be used to create verdant residential homes, which integrate food production and pleasure with architecture in small areas. The methods of dividing certain areas within these buildings and gardens to appreciate the forms, scents and colours of nature are useful when applied to the New Zealand context. Dissimilar to European countries, suburban New Zealand sites have never before experienced space restrictions as the norm.

3.5 STATEMENT SPACES

3.5.1 INTRODUCTION

The creation of statement garden spaces in Europe was the result of gardens no longer being thought of as purely utilitarian spaces; the principles and techniques used to construct statement garden spaces instead focused on creating admirable beauty for the pleasure of inhabitants.

3.5.2 ITALIAN RENAISSANCE GARDENS

Berrall explains that the period of the Renaissance came after centuries of man living a burdensome existence due to the fall of Rome. This created fears of war, god, lordly masters, hunger and death. From the Renaissance onwards man became aware of his many individual abilities and became engrossed with his relationship to himself and his world (Berrall, 1996, p. 109).

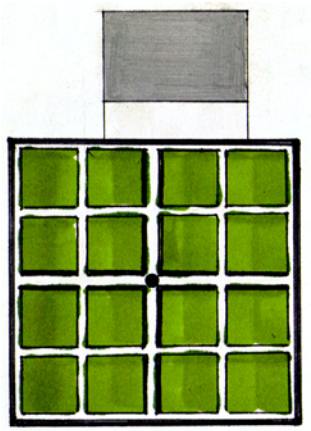


Figure 45. EARLY RENAISSANCE GARDEN. *Diagram by Author.*

Italian Renaissance Villa Gardens

As an advancement from the medieval garden where the garden was designed as an area separate from the dwelling space, the Renaissance villa garden aimed to integrate the garden with the living environment. Designs were consistent with the existing classical principles of composition, harmony and beauty which were reformulated during the Renaissance by Leon Battista Alberti in his 1485 treatise on architecture 'De re aedificatoria'. This stated that a specifically designed garden was an essential addition to houses (Vercelloni & Vercelloni, 2010, p. 37).

The Renaissance garden became an indispensible feature of the 15th Century villa; no longer purely utilitarian, it conformed to specific ethical and aesthetic concepts (Pizzoni, 1997, p. 27) providing inhabitants with regular and intimate contact with nature (see Figure 46). A hilly, sunny and windy area, that provided views over the countryside was fundamental to the design of a villa garden (Pizzoni, 1997, pp. 27-28). The layout was required to be integrated with the building, whilst being symmetrical

Figure 46. CA' MARCELLO AT MONSELICE. In the province of Padua, Italy. A residence which opens to the surrounding landscape (Pizzoni, 1997, p. 27).

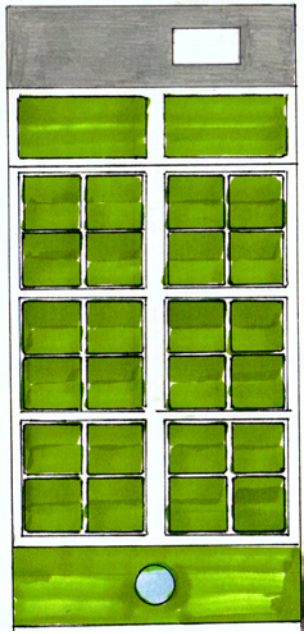


Figure 47. HIGH RENAISSANCE GARDEN. *Diagram by Author.*

and co-ordinated (see Figure 47); the garden became a central element contained within the structure providing prominent axial perspectives (Vercelloni & Vercelloni, 2010, p. 37). The enclosed garden (*giardino segreto*) became a necessity for every Renaissance villa (Berrall, 1996, p. 115) as it retained the essence of the medieval cloister garden, whilst adding the formal considerations and splendour of the Renaissance. The villa garden was an experience viewed and connected to its architecture. From the door of the house a pergola would have presented itself covered in lush planting, beyond this a central pathway would have flowed through into an enclosed private space, containing small lawns, clipped topiary, flower beds and small box hedges, all of which was carefully geometrically composed. Beyond this enclosed space the path continued as an avenue lined with trees (Berrall, 1996, p. 111). The connection between architecture and plants was explicitly designed with the desire to create pleasing views for inhabitants; these views were both constructed on site and created as views to the surrounding natural features. In New Zealand there is a tendency to design buildings around the available off site view. If there is no natural view, designs focus on the ideal building orientation and materials, which are then complemented by a garden. This section encouraged me to design architecture which creates its own natural views and spaces within its site. Equally privileging both architecture and the garden from a home's inception.

Italian High Renaissance

High Renaissance gardens were larger in scale than villa gardens. The gardens were created as a beautiful retreat; to tame nature whilst introducing culture (Don & Moore, 2011, p. 9). They were unable to be wholly interpreted from one point, rather they were experienced as a series of metaphorical representations of classical mythological ideas (Stuart, 2010, p. 131). Stuart explains that the high Renaissance garden was not ceremonial, rather it was a modest setting where nature inspired art. Fountains, pavilions and statues, were often decorated with motifs expressing this sentiment (Stuart, 2010, p. 131). The gardens were also admired for their symmetry, magnificently engineered water, fountains and pools, architectural loggias, grottos, nymphaea, greenery, shade, multiple levels, terraced sites and storytelling through statues; as well as the successful combination of all of these elements (Vercelloni & Vercelloni, 2010, p. 37). The complicated and dynamic spatial composition of the high Renaissance garden provided 'belvedere' or beautiful views, equally divided spaces, balance and symmetry and a strong central

axis, expressing an attractive command over nature by human art (Barlow Rogers, 2001, p. 126). During this period green theatres and architecturally formed hedges became common elements of European gardens. Green theatres consisted of spaces made of hollowed out plant mass which created the stage and various cylindrical and rectangular elements which could be used in the theatrical performances (Vercelloni & Vercelloni, 2010, p. 133).

Renaissance architecture showed consideration of physical climatic conditions, as well as pleasing aesthetic qualities in the design of the holistic garden and villa design. While the garden was visibly contained within walls, qualities beyond the constructed edges were considered part of the architecture. The use of gardens and vegetation would have provided inhabitants with a pleasant and functional environment to live within.

3.5.3 FRENCH BAROQUE GARDENS

".... An undoubted vigour in the disposition of detail, a feeling for vastness and pomp, together with an internal decoration which spared neither colour nor costly material to secure an effect of dazzling splendour."

Baedeker as cited in (Taylor, 2006, p. 36)

From the late 16th Century French gardens became influenced by the Italian Renaissance gardens of prior centuries. The French created similar symmetrical, gridded and geometric garden spaces to those used in the Renaissance garden . However the rigidly prescribed views, and monuments which were predominately centred along one main axis in the Renaissance garden, became less static in French designs (see Figure 48). French baroque gardens showed the control of man over nature, becoming elaborate spaces of enormous proportions when compared to their Italian predecessors.

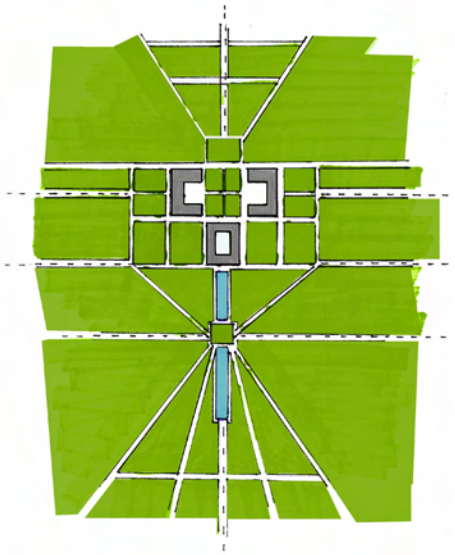


Figure 48. FRENCH BAROQUE GARDEN.
Diagram by Author.

Baroque gardens conveyed notions of drama, splendour, monumentalism and movement (Taylor, 2006, p. 36). Houses were located along a central axis from which many diversions radiated (Taylor, 2006, p. 36) each offering views and paths to alternative destinations when moving through the garden. These views were created amongst the geometrically arranged

Figure 49. THE GARDENS OF VERSAILLES, FRANCE. Axial view to west showing the large scale of the spaces.

gardens, constructing symmetrical perspectives which were evenly bisected by pathways directed at certain elements, views or landmarks. The site topography and characteristics were used to create forms such as: terraces, steps, turf banks, ramps and large hedges (Barlow Rogers, 2001, p. 195). Following the ideals of the Medieval garden discussed in Section 3.4.3, the pleasure spaces within these gardens were highly regarded and thus were often placed near the main dwelling (Berrall, 1996, p. 173). These spaces may have contained flowers, herbs and clipped shrubs such as hornbeam which were formed into swirling or geometric patterns, providing decoration and detail.

In the baroque garden, architectural structures which were previously made of wood or stone, were overlaid with vegetation. Geometrically pruned plants, topiary and climbing plants on trellis were used to create spaces and volumes with much greater meaning than plant-less manmade structures (see Figure 49). This 18th century idea of the French Revolution was suggesting that the relationship between plants and humans was vital rather than purely spectacular (Vercelloni & Vercelloni, 2010, p. 133). The designs in Section 8.11 reference this idea, utilising plants as spectacular functional elements in the design of a house concept. Baroque gardens became architectural spaces themselves, creating separate intimate areas or parterres fitting within the garden scene. Trellis was reinvigorated by Le Nôtre in the 17th Century were he designed trellis structures of great sophistication including arbours, pergolas, arches, screens and furniture made of lattice. These techniques were then used in the 18th century to enhance the illusion of space and mask domestic outbuildings (Heugel, 2003, p. 38).

3.5.4 DISCUSSION: TRANSLATING STATEMENT SPACE INTO HOME CONCEPTS

The Renaissance garden emphasised geometry and space creation through the use of solids and voids; these ideas have been used in Section 8.10 to influence inhabitation within verdant forms in a residential home concept. Baroque gardens were lavish and grand and celebrated particular elements and routes within their designs, therefore Baroque statement spaces have been explored in the framing of space concept in Section 8.11.

3.6 CONCLUSION

These garden types were all created to provide comfortable and functional spaces for their inhabitants; acknowledging and designing for the climates they existed within. The incorporation of vegetation has been shown to be for practical, sensual, aesthetic and religious reasons. As these garden typologies show, practically vegetation was used to regulate temperatures, and to provide shelter and shade. While aesthetically vegetation was valued for its decorative colours, textures, patterns and the intrinsic appeal of nature to humans.

The spatial qualities discovered through this research are used to create building design concepts in Chapters 8 and 9. Obviously creating a house has very different parameters to creating a garden, therefore the blurring of house and garden focuses on the creation of unique residential spaces which are atmospherically stimulating. This research does not claim to achieve regulated comfort levels such as those of a typically functional house, rather it is testing spatial ideas incorporating general house design principles.

part C: EXAMPLES

chapter four:
PLANT LIFE AS AN ADDITION TO ARCHITECTURAL STRUCTURE

"Humans have physiological reactions to natural beauty and diversity, to the shapes and colours of nature, especially to green, and to the motions and sounds of other animals."

Frederick Law Olmsted

(Dramstad, Olson, & Forman, 1996)

Figure 50. IVY GROWING ON GARAGE ROOF. *Image by Author.*

Figure 51 - 52. GUINIGI TOWER, LUCCA, ITALY.

4.1 INTRODUCTION

Following on from the previous chapter which explored the spatial characteristics of gardens, this chapter explores how sensual spaces can be created utilising vegetation which is added to architectural structure. It explores what verdant technologies are currently used in architecture worldwide, the historical origins of these technologies, and examines the methods and techniques used to create and maintain these verdant elements.

Designs that integrate verdant elements with building structure need to consider the sensual aspects as well as the functional and structural implications; for both the present and future. The Guinigi Tower in Lucca (Figures 51 and 52), which belonged to the prestigious merchant family of the Guinigi, began construction in 1384. It supports several impressive Holm oaks (Quercus ilex) in three 60cm deep brick planters more than 40 metres above the ground (Grant, 2006, p. 9). Miraculously, these trees were planted around the time of the tower's construction and the building structure is still operating effectively.

In contrast, the trees growing at the approximately 1000 year old ruins of Ta Prom temple in Angkor, Cambodia (Figure 53), have had an interesting impact on the temple. The *Tetrameles nudiflora* have wrapped their roots around the sandstone building ruins, stabilising them. Whilst making themselves part of the structure, they cannot be removed without immediate restoration of the ruins (Blanc, 2008, p. 81). The *Ficus* species as shown in Figure 54 is much more destructive; it has strangled the *Tetrameles nudiflora* host and has grown into tiny cracks prising open the stones of the wall (Blanc, 2008, p. 82). While the trees at the Ta Prom temple were not deliberately grown, the building's placement amongst verdant surroundings allowed these trees to easily germinate and grow amongst the ruins.

These examples demonstrate the effects that vegetation can have on architecture, and illustrate why it is essential to understand safe techniques for incorporating verdant elements with architecture; to ensure the many psychological and physical benefits are realised without negative effects to the structure. Green roofs, phytoremediation systems, facade greening, and living walls are explored in this chapter

Figure 53. STRANGLER FICUS, Destructive to the Ta Prom temple, Angkor, Cambodia.

Figure 54. TETRAMELES NUDIFLORA, root grows from the surface outwards, therefore wraps the structure without forceful squeezing.

4.2 GREEN ROOF

4.2.1 DESCRIPTION

Green roofs (also known as planted roofs, eco roofs, living roofs or vegetated roofs) are commonly described as a roof with living vegetation. Throughout history, they have been utilised in numerous countries as a natural insulator; keeping heat out in hot conditions and heat inside in cold conditions. This demonstrates the suitability of this element for countries with extreme variations of temperature. Such roofs are becoming common in contemporary building design due to the environmental and aesthetic benefits they provide (see Section 4.2.3).

4.2.2 HISTORY

Possibly the earliest green roofs are the legendary Hanging Gardens of Babylon, which are said to have been built around 700 BC (Figure 55). They were described as a series of vaulted stone structures forming massive plant-covered terraces with an extravagant range of trees and plants (Dalley, 1993, pp. 1, 9). The Greek historian Diodorus Siculus[7] suggests these 22.5 metre high palace gardens were built to please a Persian courtesan who was homesick for her native Persian landscape (Loxton, 1991, p. 14).

Figure 55. THE HANGING GARDENS OF BABYLON. Hand-coloured engraving by the 16th-century Dutch artist Martin Heemskerck.

Figure 56. TURF ROOF - Troldhaugen, Bergen, Norway.

7 - Greek historian who wrote in the first century AD (Loxton, 1991, p. 14)

The tradition of turf covered roofs in Scandinavian countries such as Norway and Iceland (Figures 56 and 57) dates back approximately 3,800 years (Grant, 2006, p. 5). Roofs covered with soil or mud as a method of insulation would grow grass over time to form a sod roof (Dunnett & Kingsbury, 2004, p. 15). These roofs have also been utilised for centuries in the Kurdistan region, in countries such as Turkey and Iran. Turf roofs would keep the temperature down in the hot summer and keep the heat in, in the winter (Dunnett & Kingsbury, 2004, pp. 15-16).

Figure 57. TURF ROOFED FARMHOUSE - Built in 1912, in Auster-Skaftafellssysla, Iceland, currently a museum.

4.2.3 CONTEMPORARY USE

In more recent times green roofs with a predominantly functional purpose have been incorporated into residential dwellings, as well as on large commercial buildings around the world. The improved building techniques of the twentieth century enabled the creation of these planted roofs, which help to passively cool buildings[8] and improve effects of the urban heat island[9] (Dunnett & Kingsbury, Planting Green Roofs and Living Walls, 2004, p. 7). Inherently porous green roofs also combat flooding issues by slowing and retaining storm-water runoff, thus minimising the need for costly storm-water systems.

There are many valuable benefits of green roofs for cities, environmentally and to some extent aesthetically; including where the roofs can be viewed from above, or physically accessed. However, users of the buildings with green roofs may have no connection to these more superficial benefits if they are not engaging with the vegetation physically, spatially or visually. In many cases, green roofs are purely functional and do not provide the other benefits that plants in architecture can provide to users of the space.

An example of a green roof that was designed to have a holistic effect on people is Austrian architect Friedensreich Hundertwasser's Hundertwasser-Haus (see Figure 58), which opened in 1986 in Vienna. The building is colourful and contains over 250 trees and shrubs. It is an inspiration to many and an exhibition of support for the move towards 'greening' the city; a movement originating in the late 1960's (Dunnett & Kingsbury, 2004, p. 17). The green roofs, at varied levels, provide inhabitants of the building with views out to these plants.

8 - The transpiration of green roof vegetation can lower local temperature (Weiler & Scholz-Barth, 2009, p. 10).
9 - Urban Heat Island: defined as the noticeable rise in temperature of any man made area due to the negative effects of urbanisation; including pollution, the replacement of natural surfaces by built surfaces, and changes to the physical and chemical properties of the atmosphere (Arrau & Peña, 2011).

Figure 58. HUNDERTWASSER HAUS - An apartment house in Vienna, Austria.

4.2.4 TECHNICAL CONSTRUCTION / STRUCTURE

There are two types of green roof; intensive and extensive. The factors which affect the choice are accessibility options, cost, and the level of maintenance required. It is considered easier to build, maintain and inhabit green roofs that are flat or slightly sloped; due to the high shear and gravity forces which act on the soil and vegetation layer on a high-pitched roof (Weiler & Scholz-Barth, 2009, p. 4). All types of green roof contain seven basic layers from the top down: plants, growing medium, filter fabric, drainage and water retention layer, insulation, root barrier, and a waterproofing membrane, all on top of the supporting building structure (Earth Pledge, 2005, p. 134). The growing membrane used on green roofs is different to top-soil or humus, used in a typical ground garden. Instead, it is a mineral base with minimal organic material, which is lightweight and allows for the necessary aeration, drainage and replacement of organic material (Earth Pledge, 2005).

Intensive

Intensive green roofs (see Figure 59) are often designed as places of recreational use for the users of a building. They can support a wide variety of plant types and sizes; due to their deep organic growing medium or substrate that can be from 150mm - 1500 mm deep. This allows for the growth of small trees and shrubs (Snodgrass & McIntyre, 2010, p. 21). Intensive green roofs can be planted similarly to ground gardens using seeds, cuttings or root balls (Earth Pledge, 2005, p. 136). Intensive green roofs are a high cost option, due to the supportive structure required and the regular maintenance requirements. However, the park amenity provided by intensive roofs is extremely valuable, particularly in built up urban areas with little green space.

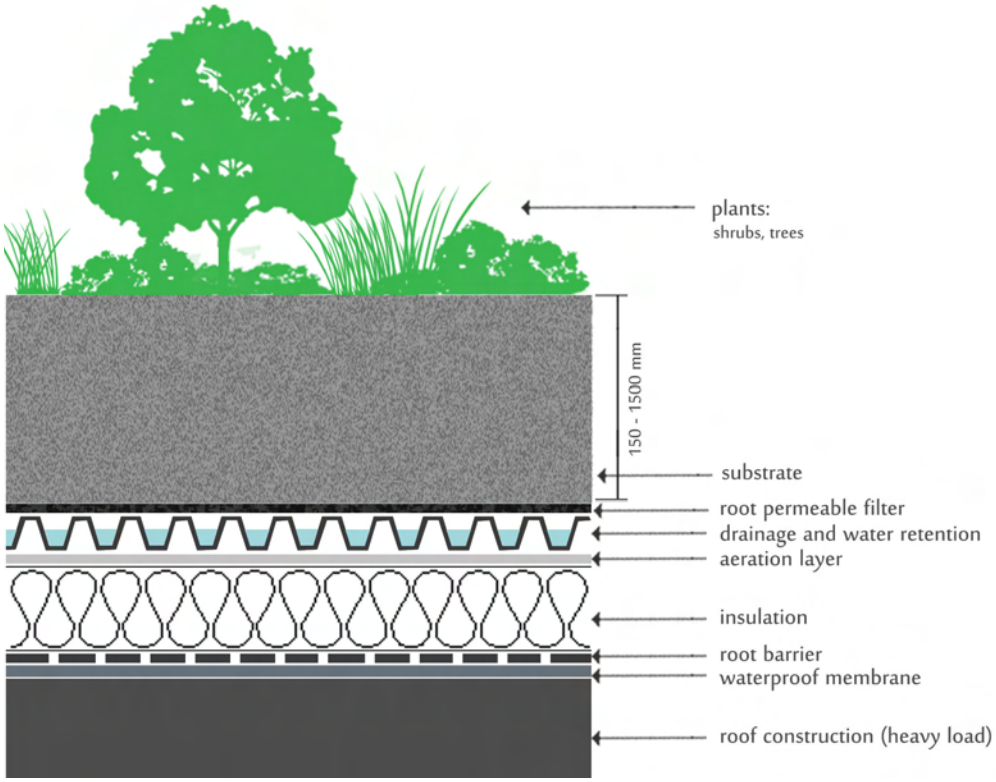


Figure 59. INTENSIVE GREEN ROOF COMPONENTS.
Diagram by Author.

Figure 60. CITY HALL'S GREEN ROOF - The rooftop tests three different systems of green roof construction Extensive, semi-intensive, and Intensive on top of a building which is over 100 years old. The roof structure only required minimal strengthening to cover over existing skylights as the existing structure was able to support the additional loads of these systems

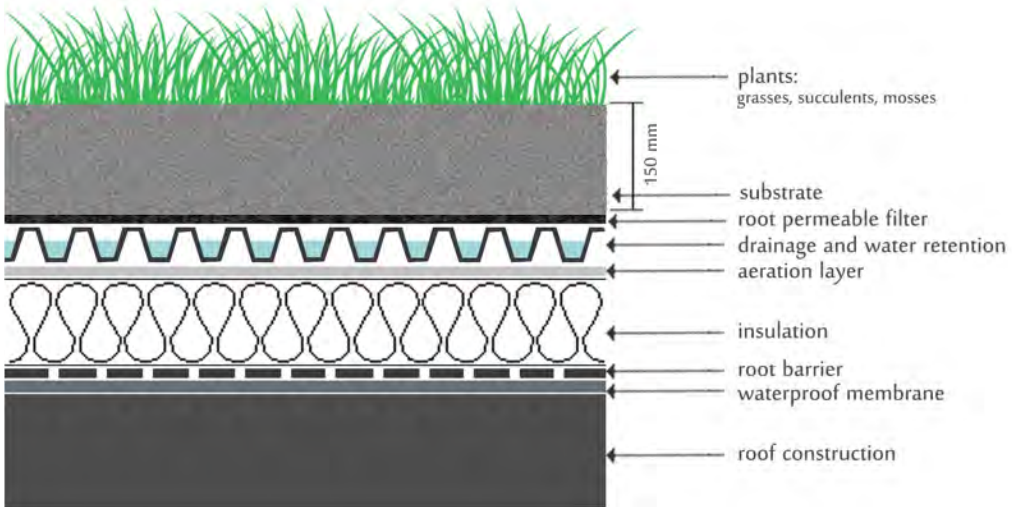


Figure 61. EXTENSIVE GREEN ROOF COMPONENTS.
Diagram by Author.

Extensive

Extensive green roofs (see Figure 61) have a shallower growing medium or substrate than their intensive counterpart; they are usually around 15cm deep, making them a lightweight structure. These roofs support mainly tough, low growing, drought resistant plants such as grasses, succulents and mosses; however, more colourful accent plants are often mixed in (Snodgrass & McIntyre, 2010, p. 22). There a number of different methods for planting an intensive green roof such as cuttings, seeds, pre-cultivated mats, plugs, or modular systems. Modular systems can be described as interlocking blocks, which contain drainage materials and pre-grown plants in soil (Earth Pledge, 2005, p. 136). Extensive roofs are used on buildings that are not accessed by people, apart from for maintenance purposes (see Figure 60). They are used commonly as a low cost option, which functions to reduce the heating and cooling requirements of the building, protect the roof surface and benefit the surrounding ecology.

4.2.5 WATER SYSTEMS REQUIRED

Extensive green roofs should not require irrigation if they have an appropriate plant mix and substrate. Intensive roofs, including those using New Zealand Native plant species, require regular irrigation to ensure constant growth at all times of year (Thorne & Thorne, 2009). There are four main irrigation systems used:

Traditional sprinkler systems: these spray water on the surface making them wasteful of water and problematic as they can encourage surface rooting.

Drip and tube systems: These are either buried in the substrate or pegged to the surface. Buried pipes are more effective as they direct the water straight to plant roots.

Capillary systems: Water introduced at a small number of locations distributes water to the whole roof through porous mats. These mats can only be used in shallow substrate depths of 20cm or less otherwise the water will not infiltrate all of the substrate.

Standing water systems: a layer of water is maintained at the base of the roof; either filled by rainwater or filled by a water supply regulated by floating control devices. (Dunnett & Kingsbury, Planting Green Roofs and Living Walls, 2004).

4.2.6 COOLING AND INSULATION PROPERTIES

Green roofs are effective both in summer and in winter, however research has shown the most substantial benefits to be in summer where plants and substrates shade the roof surface and cool the air through evaporation (Dunnett & Kingsbury, 2004, p. 72). The cooling effect of a green roof increases with those buildings which are low and flat rather than those that are tall and thin (Martens & Bass, 2006). This is because the surface area of the green roof is larger and therefore has more of an effect on the smaller building volume.

4.2.7 PROBLEMATIC PROPERTIES

While extensive green roofs are generally lightweight, intensive green roofs have more serious structural and weight implications. The design of an extensive green roof onto an existing building will only increase the loading by approximately 70 to 170 kg/m² in contrast the heavier intensive counterpart will increase the loading by anywhere between 290 and 970 kg/m² (Dunnett & Kingsbury, 2004, p. 92). This however will obviously not cause issue where the building is designed to bear the load.

Figure 62. ACROS BUILDING - South side, photograph shows continuation of the park with the building. Intensive green roof designed to support soil and plant loads

4.2.8 PRECEDENT 1: ACROS BUILDING - FUKUOKA, JAPAN

Details

Completed in 1995, the Fukuoka Prefectural International Hall or ACROS (Asian Crossroads Over the Sea) building (Figure 62 and 63), encompasses the identity of both a park and a building. Located in Fukuoka, Japan it was designed by architects Emilo Ambasz and Associates and the Nihon Sekkei Tekenaka Corporation (Grant, 2006, p. 65). The buildings fifteen verdant terraces and four underground floors reach a height of 60 metres and provide a total floor space of 97,252 square metres (Velazquez, 2010).

Concept

The building is sited on the only park in Fukuoka's city centre. Ambasz's 380 million dollar design was commissioned, as it maintained the green space of the park over the full height of the building while providing the city with a much needed multi use building (Emilio Ambasz and Associates, 1999-2011). This building innovatively solves a common problem of decreasing space in heavily populated cities and manages to integrate green amenity with a functional building. It fits with the two differing contexts it is part of; continuing the adjoining Tenjin Central Park to the south, and facing an elegant northern facade onto what Velazquez considers to be the most prestigious street in Fukuoka's busy financial district (Velazquez, 2010).

Designed as a new government building, the structure contains a museum, exhibition hall, conference facilities, a large proscenium theatre, a large number of government and private offices, retail and underground parking spaces (Emilio Ambasz and Associates, 1999-2011). Two external staircases can be used by the public to ascend to the top of the building. From these staircases, beautiful views are available down over the building and across the city (Velazquez, 2010).

Technical Construction / Structure

The structure is steel-framed reinforced concrete. This supports the four metre high terraces with a depth of six metres; providing a space for meditation and relaxation (Velazquez, 2010). These low landscaped terraces with growing medium depths from 30 -60 cm contained 37,000 short evergreen, deciduous and conifer trees of 76 varieties, ranging from 1.7 to 1.9 metres tall when

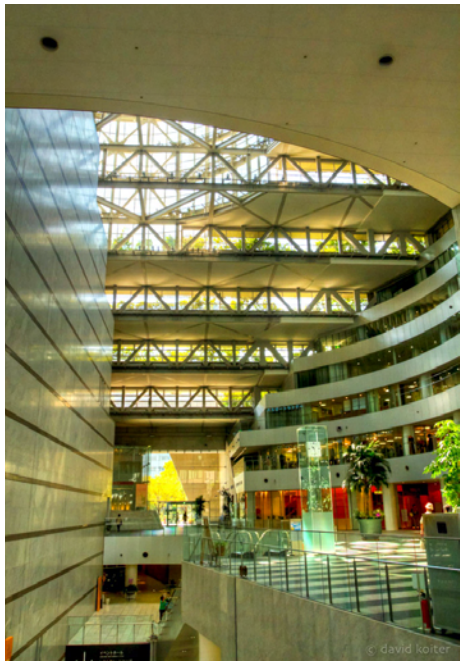


Figure 63. THE ACROS BUILDING'S INTERIOR

constructed in 1995 (Takenaka Corporation, 2005 - 2011). There are now over 50,000 plants of 120 varieties growing on the building; this increase is due to the spreading of seeds by birds (ACROS Fukouka, 2008). This increase is a practical example showing how eco-systems can greatly benefit from verdant buildings in densely populated cities with little green space.

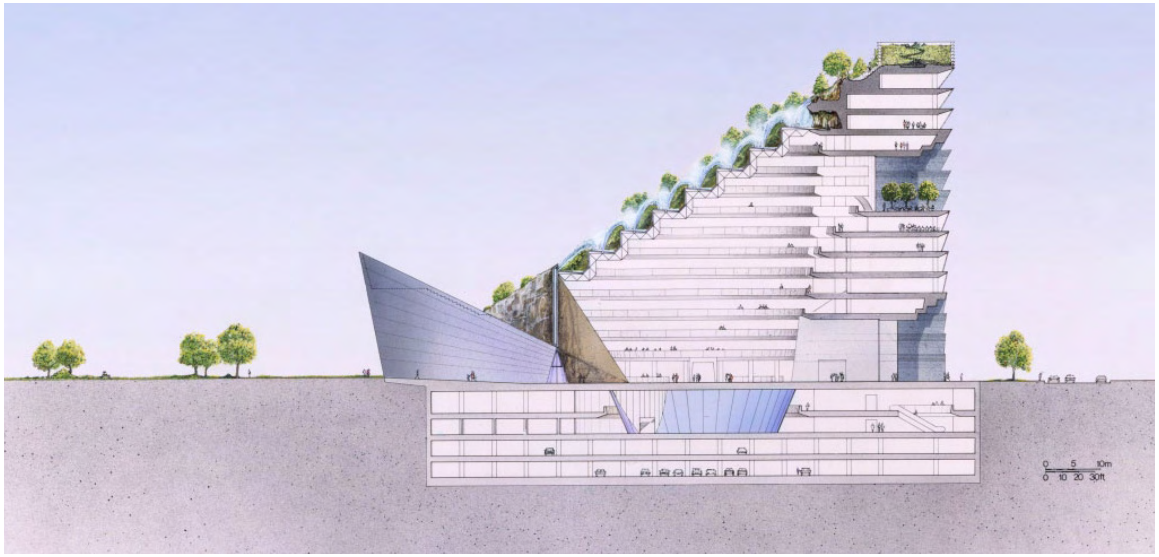
Stepped Garden

The stepped garden is composed of number of horizontal green-roofs, where the heights of some plants, and the cascading foliage of others, cover the vertical concrete surfaces; this creates the illusion of a completely landscaped mountain. This covering of plants and their supporting structure inhibits views to the vegetation from the inside of the building when not in the central atrium space (see Figure 64). Figure 65 is a section cut through the centre of the building through the atrium space where the plants grow only on the horizontal plane; a different structural system allows light to enter into the atrium space and provides views to the verdant elements from inside the building.

Services

The building efficiently reuses rainwater and passively cools it's immediate locality. Rainwater is collected on the roof and from there it filters down the building, through the water retaining artificial soil where it is collected in a large tank at the bottom. This water is then used in offices and toilets throughout the building (Condon, 2011). Above the atrium space, water from the rainwater collection tank is also used to create a ladder like waterfall down the stepped gardens; pools on each terrace create this illusion by spraying jets of water placed on each vertical rise. This water aims to mask the ambient noise of the city beyond (Velazquez, 2010). The clerestory glazing separating the pools allows diffused light to enter the atrium space below.

The 34.5 degree foliage covered terraces shade the building's exterior during the day, keeping the internal space cool. Temperatures around the building's vicinity are kept comfortably cool at night; this cooling effect comes from a downdraft created by the radiation cooling of the plants' surface temperatures, which then cools the air and creates a gentle breeze down the terraces (Takenaka Corporation, 2005 - 2011).



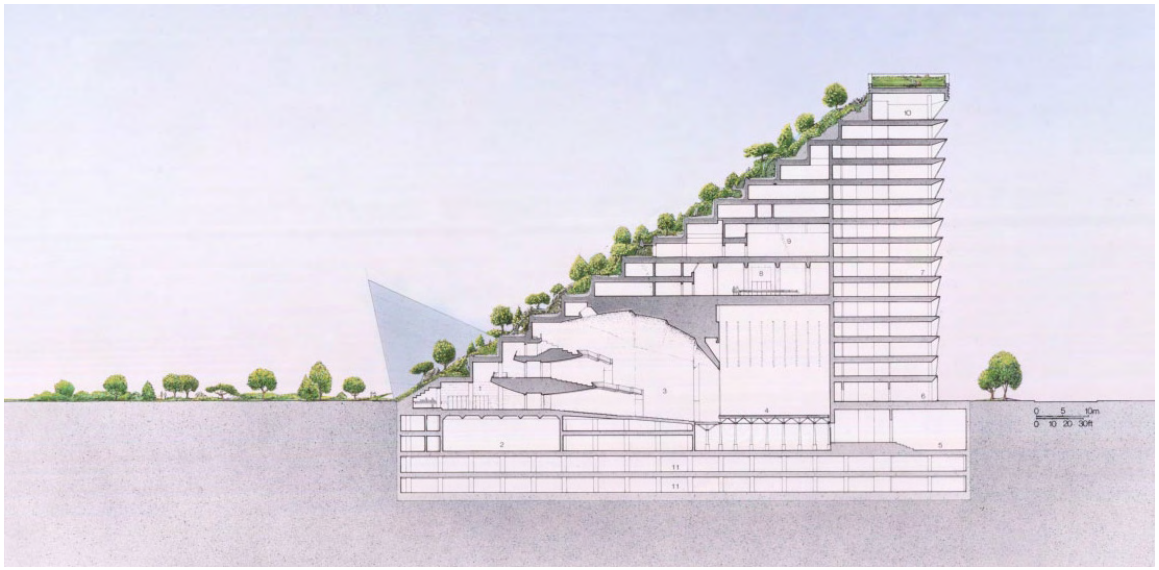
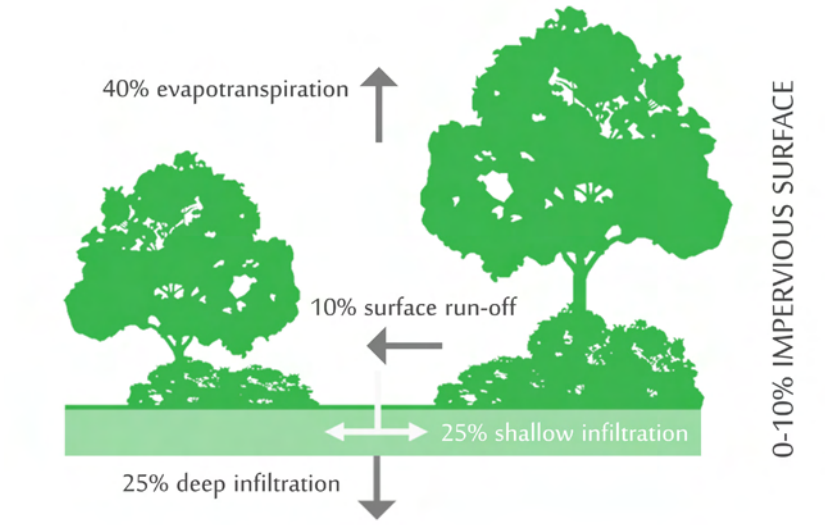
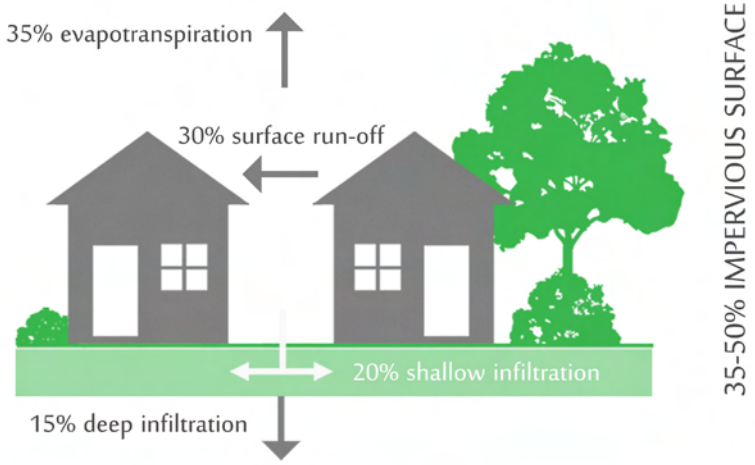


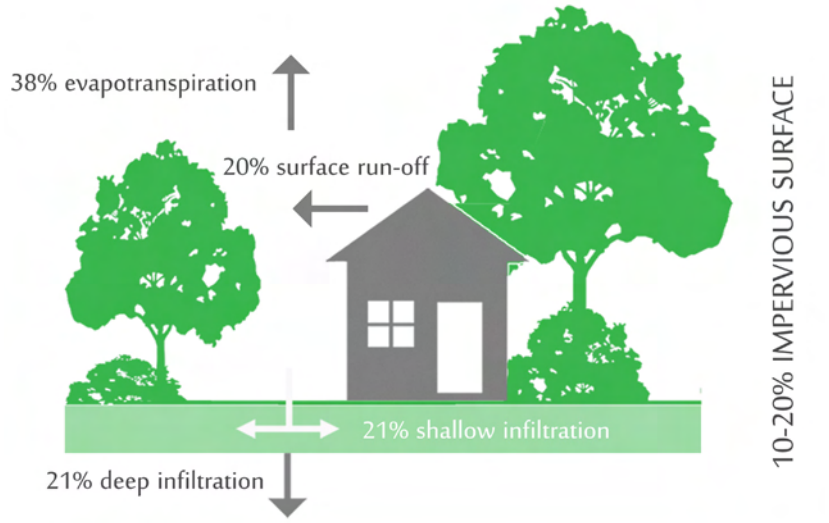
Figure 64. Above. Cross Section through the centre of the ACROS building where light penetrates through glass, water and plants to reach the interior atrium space.
Figure 65. Section through more solid structure of the building further left from the atrium space.

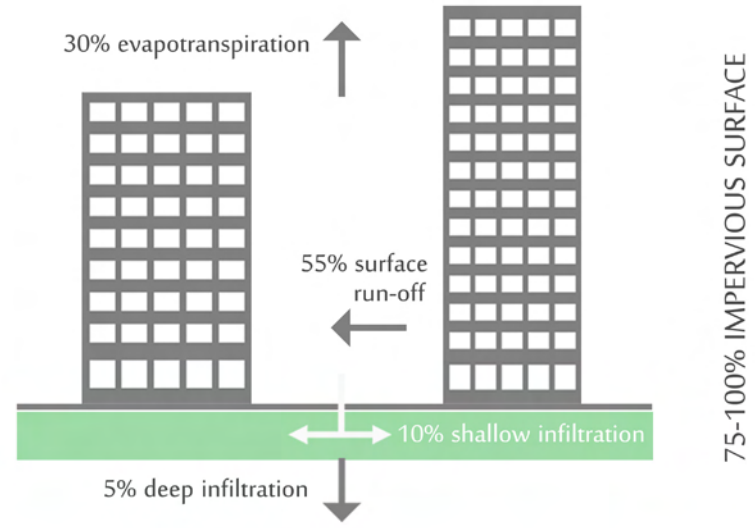
Conclusion

The green elements of this structure have been well integrated with the building and its context. They are an integral part of the form, and the stepped garden is imperative to the purpose and function of the building. Many of the benefits of the green roof are increasingly significant at the larger city scale; it provides a green amenity for the public, urban cooling, and brings birds and insects to the city centre. Inhabitants of the building are also provided with what is said to be the best view from an office in Fukuoka as there is visual access to some of these verdant plants when inside the building. The south-facing stepped garden shades and encloses the building, blocking hot sun while still providing sight-lines to the verdant plants from the atrium space. The glass on the plant-free northern side allows light in, while preventing heat-gain issues. It is somewhat of a pity that not all of the spaces along the verdant edge have views out to the stepped garden. However integration of the necessary structure for a building of this scale, as well as the functional aspects required to keep a garden of this scale alive, makes it a great achievement that so many of the interior spaces are positively affected.


40% evapotranspiration
10% surface run-off
25% shallow infiltration
25% deep infiltration
0-10% IMPERVIOUS SURFACE


35% evapotranspiration
30% surface run-off
20% shallow infiltration
15% deep infiltration
35-50% IMPERVIOUS SURFACE


38% evapotranspiration
20% surface run-off
21% shallow infiltration
21% deep infiltration
10-20% IMPERVIOUS SURFACE


30% evapotranspiration
55% surface run-off
10% shallow infiltration
5% deep infiltration
75-100% IMPERVIOUS SURFACE

4.3 PHYTOREMEDIATION SYSTEMS

4.3.1 INTRODUCTION

Phytoremediation is described as the process of alleviating pollutant concentrations in contaminated soils, water or air, with plants (Oxford English Dictionary Online, 2011). Water is an increasingly precious resource and its natural cycles are often inhibited in the human built environment. Treating polluted water through the use of plants allows water to be managed and reused on site. In the natural water cycle, rainwater filtrates through permeable ground into groundwater, or is evaporated back into the environment. However, in built up areas, human development prevents this process from happening and water is taken away in pipes and drains to treatment centres, streams or rivers (Dunnett & Clayden, 2007). Figure 66 visually explains the process of storm water movement. It shows that when built form replaces natural surfaces, storm water is no longer able be entirely dealt with naturally.

There are a number of ways rainwater, storm water and household grey water can be captured and reused resourcefully through specifically designed gardens. Dealing with water locally on each property reduces flooding and pollution problems by decreasing the load on the infrastructure that supplies and removes water. There are differing systems to utilise natural rainfall and household wastewater specific to different scenarios. Two systems will be explored in this section: rain gardens, which filter natural rainwater; and bio filtration systems, which treat grey water.

Figure 66. Left. RAINWATER BALANCE. Increasing impermeable surfaces cause increase in surface water runoff. *Diagram by Author.*
Interception: capture of rainfall or run-off by soils or plant leaves and stems and subsequent collection of water
Infiltration: downward movement of water through soil
Evaporation: water evaporates back into the atmosphere, from shallow pooled water and plant and soil surfaces
Transpiration: plants evaporate water from leaves back into the atmosphere
(Dunnett & Clayden, 2007, pp. 40-41)

4.3.2 RAIN GARDENS / BIORETENTION PONDS

Description

Rain gardens (see Figure 67), otherwise termed bioretention areas, are an easily employable concept that can make a significant difference to the management and recycling of water used in cities and towns; especially in largely landscaped residential areas. Technically a rain garden is defined as a shallow depression planted with a range of trees and shrubs and then covered with a layer of ground cover or mulch (Dietz & Clausen, 2005, p. 124). They take the rainwater run-off from a building and encourage its infiltration into the soil (Dunnett & Clayden, 2007, p. 13). This reduces the load of water moving into the storm water infrastructure, whilst also providing the site with a flourishing and functional garden. Similarly storm water planters complete the same process, generally in a smaller garden space (see Figure 68).

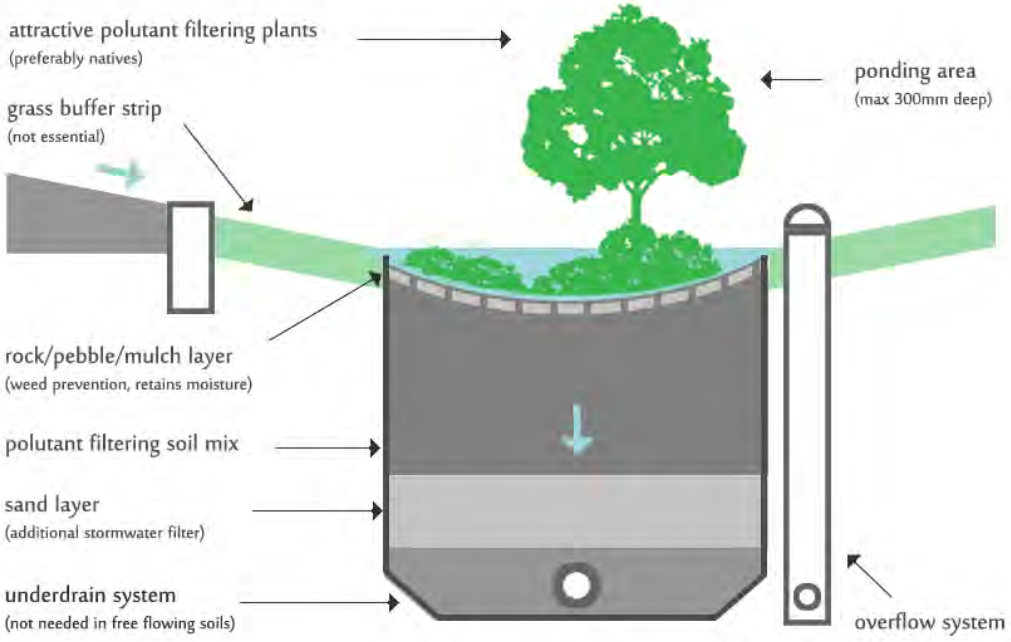


Figure 67. RAIN GARDEN CONSTRUCTION. *Diagram by Author.*

The ability of plants and soils to clean contamination from water happens through a series of processes:

Settling: suspended solids and particles settle in water ponds

Filtration: particles are filtered as they move through soil and fibrous plant roots

Assimilation: plants take up nutrients for their growth

Absorption: dissolved substances are attracted to, and bind to plant roots, soil particles and humus.

Degradation and decomposition: chemicals and organic matter are broken down by soil microorganisms. (Dunnett & Clayden, 2007, p. 42).

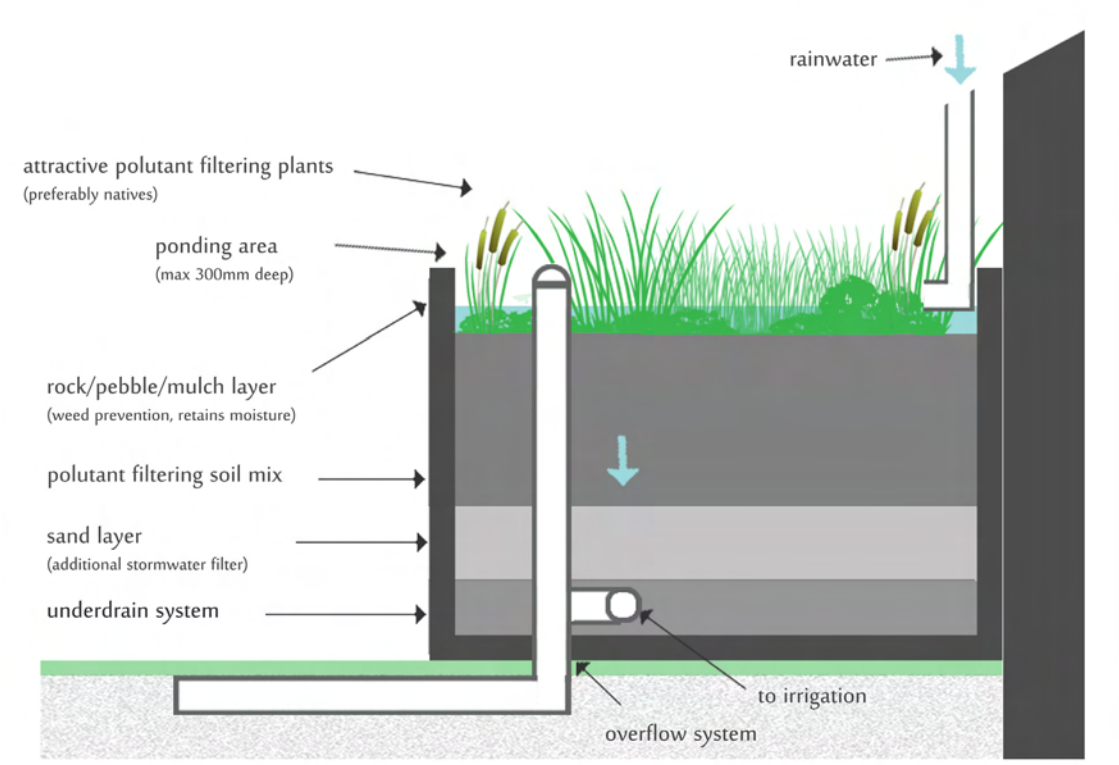
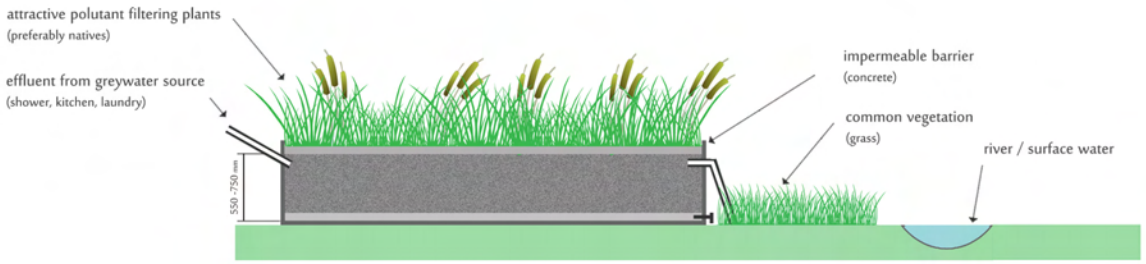


Figure 68. FLOW-THROUGH STORMWATER PLANTER BESIDE HOUSE. . *Diagram by Author.*

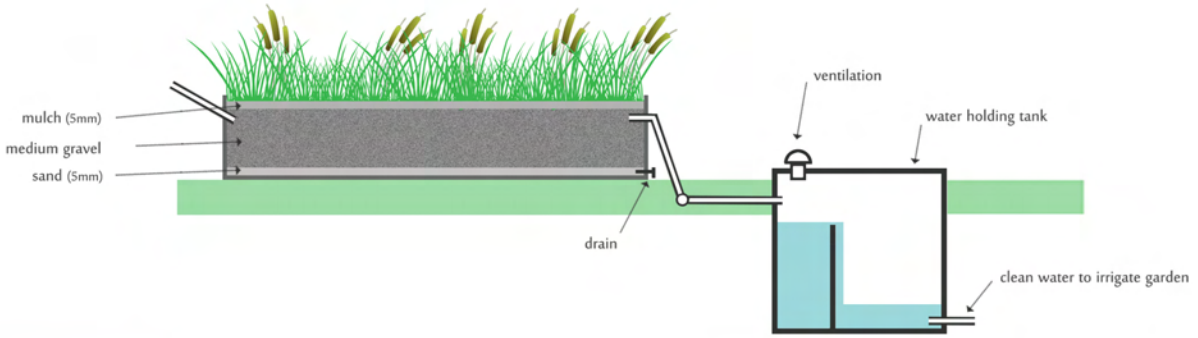
Planting

Typically plants used in the rain garden are natives, as they are well adapted to the locality; however many exotic species are also suitable (Low Impact Development Center, Inc. , 2007). Dunnett & Clayden show that rain gardens promote the planting of a variety of species. The more diverse the planting, the greater the benefit, due to the functional characteristics of differing plant types. Utilizing different plants means some can soak up excess run-off, while others deal with pollutants or contaminants in the water (2007, p. 15). Plants used need to be able to withstand the extremes of both flooding and drought (and the resultant changing levels of water) to ensure the garden stays alive at all times of year.

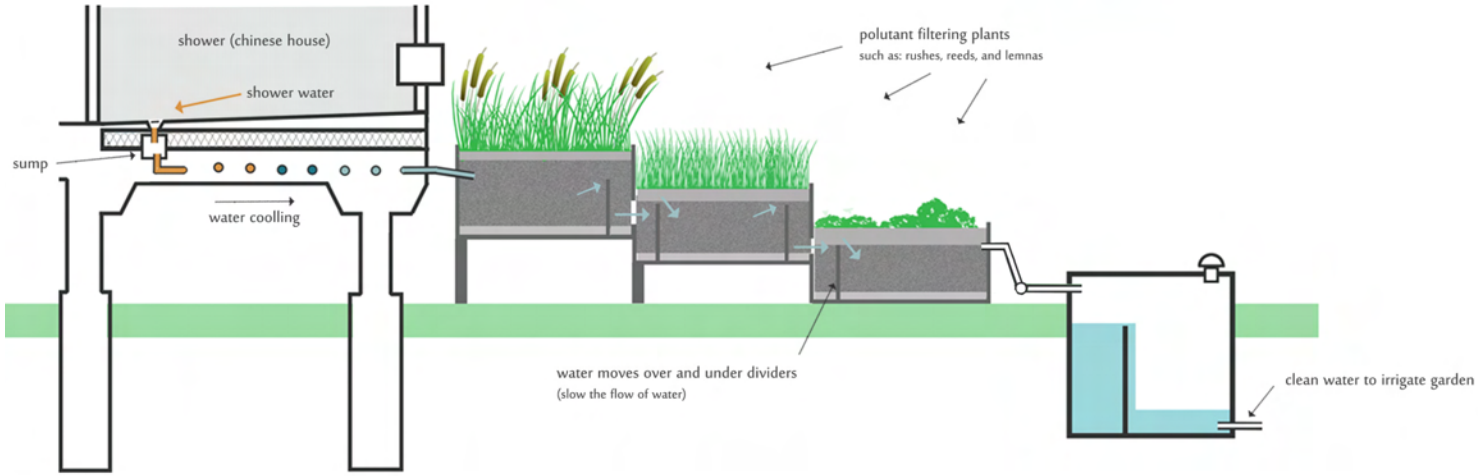
GREYWATER BIOFILTRATION TO RIVER (subsurface)
Figure 69.



GREYWATER BIOFILTRATION TO HOLDING TANK (subsurface)
Figure 70.



STEPPED GREYWATER BIOFILTRATION (subsurface)
Figure 71.



4.3.3 GREY WATER BIOFILTRATION - CONSTRUCTED WETLAND SYSTEM

Description

Grey water is the wastewater produced from kitchen and bathroom sinks, showers, or clothes washing. To treat grey water, a bio filtration system can be used where contaminants are removed from water by plants and soil (see Figures 69, 70 and 71). Greywater biofiltration systems work differently to rain gardens, where water is encouraged to pond. In biofiltration systems, the water constantly moves slowly through mechanical and biological processes where both the plants and microbes in the system filter contaminants from the water (Yocum, 2007, p. 1). In subsurface wetlands the grey water flows beneath the soil's surface, preventing ponding which can cause the water to develop dangerous pathogens (Dunnett & Clayden, 2007, p. 43). As the water moves through the soil and plants, suspended solids settle into the substrate. The plants then transfer oxygen to their submerged roots where microbes break down pollutants and organic material (Yocum, 2007, p. 2). Using a series of beds with differing depths of materials and plants allows the different contaminants to be removed from the water. This process produces water, which can be used for non-potable[10] uses on the same site.

4.3.4 DISCUSSION

Water is no longer viewed as an infinite resource. It is becoming acknowledged worldwide that systems to retain and preserve water are necessary to maintain current levels of water use. Phytoremediation systems allow private verdant spaces to become a more helpful part of the waste water chain. They improve the environmental impacts by providing treated water on-site, that can be used for irrigation, toilet flushing, and other non-potable uses. As well as their functional benefits, they create attractive and contextually appropriate spaces which privilege native plants and climate. In a large verdant house which requires a lot of watering the capturing and reuse of water would provide a large amount of this water for irrigation.

10 - Non-potable: Water which is unsafe to drink as it does not meet the requirements of drinking water standards.

4.3.5 PRECEDENT 2:
PHYTO-PURIFICATION BATHROOM

Concept

The Phytobalaneun or Phyto-purification bathroom (see Figures 72 and 73) is a conceptual design developed by Jun Yasumoto, Alban Le Henry, Olivier Pigasse and Vincent Vandenbrouck. It is a self-contained shower design, which uses the natural principle of Phytoremediation. The plants used in the design contain, degrade, or eliminate contaminants from wastewater, allowing it to be used again, thus limiting the consumption of water (Vandenbrouck, 2003).

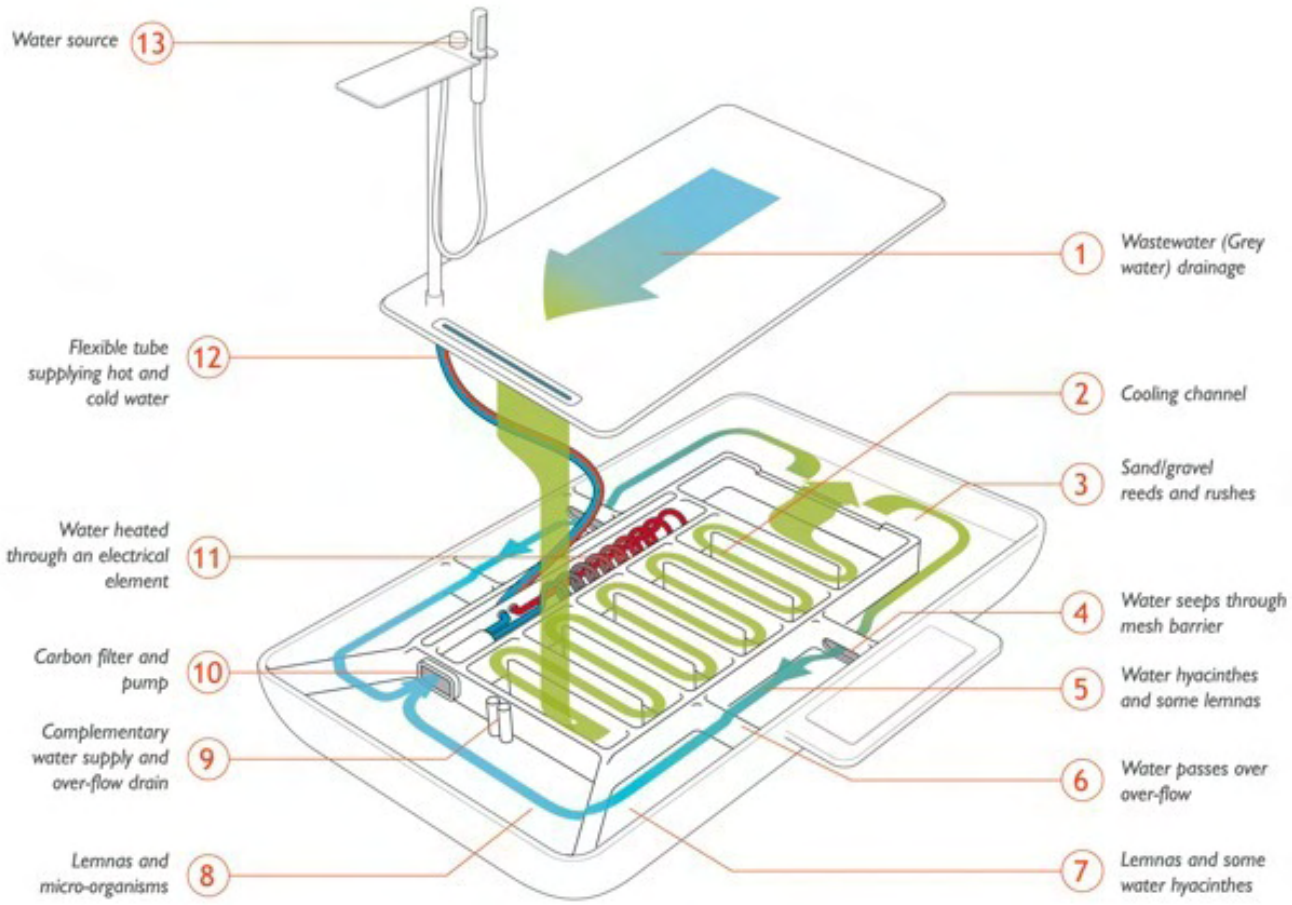


Figure 72. Left. THREE DIMENSIONAL VIEW OF PHYTO-PURIFICATION BATHROOM.
Figure 73. DIAGRAM OF THE WATER MOVEMENT AND PROCESSES.

Function

As a person showers the hot water runs into a drain. Before it is processed it passes through a cooling chamber, and is then filtered through different plant compartments. Jun Yasumoto explains the role each of the plants has in the system. The roots of the rushes break down and absorb particles, which have been filtered by the sand they are planted within. The reeds lift heavy metals from the water, the floating water hyacinths remove water-borne particles through their roots, and the lemnas (aquatic plants) bind to the remaining aquatic micro-organisms (Yasumoto, 2003).

Conclusion

The design of this system is not only exciting technologically, but spatially: the plants themselves form a screen to shower behind; which would change in depth, height, colour, and texture, regularly. This system is compact and demonstrates how the use of plants in architecture can create experiences as part of everyday living.

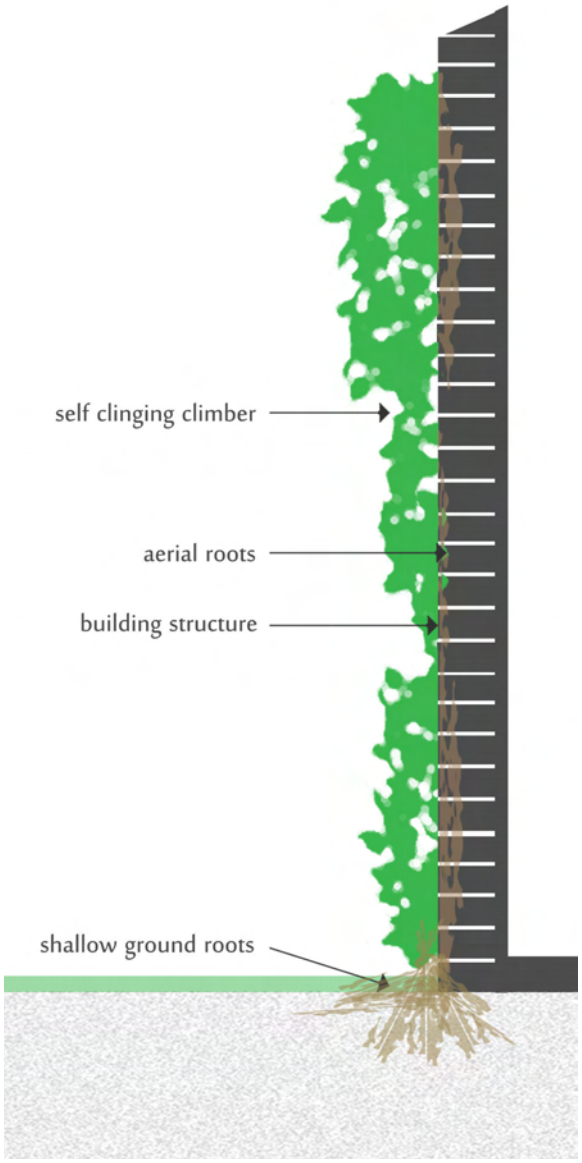


Figure 74. SELF CLINGING CLIMBER (Facade Greening).
Diagram by Author.

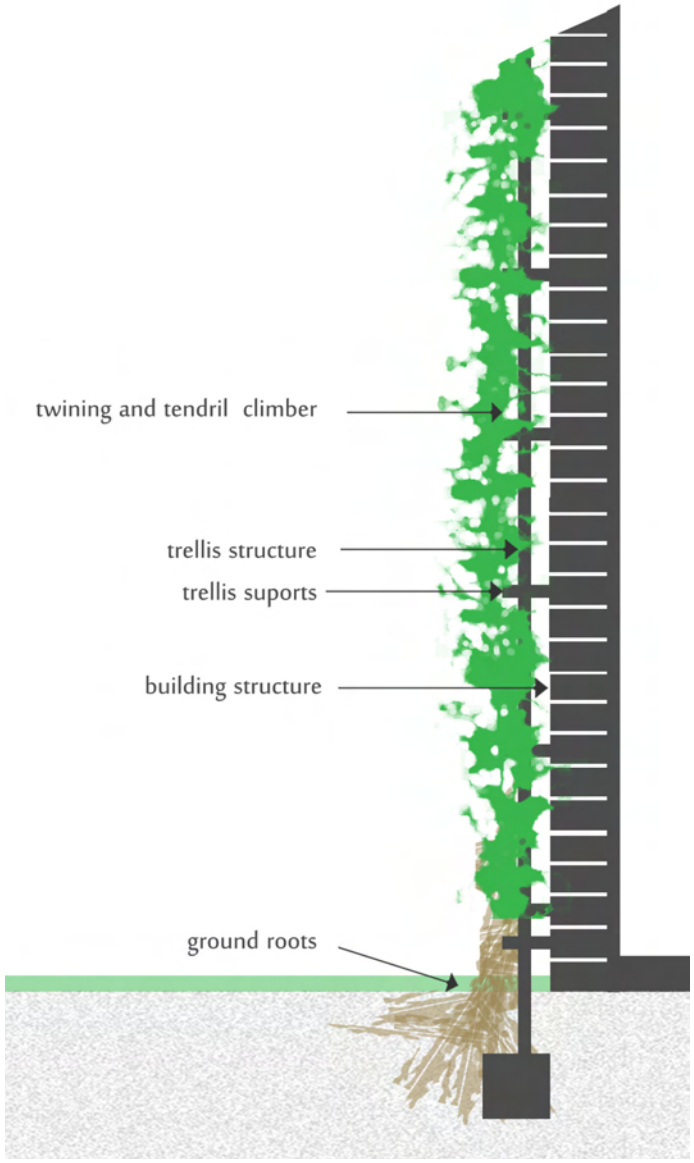


Figure 75. TWINING AND TENDRIL CLIMBER (Facade Greening).
Diagram by Author.

4.4 FACADE GREENING

4.4.1 DESCRIPTION

Facade greening can be defined as vegetation growing on a building's exterior. Two types of facade greening have been incorporated on building exteriors throughout history: one is the utilisation of self-clinging climbers (see Figure 74) and the other is twining and tendril climbers (see Figure 75), which require accommodating additions to a building's structure.

4.4.2 SELF CLINGING SPECIES

It can be assumed that self clinging species have grown wild over buildings since people started to settle in permanent dwellings (Fassadengruen, 2011). In the Romantic era facade greening was particularly fashionable; plants grew over the walls of Medieval castles, utilizing exotic colourful climbers and the commonly known species, ivy *(Hedera helix)* (Fassadengruen, 2011). The most common species used in temperate climates today include ivy, as well as Boston ivy *(Parthenocissus tricuspidata)* and Virginia Creeper *(P. quinquefolia)*; the latter two species are admired for the change to a red colour in autumn (see Figure 76). These visually pleasing species continue to be used around the world to turn building surfaces lush green with minimal or no effort required by humans. However to prevent these species[11] from problematically damaging the building materials, self-clinging climbers need to be carefully selected and regularly maintained and pruned. Where such care is not taken tendrils, which grow into materials such as mortar, and gaps, may consume and crack the structure.

4.4.2 TWINING AND TENDRIL SPECIES

In comparison the twining and tendril climber does not negatively affect building structure. Ancient Egyptians grew twining and tendril species on pergolas to create delightful shade in outdoor residential spaces (see section 3.2.2). Similarly, the grape vine (see Figure 77) has been propagated by humans since the Romans introduced it to Central Europe around 1000 AD (Fassadengruen, 2011). These climbers require a frame work to wind around and therefore usually have a purpose-made structure

Figure 76. Above. VIRGINIA CREEPER. Displaying its red colouring in Autumn in Cambridge, England.
Figure 77. Historical depiction of Grape vines on structural supports (16th or 17th century) from wine museum in Unstrut, Germany.

11 - Ivy: Originally brought to New Zealand around 1873 as an ornamental species, it is now regarded as a weed in New Zealand due to its invasive properties, which mean it can smother and kill plants in its path and destroy the integrity of building structures (Royal New Zealand Institute of Horticulture, 2010).

Figure 78. Above. Detail of a flexible grid facade greening system using stainless steel rods.
Figure 79. Imperial Glory *(Ipomoea violecea)* Growing on a tensioned wire cable system.

on which to grow; preventing damage to the building structure behind. One restriction seen with these climbers as noted by Nigel Dunnett and Noel Kingsbury is that twining and tendril climbers, unlike the self clinging species, would often struggle to grow above two storeys (2004, pp. 5, 191).

4.4.3 MODERN FACADE GREENING

The aim of modern facade greening systems is to allow entire building facades to be attractively turned green whilst protecting the building from plant-induced damage. The modern approach utilises twining and tendril climbers on trellis-work or systems of stainless steel rods (see Figure 78), cables (see Figure 79), nets and meshes, which allow plants to climb facades without touching the building structure itself (Grant, 2006, p. 56). Climbing plants are rooted into the ground; from there they grow up the trellis members creating green screens as a layer over a building's facade. These green screens cool the building in summer by providing sun shading to the facade and cool convection currents. Deciduous plants can be particularly helpful in temperate climates where sun is kept off the building in the summer, but is able to warm the building in the winter (Grant, 2006, p. 56). Some systems over particularly tall buildings may have numerous planter beds at different levels up the building to create a green facade over the full height of the building.

4.4.4 DISCUSSION

These systems are simple and can be added to practically any existing facade easily and inexpensively; they are also able to create green facades in any context through the selection of plants which are suited to a building's climate, and orientation in that climate. While these facades are successful in achieving physical benefits for the external and internal environment, like most of the other systems where vegetation is added to structure, they fail to affect the interior spaces psychologically. In Section 5.2, semi transparent living wall / facades are discussed; which have similar construction methods without the presence of solid building materials between the green facade and internal space. These systems provide positive psychological conditions for the observer, either through the use of a glass wall, allowing visual access to the green facade, or the stimulating use of these verdant structures, as a wall themselves.

4.5 LIVING WALLS

4.5.1 DESCRIPTION

Living or green walls provide similar functional and visual effects to the facade greening techniques discussed above, however methods of constructing living walls differ slightly. The surface that the selected plants grow on is attached to the surface of an existing building's facade or internal wall; consequently completely covering the materials of the solid wall underneath. In new buildings, the living wall may become the building facade itself attaching to supportive building structure. Lloyd Alter explains that living wall structures can be easily designed into a new building; or retrofitted onto an existing structure, as the structural loading is not significant (Growing Up, 2008).

4.5.2 TECHNICAL CONSTRUCTION / STRUCTURE

There are a multitude of different methods for the construction of living walls. These include: modular units, hydroponic systems, gabions, dry stone construction, stacked bags, and planted geo-textile pockets fixed to walls (Grant, 2006, p. 58). This research will look at two of the most common methods of creating living walls; modular and hydroponic systems.

Modular living wall systems

Modular systems are commonly used to create living walls, as the pre-planted modules can be easily arranged, as needed, to fit to the shape of their host wall. The modules commonly consist of a plastic housing, which contains a growing medium within a fabric case. This keeps plants and their roots inside the module (Margolis & Robinson, 2007, p. 150). Modules are then supported by a strong frame and structure to ensure the wall is secure. There are various watering systems, which are often enclosed within the walls themselves, providing an automated supply of water for the plants. Often the modules are pre-grown, planted with contextually appropriate plants, allowing the wall to be almost instantly functional once constructed.

Hydroponic living walls

Another common way to create living walls is with hydroponic systems. These systems rely heavily on water to keep plants alive. Margolis and Robinson explain that in the Naturaire system a 5cm thick synthetic mat provides the constantly wet membrane for the selected plants to become embedded in. This particular system pumps water from a bottom reservoir to the top of the wall where it drips back down the synthetic mat (Margolis & Robinson, 2007, p. 170). Air is also drawn through the planted wall or bio filter using a fan behind the wall. This process cleans and cools the air for distribution to other areas of the building (Margolis & Robinson, 2007, p. 170). Hydroponic living walls are functional and beneficial for internal spaces, however they constantly require power and water to keep them functioning.

A specialist in the creation of hydroponic living walls is the botanist and researcher Patrick Blanc. He has created over eighty hydroponic vegetated walls since 1988 (Grant, 2006, p. 58). Patrick was interested in plants from a young age and consequently studied natural sciences at university. Trips to Thailand and Malaysia as a student provided inspiration, which would lead to the invention of the living wall. Blanc recognized how many magnificent plants are capable of taking hold on any support at any height providing there is water available. Over numerous years he tested what materials he could utilise to create stable vertical living environments for the plants he had observed in their natural environments (Blanc, 2008, pp. 8-9). He invented a process whereby plants of all types can be grown on the face of a wall; it consists of a water-soaked mesh-covered felt, which plant roots attach to, eliminating the need for any soil (Blanc, 2008, p. 97).

Patrick Blanc's designs rely heavily on a constant supply of water and nutrients. These necessities are pumped from a reservoir tank to the top of the wall where they then drain back down into the tank (Grant, 2006, p. 58), keeping the felt which the plants grow in constantly wet. These walls have a very high potential to provide cooling, but also require regular maintenance to ensure that the water supply is constant; otherwise, the plants may suffer (Grant, 2006, p. 58). While his works are beautifully eye-catching, they appear to come after the building has been designed, added as an addition to typically-shaped spaces and forms. It would be exciting to see this technology used to create unconventional space, which privileges the plant and creates architecture that is specifically sensual, due to its holistically considered inclusion of a living wall.

4.5.3 EXTERNAL LIVING WALLS

Specially created external living walls are appreciated features of new and existing buildings around the world. Living walls, which can be designed to be any size and shape, provide colour and texture as well as environmental benefits such as insulation for buildings. They also encourage biodiversity, assist in the absorption and filtering of storm water runoff, reduce the urban heat island effect, and filter air particles; consequently improving air quality (Vertical Plantscapes, 2011). These walls are positive for the internal environment of the buildings they are attached to, and for their streetscape, as they provide nature within the city's often harsh man-made environment. However the users of the building are missing out on the contact with nature. From the inside, the buildings often function without appreciation of the living wall.

Figure 80. GREEN WALL AT JEAN NOUVEL- FOUNDATION CARTIER, 1991-94. - by Patrick Blanc.

Figure 81. VERTICAL GARDEN AT THE QUAI BRANLY MUSEUM - Paris, by Patrick Blanc.

Figure 82. VIEW OF STRUCTURE AT THE QUAI BRANLY MUSEUM - Paris, by Patrick Blanc.

4.5.4 INTERNAL LIVING WALLS

Living walls can also be used inside building spaces. This is a particularly exciting technology, which adds attractive visual elements to spaces whilst also benefiting the internal environment. When used inside, living walls improve air quality, reduce noise transmission, and provide inhabitants with a relaxing green work or home space (Maccaferri New Zealand, 2011). However, a problem with internal living walls is that they are often not designed as part of the architecture; they are instead treated as an addition to a building feature of a particular space. Consequently they miss out on the space-creation possibilities they have to the potential to provide. Consideration of the needs of living walls for day-lighting may also be neglected, where instead artificial light is used to maintain them.

4.5.5 DISCUSSION

These technologies are relevant to current building practice, which places emphasis on sustainable buildings and buildings that are ‘green’ in appearance. They are beneficial if all aspects of the buildings construction and function are considered. For example a large, highly air-conditioned, over-glazed building with one beautiful interior green wall is still an unsustainable building. Noticeably green technologies need to be part of the entire building to improve human comfort and experience within living environments. Living walls, which affect only the inside, or only the exterior are appropriate for many contexts, including New Zealand. However, in New Zealand’s temperate climate these walls could be further utilised to challenge the typical materials of buildings by creating architectural elements using vegetation.

4.5.6 PRECEDENT 3: HARMONIA 57 - SAU PAULO, BRAZIL

Details

Harmonia 57 completed in 2008 is located in Sao Paulo, Brazil (Figure 83) and was designed by Triptyque Architects: Greg Bousquet, Carolina Bueno, Guillaume Sibaud and Olivier Raffaelli. Originally designed as a series of six artists' studios, it is now a flagship clothing store (Bullivant, 2009) with a 500 sqm site area and a constructed area of 1,060 sqm (Saieh, 2008).

Figure 83. STREET FRONTAGE, HARMONIA 57, SAU PAULO, BRAZIL

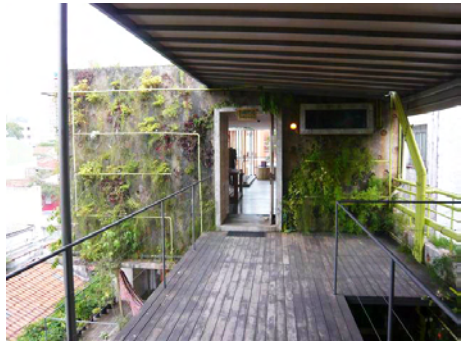


Figure 84. Above. IMAGE SHOWING THREE STOREY'S - Harmonia 57
Figure 85. OUTDOOR SPACE - Harmonia 57

Concept

The building aims to combine natural systems and growth with function and the notion of structure. Nestled in the artistic west side of Sao Paulo, the building fits in well with its lush surroundings, and aims to bring to life the phases of its development. This includes exposing irrigation systems and external plant growth occurring on the building (Architonic, 2010). The four-storey building consists of two blocks connected by wood-planked metal footbridges within a central plaza (see Figure 85). The concrete exterior cladding contains moulded cavities where inserted vegetation grows in a substrate (Bullivant, 2009). Spaces within the house have varied volume sizes, light qualities, and transparencies, which create an engaging environment. The front of the house is elevated on piles (see Figure 84), while the back is resting in the ground (ArchDaily, 2008).The building's services and irrigation systems can be clearly seen on the outside, allowing minimalistic interiors to be created.

Function

The design is served by a system of yellow water pipes and electric pumps, a water treatment system, and a rooftop tank. The planted facades and green roof are watered by humid mists from sprinklers attached to the external network of pipes (see Figure 86). Water is provided at an electronically controlled frequency, which senses the regularity of natural rain; while fertiliser is provided to the plants on a periodic basis (Bullivant, 2009, p. 105).

Conclusion

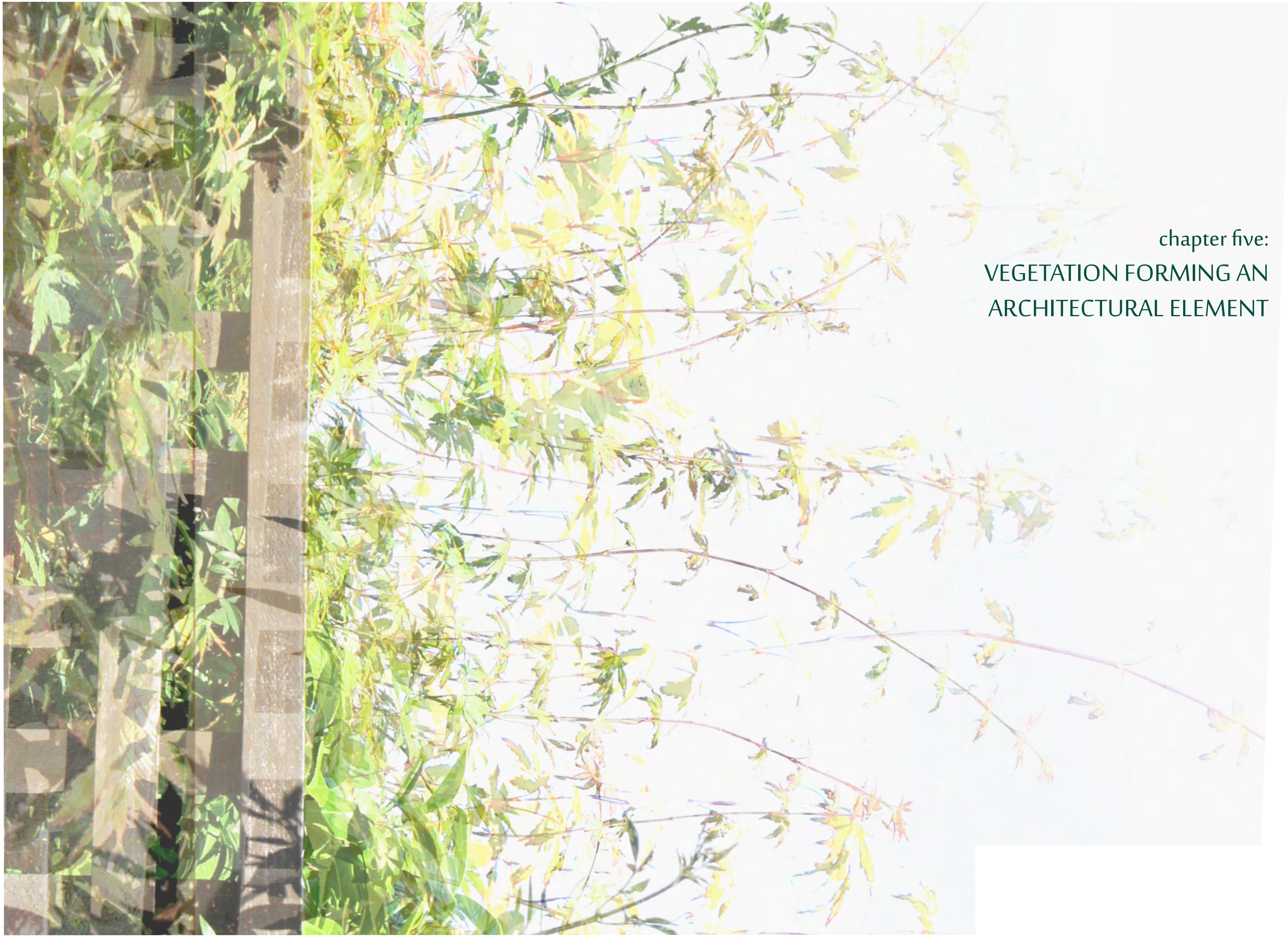
Harmonia 57 is a functionally magnificent piece of verdant architecture. It is technologically successful; the exterior green roof, living walls, and misting system will cool the interior spaces in summer, reduce storm water runoff, and reduce urban heat island effects. The building also provides access to the psychological benefits of plants for the passersby and users of the external living spaces. However, the interior spaces contained by these verdant walls are designed to be minimalist space, isolated from the contrasting verdant exterior walls. This disconnection means that the building does not provide its inhabitants with the atmospheric and psychological benefits that plants have on the interior spaces.

Figure 86. PLANTS GROWING IN CONCRETE STRUCTURE - Yellow pipes of the misting system shown.

4.6 CONCLUSION

This chapter has shown that there are many ways plants can be used as an addition to architecture. These additions are positive for human beings, the environment and surrounding ecosystems. The incorporation however does not always result in sensual interior spaces. Some of the precedent buildings have exemplified positive ways of incorporating plants illustrating the productive sensual and experiential qualities within space. For example if the phyto-purification bathroom concept was developed into the design of a permanent bathroom, one would be able to cleanse amongst the smells, textures and shadows of the plants. This research has also found that adding verdant elements to a building does not automatically create sensual internal spaces. For example the Harmonia 57 building utilises spectacular external living walls to form its facade, however this use of plants does not create correspondingly spectacular interior spaces; rather the interior is isolated from the plants. The technologies from this chapter are used to generate design concepts in Part E which create sensual interior spaces.

Figure 87. Right. PLANTS GROWING ON TRELLIS STRUCTURE - Semi-transparent living wall. *Image by Author.*



chapter five:

VEGETATION FORMING AN ARCHITECTURAL ELEMENT

5.1 INTRODUCTION

The previous chapter discussed systems which are an addition to architectural structure. If used innovatively these systems can have sensual effects on interior space. Sadly, due to the single sided nature of their construction the often beautiful elements may have no psychological effect on the interior spaces they externally cover. Contrastingly, vegetation which forms an architectural component is much more likely to have been considered as an important element, integral to a space due to the fact that the space would not be complete without it. This chapter explores both the functionality of verdant materials and components as well as the desired sensual effects which are possible due to their integration. It provides examples of verdant components which are supported by minimal structure and those which grow their own structure.

5.2 SEMI TRANSPARENT LIVING WALLS/FACADES

5.2.1 DESCRIPTION

Semi transparent living walls / facades combine techniques used to create green walls and facades discussed earlier in Sections 4.4 and 4.5. They are verdant elements, which utilise the minimal supportive structure required to grow a wall, between, over or around a framework; thus becoming a component of architecture themselves. Semi transparent living facades provide benefits for the users of the spaces they envelop. The living components provide nature, diverse light and environmental variations for both internal and external spaces. While providing similar benefits, internal semi transparent living walls also attractively divide multiple internal spaces incorporating nature into areas which are far from the edge of a building. A semi transparent living wall in terminal three at Singapore's Changi airport (see Figure 88), demonstrates how these walls can be used to provide not only a beautiful green element, but a functional element. The wall utilises its transparency to provide a large green screen for the large terminal space on one side (see Figure 89), while on the other the walls creates sensual light effects for diners to enjoy, whilst isolated from the large atrium space (see Figure 90).

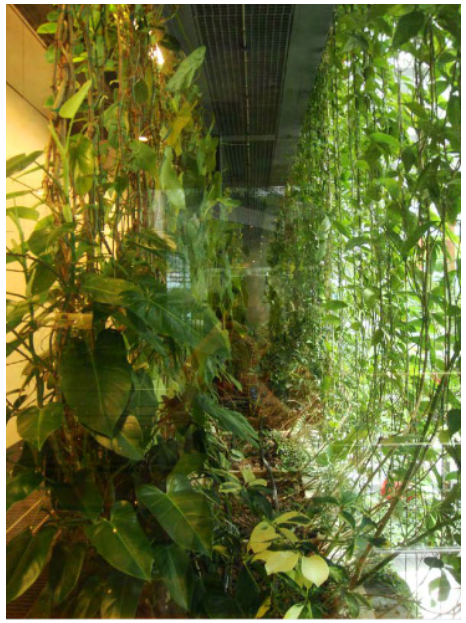


Figure 88. SECTION THROUGH SEMI TRANSPARENT LIVING WALL - Terminal 3, Changi Airport, Singapore.

Figure 89. FIVE-STOREY HIGH SEMI TRANSPARENT LIVING WALL - Terminal 3, Changi Airport, Singapore.

Figure 90. RESTAURANT SEPARATED FROM TERMINAL BY SEMI TRANSPARENT LIVING WALL - Terminal 3, Changi Airport, Singapore.

5.2.2 PRECEDENT 4: REGIS GARDENS - MINNEAPOLIS, USA

The use of vegetation as structure can be seen in many unique parks around the world. In this innovative example at the Regis Gardens (from 1986–1988) in Minneapolis, 4.8 metre vine-covered topiary arches were created in the South House (see Figures 91 and 93). These were made possible by the construction of a stainless steel superstructure, which was then covered in a non-ultraviolet-degradable mesh, then divided into horizontal layers of growing medium. These layers were then supplied with an internal drip irrigation system allowing the tall arches to be created (Michael Van Valkenburgh Associates, 2011). The system utilised in this example has allowed the landscape architects to create walls which are lush and solid through the incorporation of multiple irrigated horizontal layers. These impenetrable arches define the space they exist within, while the weight of the verdant material (which is gently enclosed by the translucent roof) provides space with a pleasing openness.

Figure 91. 4.8 METRE VINE COVERED TOPIARY ARCHES IN THE SOUTH HOUSE. - Regis Gardens, Minneapolis

Figure 92. 4.8 METRE VINE COVERED TOPIARY ARCHES IN THE SOUTH HOUSE. - Regis Gardens, Minneapolis

Figure 93. 4.8 CLIMBING VINES COVERING SCRIM WALLS ALTERNATING WITH FLOWING GROUNDCOVER PLANTS IN THE NORTH HOUSE. - Regis Gardens, Minneapolis

In contrast, the scrim walls (see Figure 92) incorporated in the North House provide a structure for the vines to grow up, whilst generating transparent qualities for each wall. The layering of these walls if viewed from a perpendicular position creates varied levels of transparency. Additional walls provide an innovative way to change levels of privacy.

Figure 94. CONTEXT THAT THE PARK FITS WITHIN - MFO Park in Zurich.
Figure 95. THE SCALE OF THE PARK - MFO Park in Zurich.

Figure 96. PARK SPACE - MFO Park in Zurich.

5.2.3 PRECEDENT 5: MFO PARK - ZURICH, SWITZERLAND

MFO Park in Zurich, Switzerland was designed in 1998 by architects Burckhardt + Partners in collaboration with the landscape architects Raderschall. The multi tiered urban park is located in a previously unwelcoming industrial area (see Figure 94). The park's expressive forms and complex open-aired trellis, reference the site's industrial history (Hill, 2007). Two verdant skins consist of a network of steel cables populated with multiple vine species (see Figure 95, 96 and 97). These define the perimeter of the space whilst also encasing walkways and a steel staircase to upper level platforms (Margolis & Robinson, 2007, p. 16). This structure undergoes striking seasonal transformations as the varied foliage provides spectacular displays of flowers and colours. The vegetation and its structure enclose the space, creating an amalgamation between architecture and park. Irrigation for the vegetation uses the site's internal watershed. On the ground, water is directed to the planting pits. Excess water is collected in a cistern and pumped as needed to the upper level of plants (Margolis & Robinson, 2007, p. 16).

Figure 97. STRUCTURE WHICH VINES GROWN ON - MFO Park in Zurich.

Figure 98. ENTRANCE TO THE HEDGE BUILDING - Rostock, Germany.

5.2.4 PRECEDENT 6: HEDGE BUILDING - ROSTOCK, GERMANY

The Hedge building was designed by the German architectural firm Atelier Kempe Thill as the Dutch pavilion for the 2003 International Garden Exhibition, in Rostock, Germany. It is now used as a cultural building by the city (e-architect, 2011). The pavilion expresses the rationalisation and industrialisation behind Dutch agriculture, whilst exploring the poetic possibilities that can be created when using these principles (Atelier Kempe Thill , 2011).

The space is formed by a ten-metre high semi transparent living facade, which is created by 1.2 by 1.8 metre 'Smart screens' (Atelier Kempe Thill , 2011). These regimented ivy-covered screens are prefabricated panels, which edge the space uniquely, providing a visual and physical connection to the outdoor environment from inside the space. Five horizontal steel beams contain the growing mediums and irrigation system of each of these panels, while thin vertical columns carry gravity loads to the ground (see Figures 98 and 99). These unobtrusive horizontal beams emphasise the rationalisation behind the concept whilst supporting the vegetated walls (e-architect, 2011). The large room can be compared to an outdoor pergola structure, however it also provides the feelings of an interior space emphasised by the enclosing frosted ceiling (see Figure 100). This building is an admirable utilisation of verdant elements as architectural elements.

Figure 99. HEDGE BUILDING - Rostock, Germany

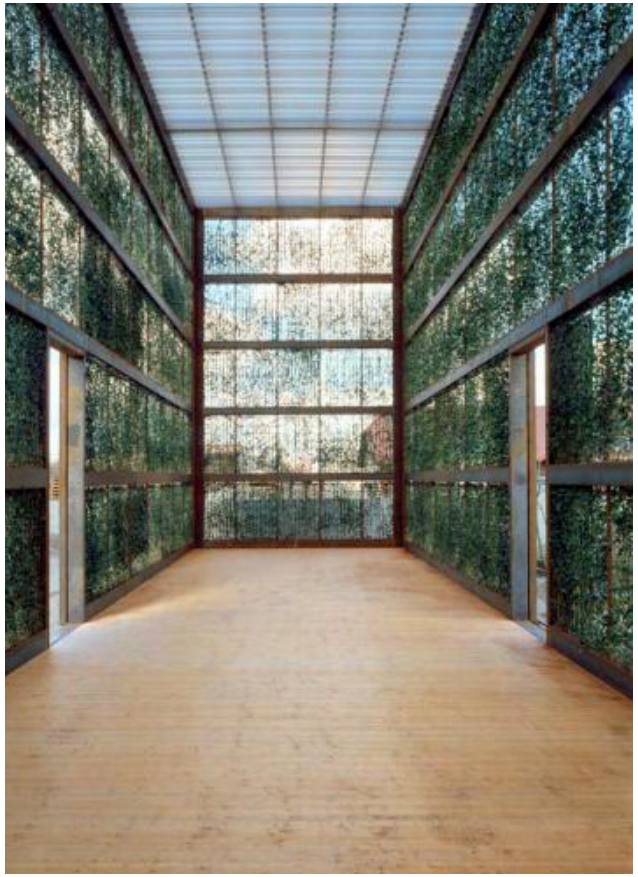


Figure 100. LIGHT EFFECTS INSIDE THE HEDGE BUILDING.. - Rostock, Germany

5.2.5 DISCUSSION

The semi transparent living walls and facades explored in this section create sensual spaces. The transparency of the walls have a strong effect on light qualities and colours which are able to be experienced inside and outside of the spaces. The Hedge Building is a particularly good example of the spatial effects which can be achieved when allowing exterior conditions to influence internal space. The dense verdant arches used in the Regis Gardens do not allow light through, if fragrant plants were used in similar situations, pleasant scents would add sensual qualities to both internal and external space. These buildings have undoubtedly integrated verdant components from the beginning of the design process. They are integral, forming both building structure and wall materiality, and are therefore *part of the architecture.*

Figure 101. A LIVING ROOT BRIDGE IN MEGHALAYA, NORTH EASTERN INDIA - formed by 10 to 15 years of planting and manipulating the roots of multiple betel nut trees.

5.3 PLANTS AS A STRUCTURAL MATERIAL

5.3.1 INTRODUCTION

Buildings can be grown from living and breathing components, reducing the need for processed materials in the creation of a home, providing an alternate way of viewing construction. Instead of materials being grown offsite then killed, altered and brought to site, building elements are grown customary to their specific purpose and site context (see Figure 101). The previous sections in this chapter have looked at growing plants on supplementary structures. This section looks at Arborsculpture (a method of manipulating tree growth into desired forms or building structure). It then discusses the FAB TREE HAB building concept and the advantages of utilising living components *as architecture.*

5.3.2 HISTORY OF ARBORSCULPTURE

Historically the growth and manipulation of trees has been used to create small structures within the context of gardens. This was done using the art of arborsculptor which is defined by Richard Reames[12] as creating functional items through the art of shaping tree trunks by bending, grafting, pleaching, pruning, and multiple planting. This technique was recorded as early as 1516 in a painting from medieval times however the first physical object a chair by John Krubsack was not documented until 1919 (Reames, Photos, History: Arborsmith Studios, 2007 - 2011). Axel Erlandson was a modern day pioneer of the use of arborsculptor he created the tree circus which is a well-known attraction show casing his remarkable manipulation of trees (see Figures 102 and 103). Arborsculptor techniques utilised the inherent strength of trees which can be used to create buildings that grow their own structural support systems. It is still practiced by some today, as are other methods of creating architectural structure out of living plants.

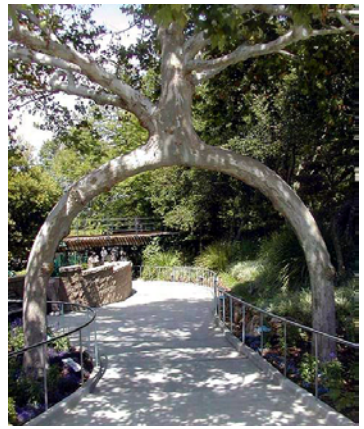


Figure 102. Above. ERLANSON'S NEEDLE AND THREAD TREE
Figure 103. ERLANSON'S ARCH TREE

12 - Richard Reames is an American arborsculptor; he studied botany and horticulture at college and has written two books on the subject (Reames, Home: Arborsmith Studios, 2007 - 2011).

5.3.3 PRECEDENT 7: FAB TREE HAB - CONCEPTUAL BUILDING

FAB TREE HAB Local Biota Living Graft Structure is a home concept developed at MIT by Mitchell Joachim[13], Javier Arbona and Lara Greden (see Figures 104 and 105). This building design is attempting to create a living environment, which benefits both its inhabitants and the surrounding ecosystem. Only some of the elements have been physically tested; although this is a highly resolved conceptual building.

Its structure would be created by growing native trees around computer generated scaffolds; enabling control of the trees growth (Joachim, Arbona, & Greden, 1997 - 2011). Other plants such the weeping willow (salix × sepulcralis) would grow up these designed scaffolds and be grafted to form the wall of the building (see Figure 106). The walls would also contain integrated soil

Figure 104. FAB TREE HAB MODEL

Figure 105. FAB TREE HAB VILLAGE

13 - Mitchell Joachim had received numerous awards for his commitment to sustainability he is a TED fellow.

pockets for other plants to grow in. The original scaffolds would be removed once the plants have been grafted and pleached[14] together. Mitchell Joachim of Terreform suggests that it would take 7-10 years to grow one of these homes or a village of them (Joachim, Arbona, & Greden, 1997 - 2011).

The buildings would integrate numerous passive systems allowing them to function as part of the surrounding environment. In summer the crown of the building is designed to shade internal spaces, cooling the building, while in the winter large southern windows would allow sunlight to heat the large thermal mass of the floor (Joachim, Arbona, & Greden, 1997 - 2011). The interior is constructed from clay and straw composites, which would function to insulate the building and block moisture, as well as providing a pleasing aesthetic. The water system utilised in the building would capture, reuse and treat the water on site. Water would be collected on top of the roof for human consumption inside the space, once used it enters an internal grey water stream. This stream leads to a pond where organic waste is removed from the water by fish, plants and bacteria. This purified water could then be used to water the plants and cool the building through transpiration (Joachim, Arbona, & Greden, 1997 - 2011). As the building is created from living plants it will continue to grow and will require some maintenance. The building would need to be treated for pests and bugs, and the plants would need to be pruned, fed and watered as required.

BIO FAB HAB buildings aim to become part of the existing ecosystem, embracing and protecting it, by using natural materials and native plants that are suited to the context. They are designed as a holistic source of sustainability, due to the rejection of typical building materials which may negatively influence the environment (Joachim, Arbona, & Greden, 1997 - 2011). The buildings would utilise native plants so that they fit within their context and provide numerous edible plants and herbs to provide food for humans and other organisms. They would contain sensual spaces created by changing light qualities, various scents, variable temperatures, different wall depths and textures and the way the living elements are designed to enclose space.

Joachim, Arbona and Greden believe that many worldwide efforts to create “sustainable” buildings fail to consider the whole building as a functional system, only considering certain aspects of sustainability which are either convenient or portray the

Figure 106. FAB TREE HAB PLANTING TESTS - - completed in Brooklyn with Landon Young

14 - Pleaching: method of forming arches, lattices or screens by weaving together tree branches

desired “green” image. Innovative designs are often stifled due to the standardised requirements and societal expectations of residential buildings (Joachim, Arbona, & Greden, 1997 - 2011). This opinion is admirable and mimics the argument presented in this thesis that plants are too often added to buildings without full consideration. The concept that the building is entirely a living organism is commendable, however it would take a long time to completely grow these houses (compared with typical residential construction time spans). The technological systems behind this design are useful precedents for the design of partially living building concepts which challenge the typical New Zealand building typology. Using current building techniques to support and integrate living elements as part of sensual architectural spaces is an achievable step towards changing the way houses can be built.

5.4 DISCUSSION

This chapter has explored spaces which are sensually exciting and unique due to their use of semi-transparent living-architecture technologies. The buildings included in this chapter all created unique rooms and areas where the space would not have been defined without the verdant elements, thus making them integral components. Only the BIO FAB HAB precedent was designed to be a home, compared with a commercial building, a glasshouse installation and a pavilion. The minimal use of these technologies in residential buildings is possibly due to the costs involved with non-standard construction and also problems with gaining building code compliances. The spaces shown in this chapter offer exciting possibilities for use in the design of residential living spaces and have been utilised in the Part E to test what spatial affects are possible in the design of a home (see Chapter 8 and 9).

part D: NEW ZEALAND CONTEXT

chapter six:
ARCHITECTURE / NATURE RELATIONSHIPS IN A MUDDLED CULTURE

"In New Zealand we have produced no indigenous architecture.

By this I mean an architecture which carries the consensus, or

the creative embrace of Maori and European values."

Russell Walden

(Walden, 1988, p. 92)

6.1 INTRODUCTION

This thesis explores how verdant elements can be incorporated with architecture. It is therefore necessary to understand New Zealand's past and present use of plants, in and around living spaces. New Zealand is a beautiful country where indigenous nature is admired by its people, and promoted as 100% Pure New Zealand (New Zealand Tourism Board, 1999-2011) to the rest of the world. However, most New Zealanders live in homes where this nature is missing; having been removed by settlers attempting to recreate the familiar in a new land (Park, 2006). The buildings are heavily prejudiced by western ideals, and largely disregard New Zealand's native planting, climate, topography and indigenous use of land. This section summarises the use of vegetation in the context of living environments in five significant periods throughout New Zealand's history. It discusses: the living spaces of the Indigenous Maori inhabitants, the settlers' transference of their architecture into a new context, the first gardens of New Zealand, twentieth century suburbia, and finally the increasingly plant-less twenty first century.

6.2 NEW ZEALAND'S INDIGENOUS RELATIONSHIP TO THE LAND

" Man perishes but the land remains."
Maori Proverb (Wilson, 1989, p. 8)

As the indigenous people of *Aoteroa* (New Zealand) the Maori developed architecture to suit the climatic conditions as well as the holistic needs of their people. They lived off the land and their buildings were part of the landscape. Their structures were not aiming to create a sterile internal space; rather surrounding nature could be felt in their buildings. Bill McKay and Antonia Walmsley describe that the Maori were in touch with the surrounding environment and therefore their architecture was; open, flexible, responsive and adaptive (McKay & Walmsley, 2005, p. 62). While a transient architecture such as that of the Maori is not suitable for modern New Zealand society, the spatial approach and sensitivity to nature can be explored through design.
One of the first Maori to study architecture was the respected architect John Scott, quoted as saying:

Figure 107. Previous Page.NEW ZEALAND FERNS AND ENGLISH ROSES. *Image by Author.*

"The wharepuni (Meeting House) has a spiritual basis and the building itself is unimportant. The Maori will not worry about buildings but he will worry about those particular kinds of things he has around – the carvings, the teko-teko (statue of ancestor on the peak of the gable) work." (Scott, 1973, p. 290)

This logic suggests that for Maori, the structural materiality of the building was not as important as the role it had in supporting features of cultural significance. In contrast, items of significance in western architecture (such as artwork and photographs) do not dominate interior spaces, rather they aim to complement the architecture.

6.3 19TH CENTURY COLONIAL IDEALS

The architectural forms and ideologies of the Maori were largely lost when New Zealand was colonised by Europeans, who brought their building style to New Zealand. McKay and Walmsley write that a characteristically functional, permanent and climate-resistant western architecture replaced the more transient architecture of the Maori (McKay & Walmsley, 2005, p. 62). Bill McKay further explains that New Zealand's landscape was altered to suit European colonial buildings in the nineteenth century (McKay, Maori Architecture: Transforming Western, 2004, p. 1); rather than building designs experiencing alteration considerate of the existing landforms. The introduction of western styles was abrupt; in accordance with the aims of colonisation. Geoff Park noted the:

" ... quest for influence and power; ... creation of the perfect colonial space without first experiencing either the site for it, or the people already inhabiting it. " (Park, 2006, p. 42)

The architectural style of the colony was determined prior to New Zealand's colonisation. Consequently, the rich potential for integration of new western technologies and the New Zealand landscape was lost.

6.4 THE ORIGINS OF NEW ZEALAND'S GARDENS

"The chief result of recent events has been to bring home to New Zealanders a fact which they have not always seemed to regard as important: New Zealand is in the Pacific." (Sinclair, 1988)

The Maori were the first gardeners of New Zealand. Native plants were combined with introduced crops from Eastern Polynesia to develop a successful horticultural system. They also began to integrate European crops after contact with Europeans in the eighteenth century (Bradbury, 1995, p. 5). Unlike the Maori (who gardened only certain areas), the European settlers viewed the whole of New Zealand as a garden, and believed it was capable of improved prosperity under their supervision (Bradbury, 1995, p. 5). This belief would have influenced the decisions to remove substantial areas of the native bush in order to cultivate what they felt were *gardens* on the land. This again was an attempt to recreate the landscapes of Europe.

The first European gardens in New Zealand were probably those of the missionary settlements in the Bay of Islands. Initially the missionaries grew items of necessity, such as vegetables, herbs, grains, and pulses; as supply of food from overseas was not reliable (Raine, 1815-1840: The First European Gardens, 1995, pp. 53-54). These gardens were plain, functional, cottage style gardens, where food production was the priority (although Raine states that some missionaries grew flowers in front of their houses for ornamentation) (Raine, 1815-1840: The First European Gardens, 1995, p. 55). As the century progressed and additional settlers arrived, gardens continued to be a place of food production. However, settlers soon began to consider aspects of pleasure, influenced by overseas garden style. Consequently, an increase in the use of ornamental and exotic plants occurred (Raine, 1815-1840: The First European Gardens, 1995, p. 57). Gardens also began to utilise palisade fences and gorse hedges to keep out livestock and 'marauding Maori' (Raine, 1815-1840: The First European Gardens, 1995, p. 56). These isolated plots within the unfamiliar New Zealand landscape provided space for the creation of European gardens; from which the New Zealand

typology of the domestic garden began. Rod Barnett describes Kiwi gardens as the recreated gardens of many places of the world (Barnett, 1995, p. 174). These gardens would have given the settlers comfort and reminded them of home.

6.5 POST COLONIAL GARDENS

Over the next century, gardens continued to draw on overseas styles. The increase of city populations and the rise of the middle class lead to the creation of suburban gardens, which became the most typical New Zealand garden (Raine, Early Twentieth-Century Gardens, 1995, p. 127). These well-kept gardens featured neat paths, smooth lawns, curving colourful flower beds, exotic trees and shrubs (Raine, Early Twentieth-Century Gardens, 1995, p. 128). From the late 1920s to the 1950's, the suburban garden was a necessary food provider for many New Zealanders, due to the effects of the Depression and the Second World War. Fruit trees and vegetable gardens continued to be common, as was the keeping of bees and chickens (Beaumont, 1995, p. 145). In the 1950's and 1960's, the production of food decreased and gardens became places providing 'lifestyle'. Gardens of this time incorporated increasing amounts of flowering shrubs and native New Zealand plants in their designs (Beaumont, 1995, p. 170).

6.6 CHANGING RELATIONSHIP OF NEW ZEALANDERS TO THEIR GARDENS IN THE 1980'S

From the 1970's onwards, higher density housing, subdivision and gradually shrinking sections resulted in pocket-sized backyards. Rod Barnett suggests that without space for front yards, previously socialistic suburban gardens turned away from the street and became private retreats (Barnett, 1995, pp. 182-183, 191). With the rise of postmodernism and globalisation, gardens also lost much of their original provider status. In domestic residences, the 'backyard' and 'vege-patch' were no longer strictly typical of a living environment. People did not need to rely solely on the garden to grow their vegetables when the supermarket provided a more convenient option (Barnett, 1995, p. 174). Gardens instead became places of leisure and relaxation.

6.7 CURRENT RELATIONSHIP

In this day and age, people spend less time outdoors and more time inside with the television, computer, or at work. When those who have gardens retreat to their private spaces, they like them to be areas for entertainment and pleasure. Many suburban residences have minimal gardens, either by choice or because there is not the space. This is notable when travelling through suburban streets, where large physical systems dominate space (Barnett, 1995, p. 188). Here, often the only vegetation present is small lawns in front of houses and generic trees lining the footpath. This vegetation struggles to interact with the architecture, and instead appears to have been created as an afterthought, or a space-filling necessity. Incorporating verdant elements with architecture allows people to be in contact with nature even when indoors, changing the current form of gardens and making them more accessible for the 21st century lifestyle. To integrate everyday living with the garden, extra space, time, and effort are not necessarily required.

chapter seven:
LOCATION SPECIFIC CHARACTERISTICS

"The city is the ultimate expression of artifice, a second nature built as an alternative to living exclusively within the natural world. In perfecting this second nature, we have progressively separated ourselves from real nature."

Norman Crowe

(Crowe, 1995, p. 230)

7.1 INTRODUCTION

Humans evolved in environments which varied in temperature, humidity, light and wind condtions (Bainbridge & Haggard, 2011, p. 4). Modern design has failed to preserve this primal feature of human existence, instead creating spaces that promote the opposite. All sites should be designed for their context, incorporating existing positive and negative microclimatic qualities. Many New Zealand homes do not utilise the positive aspects of New Zealand's climate, requiring artifical heating and cooling. The inherent flaw of regulated environments is that they do not provide a physical connection to the outdoors. Instead, they struggle to maintain a regulated environment, and are challenged by the constantly changing external influences. This section explores the environmental characteristics of Wellington, New Zealand, which make this location ideal for the creation of a *verdant home.*

7.2 NEW ZEALAND'S TEMPERATE CLIMATE

Many areas of New Zealand have warm temperate climates, with few extreme temperature variations, seasonally or irregularly (Garnier, 1950, pp. 46, 84). This makes Wellington an ideal climate for the creation of *verdant architecture.* The New Zealand climate change website explains that there is likely to be an increase in temperature over the next 30 to 40 years, which may promote the growth of exotic plant species. This may be detrimental to New Zealand native flora and fauna (Ministry for the Environment, 2010). The use of verdant elements would increase the incidence of native plants in New Zealand, thus providing increased protection for the species.

Figure 108. Previous Page. IMAGE SHOWING NEW ZEALAND FERNS AND A DECK CHAIR - AN ITEM OF CULTURAL SIGNIFICANCE. *Image by Author*

7.3 TEMPERATURE

Using vegetation within domestic residence is a way to regulate and improve the air quality of the internal environment; creating passive and thus sustainable living space. Research suggests that in each different climate, the temperature that is comfortable for people will vary. As outdoor temperatures fluctuate, indoor temperatures change accordingly, causing the occupants within these buildings to change their clothing. Therefore, the temperature people find comfortable inside is related to the outdoor temperature (Chartered Institution of Building Services Engineers, 2006, pp. 1-16). This research suggests that a way of living which incorporates the external environment can have a positive effect on the internal environment. It also suggests that human beings need to more in touch with nature, and that architecture should allow the exterior climate to affect interior space more directly. This type of building is possible in Wellington's temperate climate where contextually appropriate verdant elements can be created as edges, divisions, frames of space and spaces to live within. In winter, the inclusion of radiant heaters and fully enclosable spaces in the design (as well as the building orientation and choice of materials) can create a house that is liveable all year round. However, determining the exact conditions inside the house is beyond the scope of this research.

7.4 HUMIDITY

Moisture is generally not apparent to inhabitants of a space until the operative temperature rises above 26 to 28 degrees Celsius (Chartered Institution of Building Services Engineers, 2006, pp. 1-5). Thus, in moderate thermal environments such as Wellington (where temperatures do not fall within this range), a relative humidity in the range of 40 - 70% is generally acceptable. Causes of high room humidity are a usually a combination of poor ventilation, evaporation from moisture sources and/ or high outdoor humidity (Chartered Institution of Building Services Engineers, 2006, pp. 1-5). Quirouette explains that a space containing around 30 houseplants releases around two litres of water a day equating to around 0.5 litres of water per average size plant per week; compared to the daily human release of 1.25 litres of vapour due to respiration and perspiration (Quirouette, 2001).

Plants are therefore not overly problematic in an internal space, provided it is appropriately ventilated. In the case where plants are creating the facade or a permeable edge to a space, much of their moisture would be passively released to the outdoors, benefiting the space through the removal of moisture and the provision of ventilation.

7.5 LIGHTING

Lighting has three purposes within a building: to enable occupants to work and move safely; to enable the correct execution of tasks which need to be completed; and to create a pleasing appearance (Chartered Institution of Building Services Engineers, 2006, pp. 1-20). This thesis focuses on the ability of light to create pleasing spaces, where natural daylight in a verdant house provides the potential for unique atmospheric effects which vary throughout the day.

7.6 SHELTER

Wellington is a windy city where only approximately 11% of days are calm. North-westerly winds prevail in spring and summer, with southerlies in winter (Maclean, 2009). Due to this high level of wind, the design of verdant spaces needs to provide appropriate shelter for inhabitants. Layering of verdant materials and appropriate placement can ensure that comfortable spaces are created.

part E: DESIGN

Figure 109. IMMERSED WITHIN THE GRASSES.
Image by Author.

chapter eight:
THE BEGINNINGS OF A VERDANT HOME:

"The scale of our buildings and artifacts on earth have now gotten so large that we must now think of them more like living organisms that are part of an ecological systems if we are to be a healthy part of the planet and not some self destructible parasite."

Ian McHarg

McHarg as cited in (Bainbridge & Haggard, 2011, p. 11)

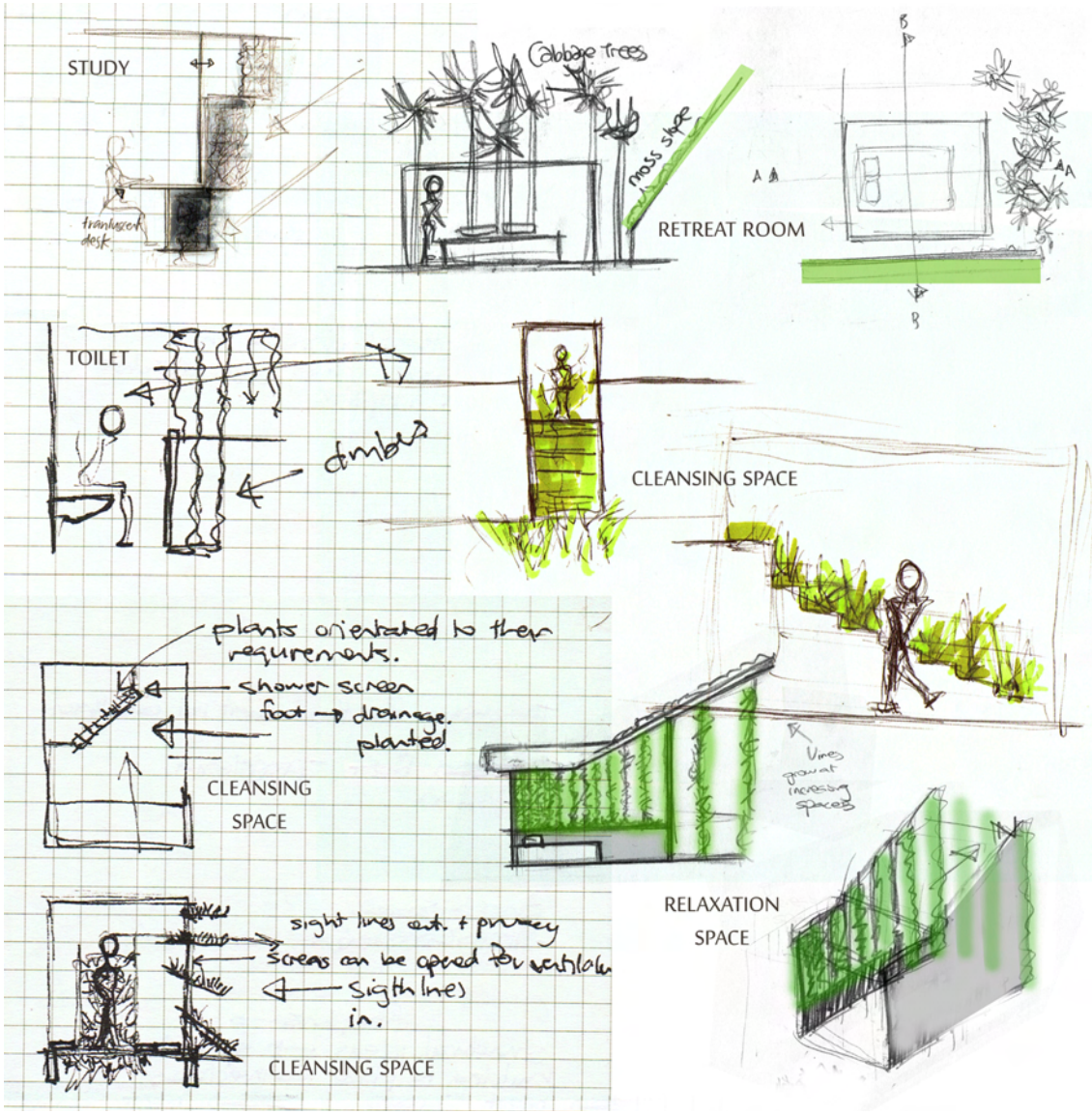


Figure 110. INITAL SKETCHES. *Image by Author.*

8.1 INTRODUCTION

The ideas introduced earlier in this thesis have lead to the creation of verdant home concepts which are attentive to spatial and technological considerations. The designed spaces are a blurred integration of house and landscape, which predominately utilise New Zealand's native plants; creating contextually appropriate spaces.

By analysing historical gardens with direct consideration of their spatial and experiential qualities, a method of design seeking to create experience and mood was established. Translating these qualities into design concepts for New Zealand is appropriate; throughout New Zealand's history people have adapted architecture and garden styles from other parts of the world, transforming the desired principles to suit the local context. Knowledge of New Zealand's indigenous and more recent relationship to land and building (see Chapter 6), combined with an understanding of modern green technologies (see Chapters 4 and 5), has influenced the production of designs which would reconnect human and natural systems in the built environment. These designs provide humans with psychological and physical benefits (see Chapter 2).

In this chapter the use of New Zealand native plants, domestic living space expectations and a consideration of site and climate, are factors which led to the creation of designs suitable for the Wellington site. The designs challenge how planting can become a significant space creating material, connecting inhabitants to nature, whilst using the idiosyncrasies and varied properties of plants to produce diverse interior atmospheres.

8.2 DESIGN METHODOLOGY

The incorporation of verdant elements as architectural components can improve architecture in three ways. The use of verdant elements can improve the psychological environment for humans, making the architecture a more pleasant and experiential place to inhabit; it can improve the physical qualities of space making it a healthier environment to inhabit; and it can improve a buildings connection to place by supporting natural ecosystems. Therefore, the design methodology had three key concerns when creating architecture. These were to design architecture which:

1. Is comprised of sensual spaces
2. Positively utilised functional verdant technologies
3. Produced contextually appropriate verdant buildings

The creation of sensual verdant spaces was the focus of the design; however the use of verdant technologies and the design of contextually appropriate buildings were also important design considerations. The design method used to address these concerns, is explained below.

8.2.1 SENSUAL SPACES

An assessment of the literature on historical garden design in Part B formed a spatial understanding of the many ways gardens create pleasurable space. Four conceptual verdant home designs were created by translating these garden virtues into architectural space. The concepts possess the fundamental qualities of particular gardens, but do not explicitly read as particular garden typologies.

8.2.2 VERDANT TECHNOLOGIES

The designs tested the verdant technologies explored in Part C, by experimenting with the conventional design of the inherently attractive elements. After researching the existing technologies, the forms and functions were explored through design to test how they could be utilised to create desired sensual qualities.

8.2.3 CONTEXTUALLY APPROPRIATE VERDANT BUILDINGS

The building concepts and the numerous accompanying plants have been orientated according to the sun's movement, the wind, and the relationship with the surrounding infrastructure and buildings. An assessment of the surrounding context, site history and New Zealand's historical relationship to the landscape provided ideas for how the building could fit physically within the context (see Part D). Factual exploration and practical observation of New Zealand's native plants informed the selection of certain plants for use with the verdant home designs (see Appendix A).

Spaces were designed through initial sketches and diagrams, computer models, hand drawn sections and physical models. Utilising these multiple techniques of analysing and generating space, insured that the desired spatial qualities were thoroughly explored from various angles.

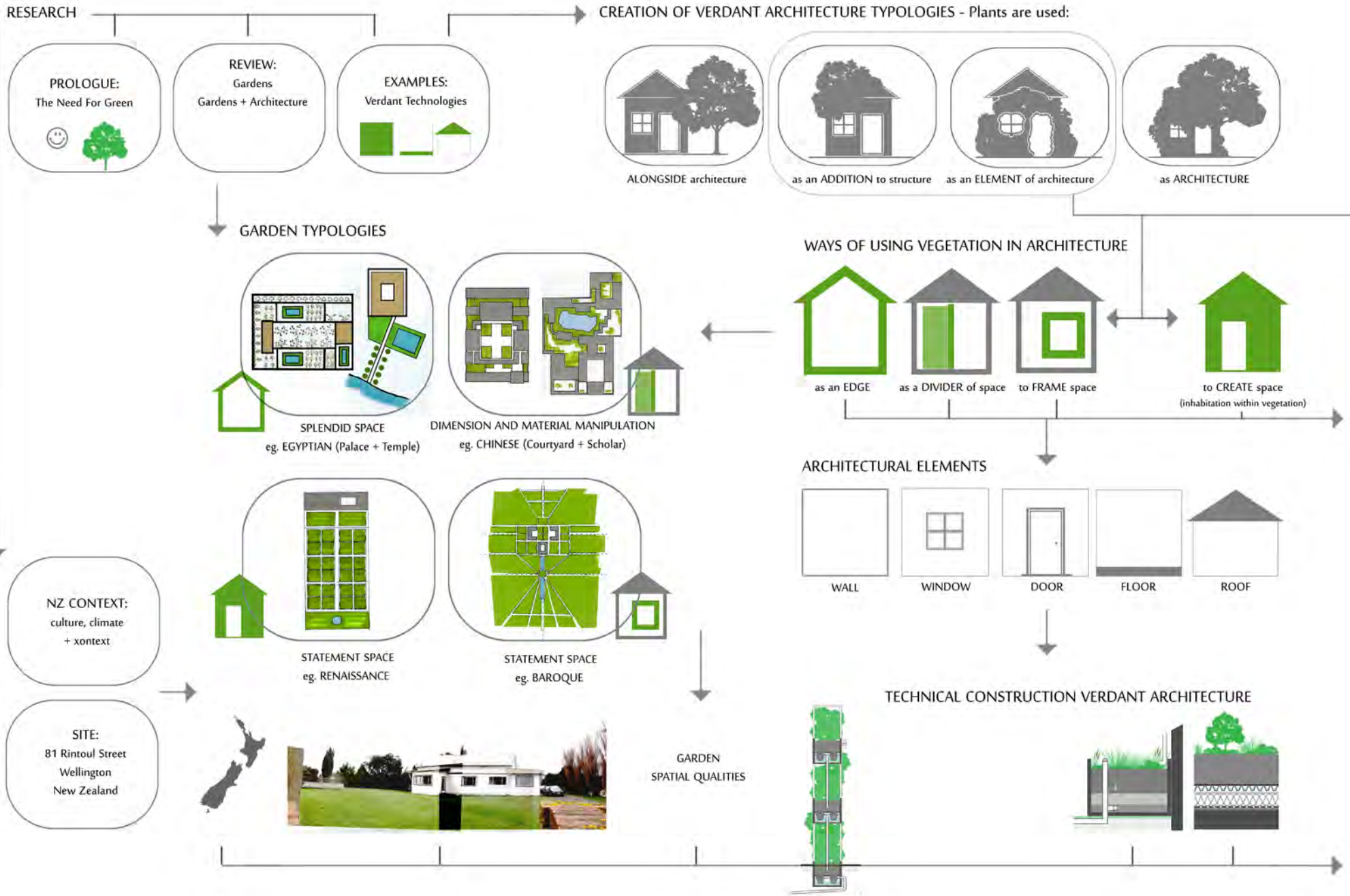


Figure 111. METHODOLOGY DIAGRAM.
Image by Author.

PRECEDENTS

GREEN ROOF
(eg. ACROS Building)

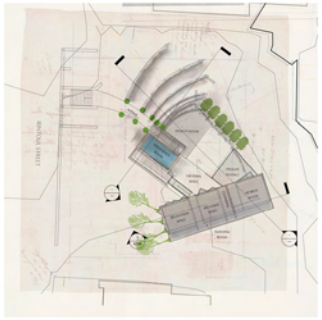
PHYTOREMEDIATION SYSTEMS
(eg. Phyto-Purification Bathroom)

FACADE GREENING

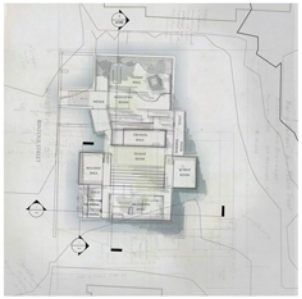
LIVING WALLS
(eg. Harmonia 57)

LIVING WALL-FACADES
(eg. Hedge Building)

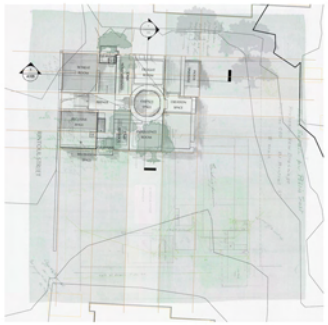
VERDANT HOME: CONCEPTUAL DESIGNS



CONCEPT 1
SPLENDID SPACE



CONCEPT 2
DIMENSION AND MATERIAL MANIPULATION



CONCEPT 3
STATEMENT SPACE

CONCEPT 4
STATEMENT SPACE

REFINED VERDANT HOME

Figure 112 and 113. HOUSE WITHIN STREET CONTEXT
Showing site and its varied surrounding context. *Image by Author.*

8.3 SITE

The site located at 81 Rintoul Street, Newtown in Wellington, New Zealand (see Figures 112 and 113) was predominately selected for its physical location as well as the varied man-made materials and forms which surround it. It was selected from numerous possible locations and building typologies, including a central city parasitic site, a central city grounded site, and a rurally located site. The selection of a suburban site offered enough room to create the planted building without a major focus on structural systems. This would have been required on a parasitic site, to support the loads of soil and structure. The lack of a spectacular view to the landscape from the site also allowed the project to be more inwardly focused on creating the garden and pleasurable space within the site.

The large residential site is located on a northern facing incline of Rintoul St; which has minimal verdant elements and lacks views to Wellington's green belt (see Figures 114-117). It is ideal for the creation of a verdant house as construction materials, colours and typologies on the street are varied; including timber villas, colourful stucco apartments and a concrete rest home. This variation, which is a common occurrence in New Zealand suburbia, allows form and verdant materials to be freely investigated, without having to fit within a certain style.

Figure 114. SUBURB CONTEXT
Scale of Grid. *Drawing by Author.*

Figure 115. SITE CONTEXT
Surrounding plot sizes. *Drawing by Author.*

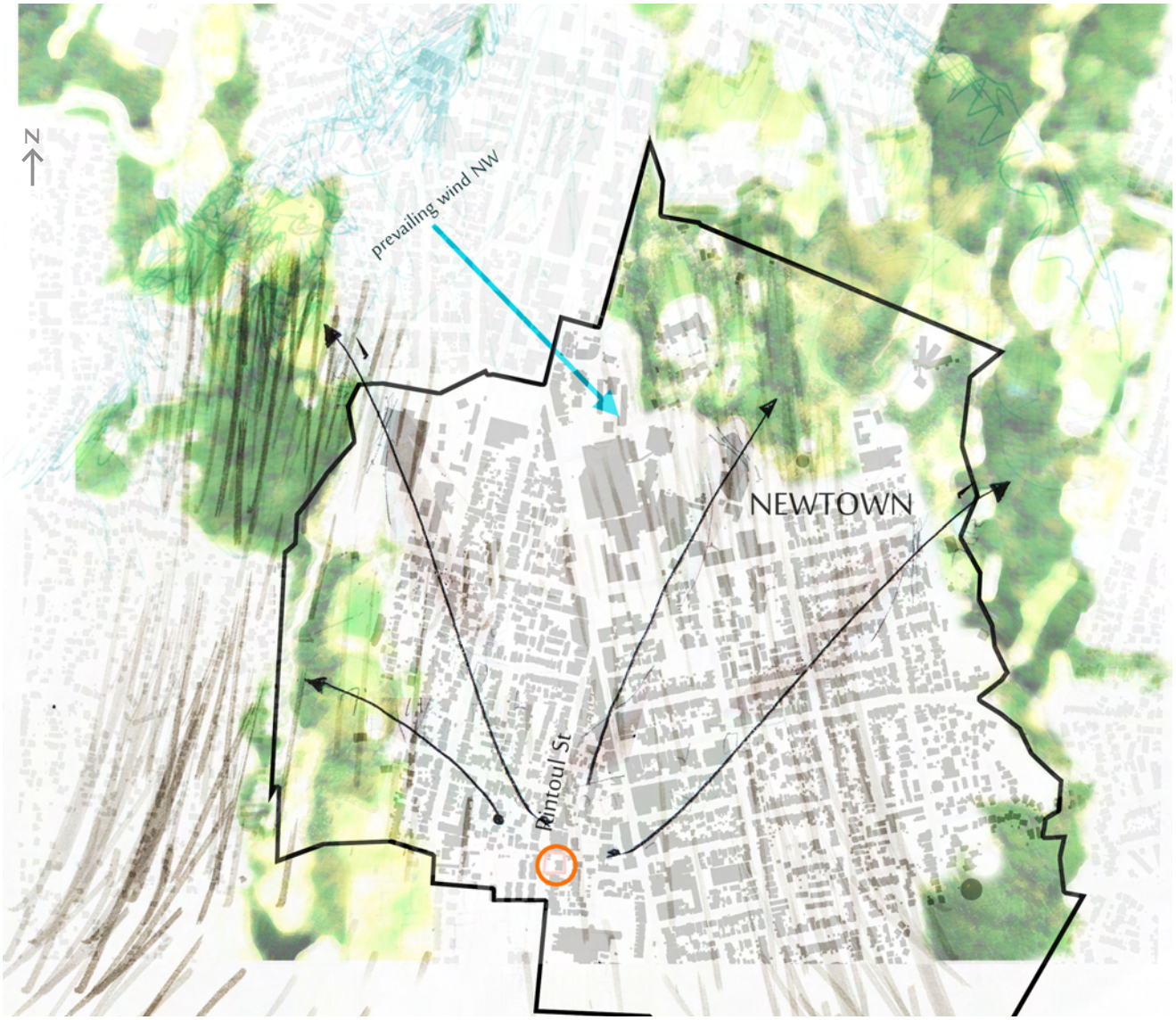


Figure 116. CITY CONTEXT
Relationship of suburban Newtown to areas of vegetation. *Drawing by Author.*

Figure 117. AERIAL PHOTOGRAPH
1-Rest Home, 2-Villas, 3-Modern Apartments, 4-Site.
Image by Author.

Figure 118 . IMAGE OF SITE
Images by Author.

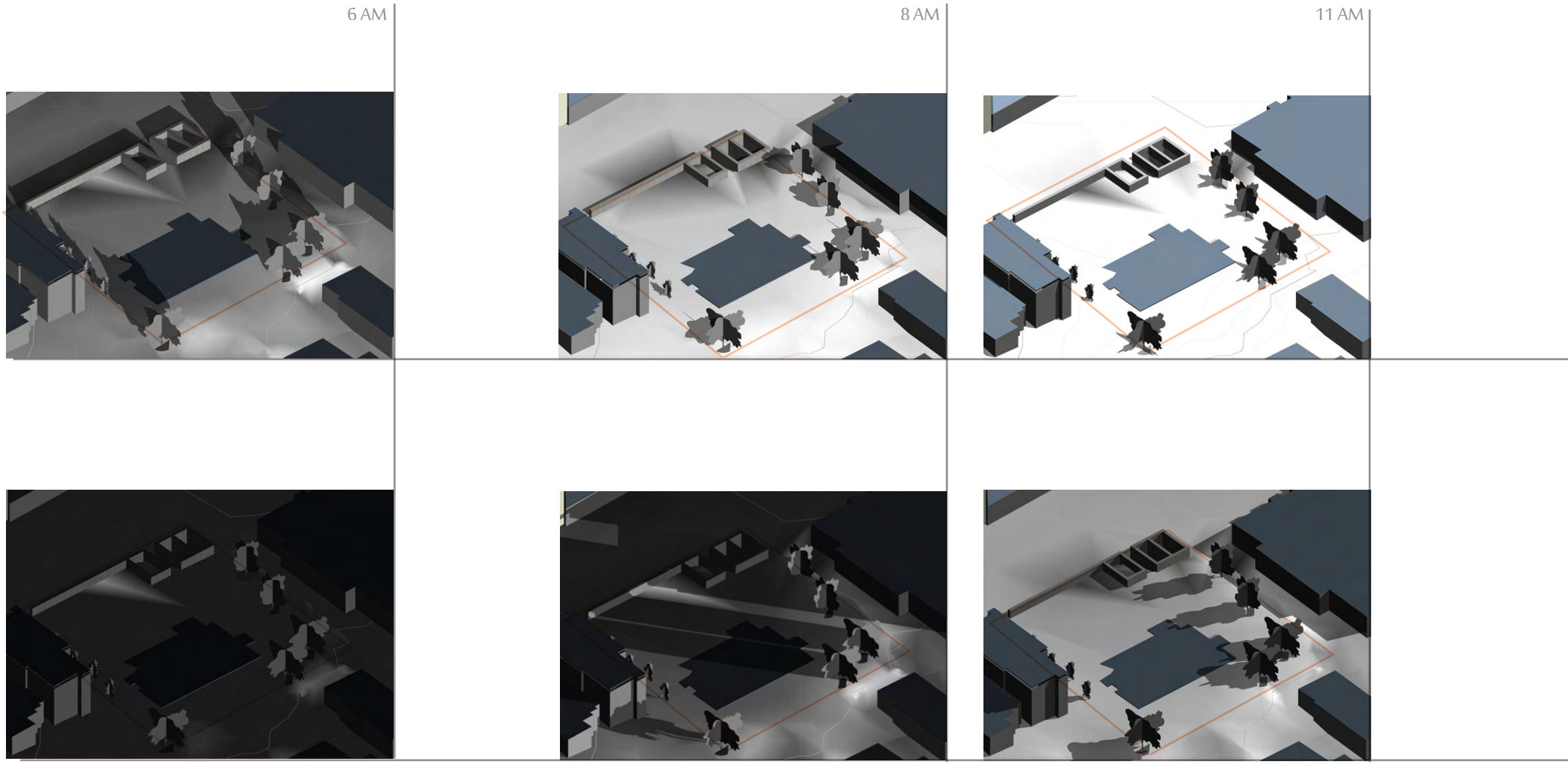


Figure 119. SITE SUN STUDIES WINTER AND SUMMER SOLSTICE.
Revit analysis showing the existing building footprint and current site vegetation.
Scale and location of surrounding buildings also shown. *Image by Author.*

2 PM

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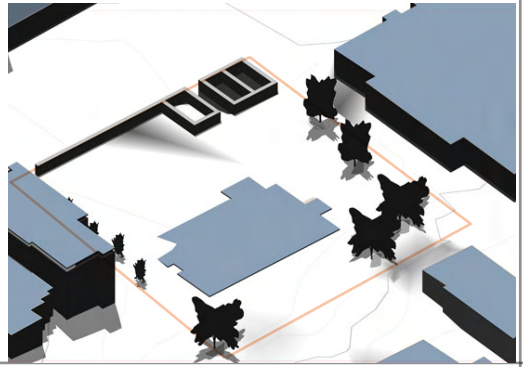
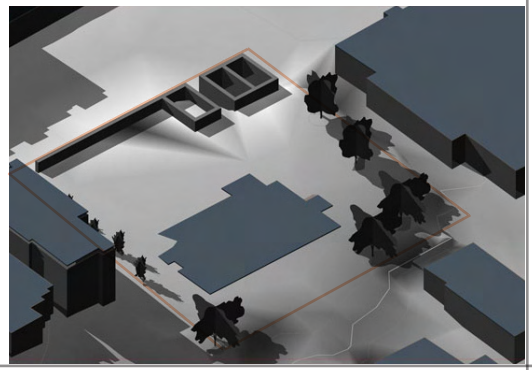
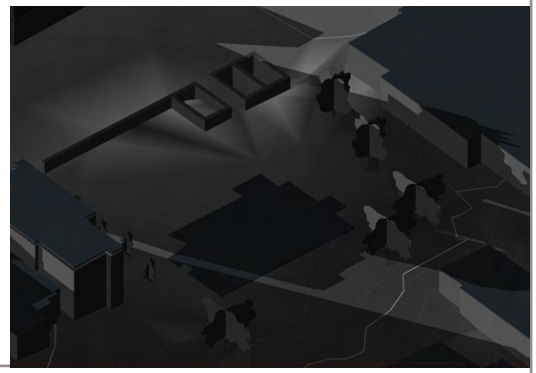
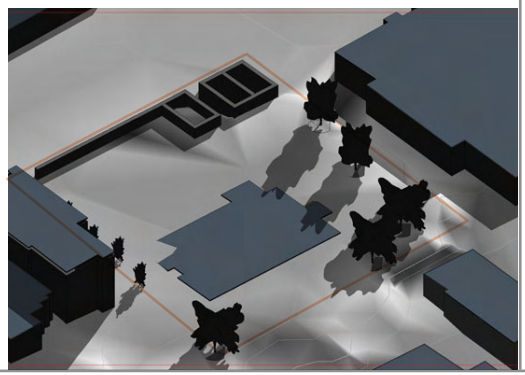
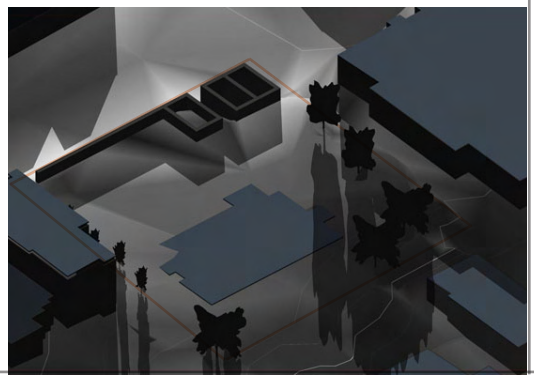






SUMMER SOLSTICE





WINTER SOLSTICE

SCALE 1:250

Figure 120 .EXISTING PLAN - SPACES RENAMED
Taken from Revit model of existing building. *Image by Author.*

8.4 RENAMING SPACE

The house currently on the site is typically sized for a New Zealand home. It was constructed prior to 1891 as it is shown on the historic Thomas Ward Maps of Wellington; created in 1891 (Wellington City Council, 2011). The house is poorly orientated and designed, with minimal windows on the northern face and a sunroom to the south. It inadequately interacts with the vegetation planted to the north, east and south of the site, where the building offers only coincidental views to these plants. The design also fails to take advantage of the size and largely open position which this elevated site offers. Due to these design oversights this thesis treats the site as if the building has been removed; while extracting the existing space sizes and uses as an abstracted programmatic requirement for the new concepts. Furthermore the existing building spaces have been renamed to remove stereotypes and expectations associated with conventional space; allowing the designs' to prioritize the creation of sensual experiences.

Figure 121 .EXISTING WEST ELEVATION
Showing minimal interaction of house with vegetation. Taken from Revit model of existing building. *Image by Author.*

SCALE 1:250

8.5 PROGRAMME

The residential concept designs explored in this section and the refined house concept (see Chapter 9) are designed to accommodate a family of New Zealanders. The family consists of a young couple in their early 30's with two children; both girls aged four and five. The couple are keen gardeners and would maintain the verdant house themselves. All the functions of a typical New Zealand home are included in the house, the difference is that these functions are found within uniquely designed sensual spaces, which provide the pleasure of a garden while one is inside. The programme was taken from the space sizes and functions of the house which is currently on the site (see Figures 120 and 121). The designs include a kitchen (creation space), bathroom (cleansing room), laundry (swishing room), passage (avenue), dining area (indulgence room), lounge (delight room), one master bedroom (relaxation space) and two other bedrooms (retreat room and reclusive space). The concepts are designed to accommodate the family in their present state, while also providing for their future needs. Spaces such as the children's rooms are designed to provide for their changing requirements as they grow, including space for play as well as areas for study in the future.

8.6 THE CREATION OF SENSUAL SPACE

Distinctive garden theory was used as a precedent to design verdant home concepts, which use plants as an architectural material in the creation of sensual spaces. The historical garden design typologies explored in Part B are shown in Figure 122. These gardens provided strong spatial philosophies which were able to be translated into plant enriched architectural spaces.

Figure 122. DIAGRAMS OF HISTORIC GARDEN STYLES.
Hand drawn and computer enhanced. *Image by Author.*

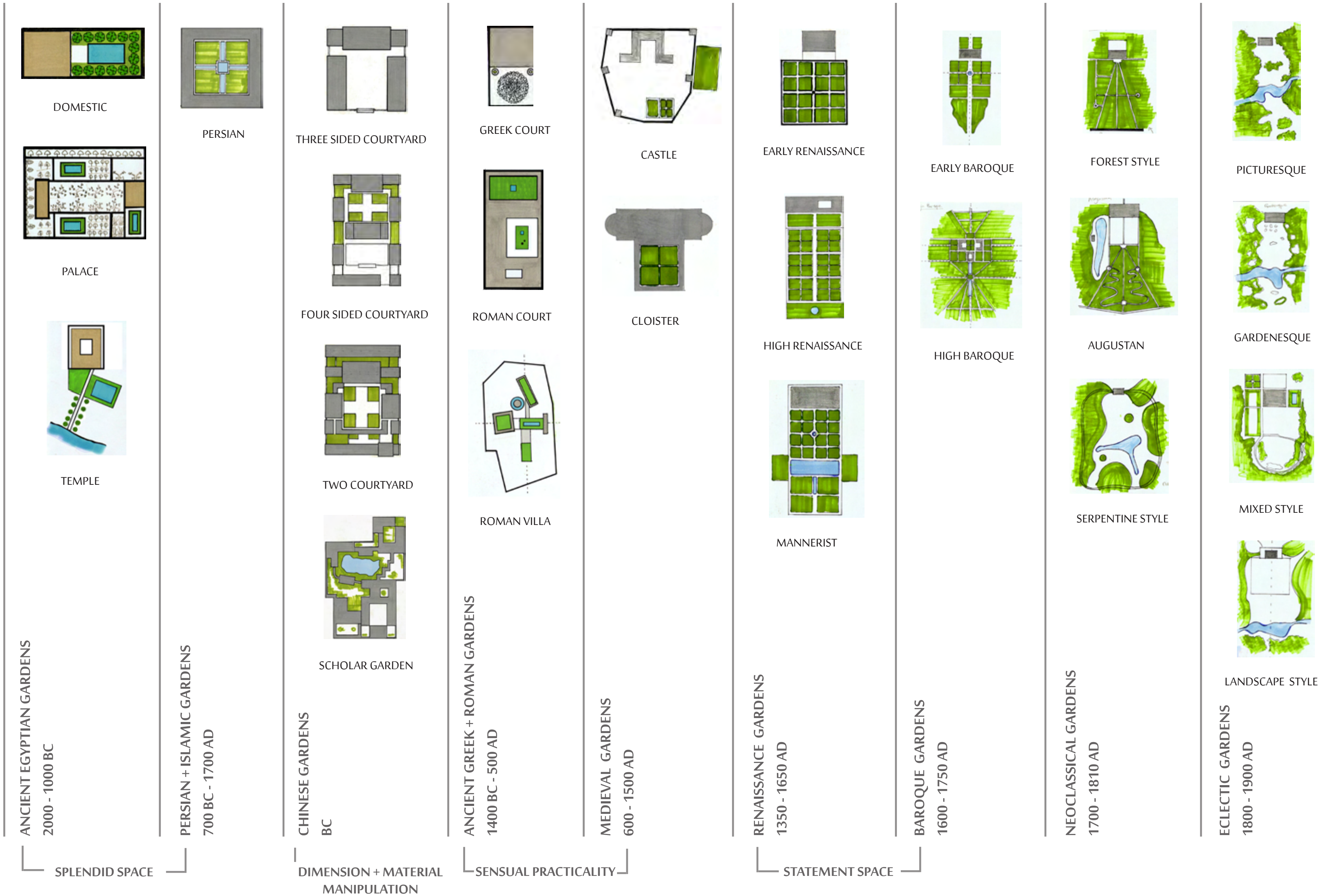

ANCIENT EGYPTIAN GARDENS
2000 - 1000 BC
DOMESTIC
PALACE
TEMPLE
PERSIAN + ISLAMIC GARDENS
700 BC - 1700 AD
PERSIAN
SPLENDID SPACE
CHINESE GARDENS
BC
THREE SIDED COURTYARD
FOUR SIDED COURTYARD
TWO COURTYARD
SCHOLAR GARDEN
DIMENSION + MATERIAL MANIPULATION
ANCIENT GREEK + ROMAN GARDENS
1400 BC - 500 AD
GREEK COURT
ROMAN COURT
ROMAN VILLA
MEDIEVAL GARDENS
600 - 1500 AD
CASTLE
CLOISTER
SENSUAL PRACTICALITY
RENAISSANCE GARDENS
1350 - 1650 AD
EARLY RENAISSANCE
HIGH RENAISSANCE
MANNERIST
BAROQUE GARDENS
1600 - 1750 AD
EARLY BAROQUE
HIGH BAROQUE
STATEMENT SPACE
NEOCLASSICAL GARDENS
1700 - 1810 AD
FOREST STYLE
AUGUSTAN
SERPENTINE STYLE
ECLECTIC GARDENS
1800 - 1900 AD
PICTURESQUE
GARDENESQUE
MIXED STYLE
LANDSCAPE STYLE

Figure 123. VERDANT ELEMENT TYPOLOGIES
Computer drawn. *Image by Author.*

8.7 FOUR TYPOLOGIES OF VERDANT ELEMENTS

As written about in part C, architectural technologies can be integrated with structure in a number of ways. I have defined four ways in which verdant elements can be incorporated as part of architecture (see Figure 123): these are as an edge, a division, to define space for inhabitation within, or as a frame. When designing each of the concepts a different typology was focused on, this enabled the designs to explore how verdant elements could define and sensitise space in different ways.

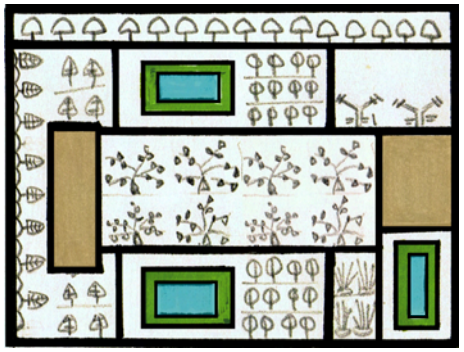


*Figure 124.*EGYPTIAN PALACE GARDEN.
Diagram by Author.

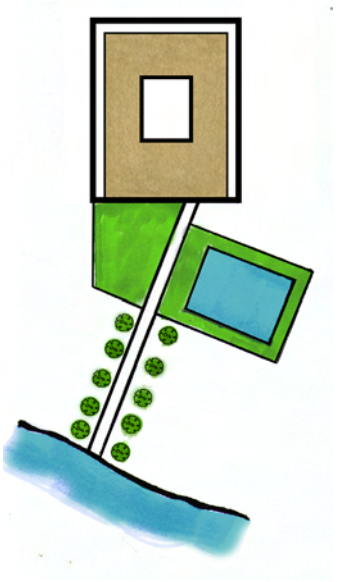


Figure 125 .EGYPTIAN TEMPLE GARDEN.
Diagram by Author.

8.8 HOUSE CONCEPT ONE - EDGE

8.8.1 EDGE (SPLENDID SPACE)

The verdant edges concept challenges a current expectation of New Zealand residential houses; that each room will be bordered by a solid impenetrable wall with a number of windows. The house design draws from Egyptian and Persian gardens which created places of splendour, seemingly isolated from their barren surroundings. This concept creates different atmospheres in adjacent spaces, through the use of verdant edges.

8.8.2 PLASTER MODELS

Plaster models were created to test the principles of splendid space. In Figure 126 the model is exploring the depth and scale of shadow, in contrast to areas of bright light; as well as physically interpreting the spatial layout of the Egyptian palace garden. The physical density of the plaster provided an abstracted visualisation of how comfortable conditions (shaded) in these spaces would have drastically changed throughout the day. Figure 127 is a model of solid versus varied void size. This model explores how the volume of void affects the resulting shadow and perceived depth of space. Splendid spaces did not only utilise a solid or a void, rather a large spectrum of material densities were made use of. The Persians and Egyptians used plants and beautifully patterned walls to dampen sunlight, resulting in exquisite and airy spaces. This concept house challenges the contemporary use of either transparent window or solid wall, instead using planted architectural components as space edges, to explore the possibilities of emptiness, transparency and solidity.

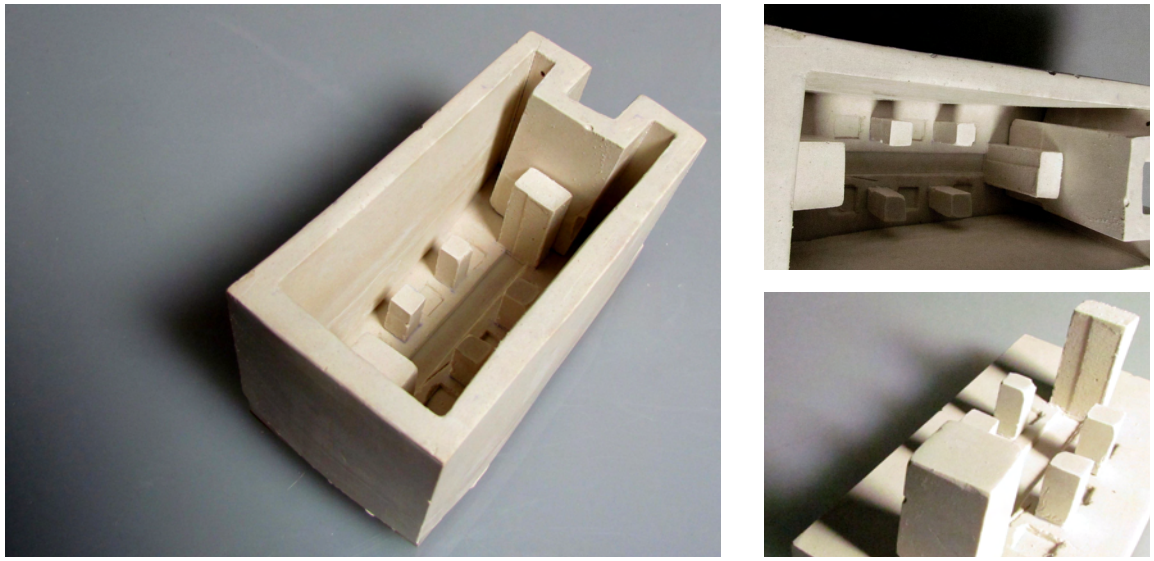


Figure 126. IMAGES OF EGYPTIAN PALACE GARDEN MODEL.
Plaster of Paris. *Model by Author.*

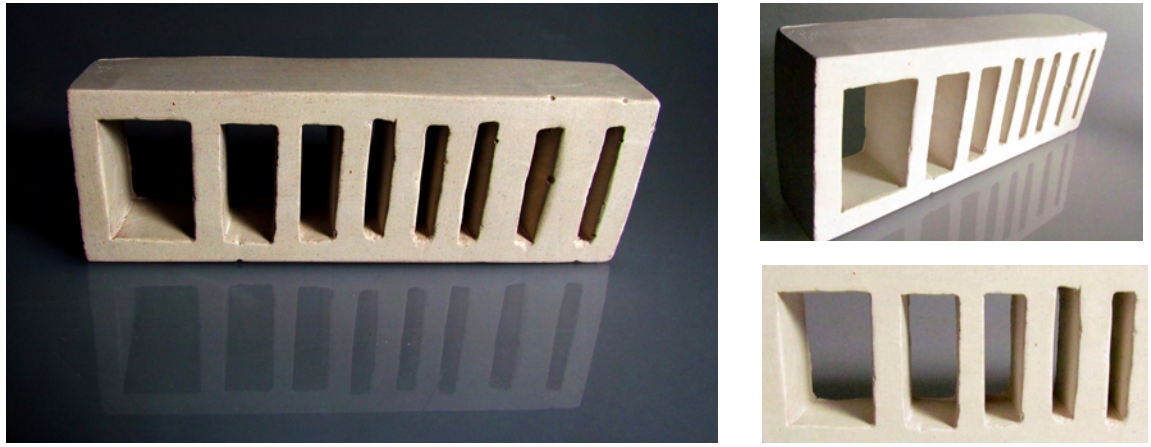


Figure 127 .IMAGES OF EGYPTIAN TEMPLE GARDEN MODEL.
Plaster of Paris. *Model by Author.*

8.8.3 HOUSE DESIGN

This design is a series of spaces which vary in levels of connection to the outdoors. The plan layout (see Figure 128) is constructed around an angled avenue with spaces projecting from this central axis. The spaces within the building are arranged with the most public areas closest to the street and the private spaces to the rear and on the second floor.

The spaces in the house range from complete enclosure to total exposure. The indulgence room is walled by solid concrete and is isolated from the outdoors. In contrast, the delight room (see Figure 129) utilises varied densities, layers and orientations of verdant walls to constantly interact with the changing outdoor light; dependant on the time, day or season. The north-east facing courtyard is edged by a series of vertical poles drenched in climbing plants. These mark the divide between inside and outside, without becoming a physical barrier between the two. The playful nature of the shadows cast, and the openness of the space, would encourage recreation within this area. To the north-west of the delight room a series of curving semi-transparent living walls physically shelter the space from wind whilst still allowing light to penetrate through them. Escaping between the walls of this space, one could find a sheltered and cosy place to read or think. The walls of Muehlenbeckia astonii are constructed from a number of horizontal growing mediums similar to the construction system used in the Regis Gardens North House (see Section 5.2.2).

A criticism of this concept is the use of semi-transparent living facades in typical spaces; such as the cleansing rooms, reclusive space, retreat room, and relaxation space (see Figure 130). The uniformity of the facades in the conventionally shaped spaces does not integrate the verdant element as part of the architecture. In contrast the curved walls and irregularly spaced posts in the delight room create interesting spaces of which the verdant elements are an integral part; they integrate considered architectural form and beautiful plants.

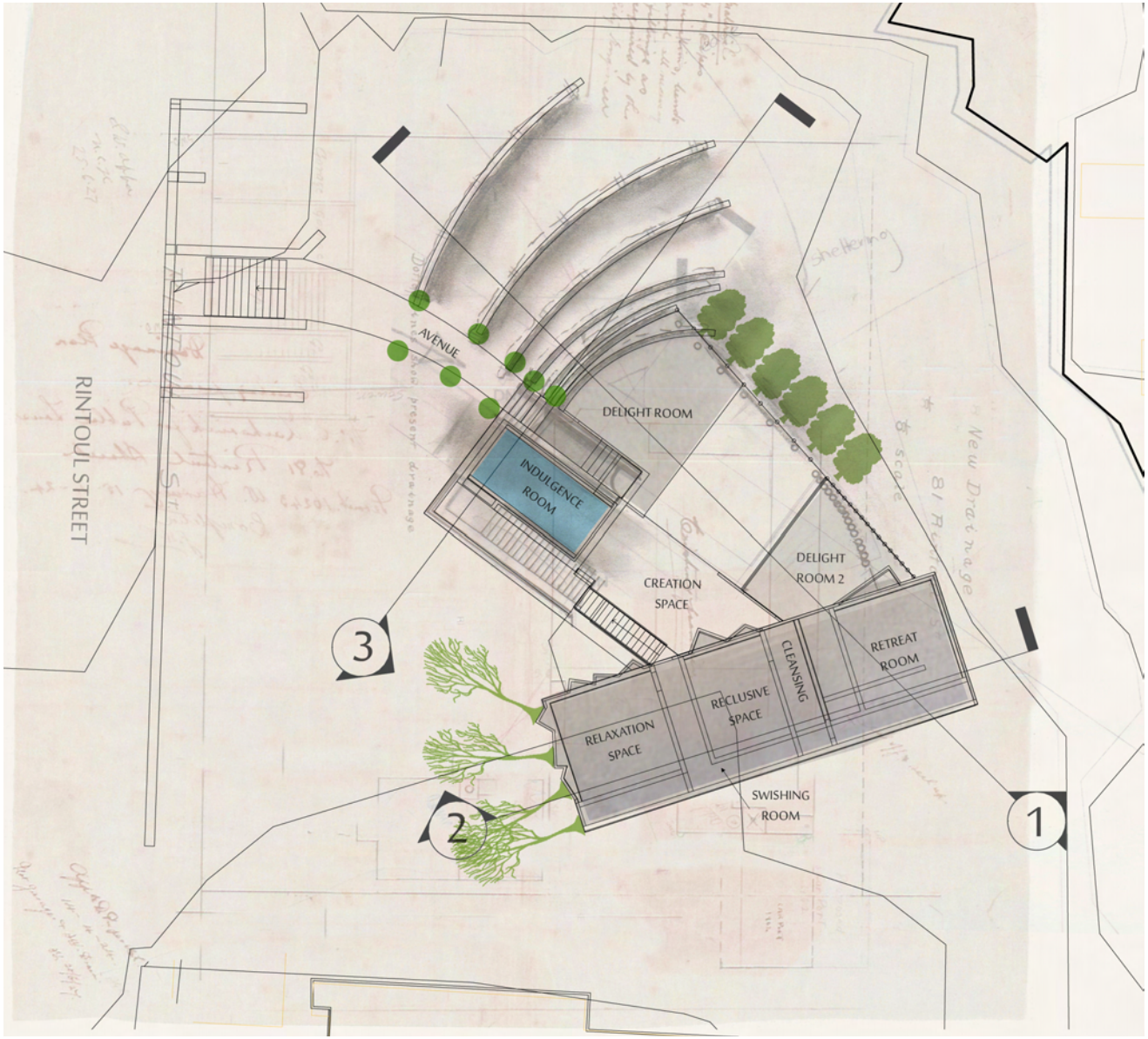


Figure 128 .PLAN VERDANT EDGES TO SPACE
Drawing by Author.

SCALE 1:250

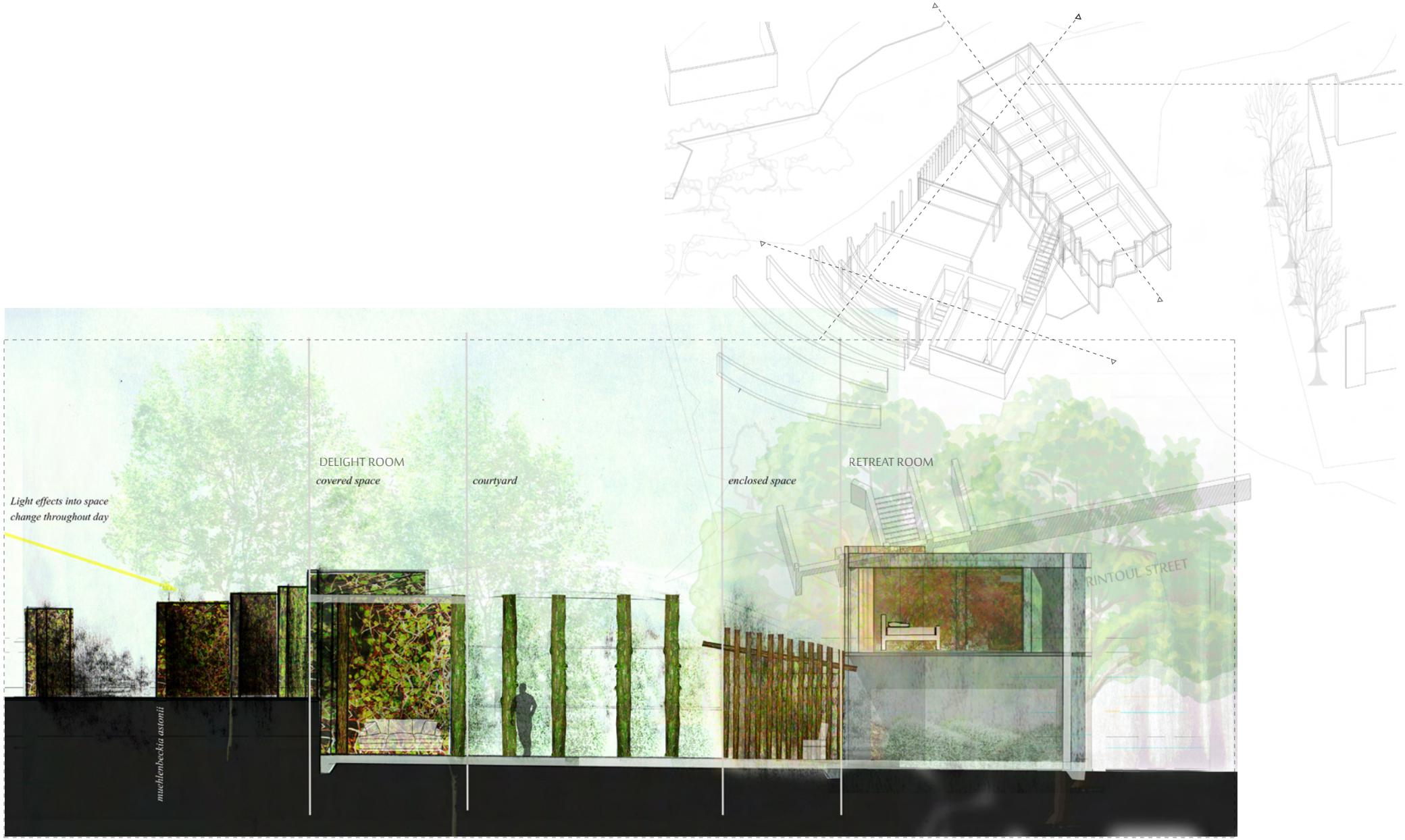


Figure 129 .SECTION 1: DELIGHT ROOM + RECULSIVE SPACE
To left delight room showing varied verdant element spacing and size, retreat room showing verdant walls. *Revit model, photoshop, hand drawing by Author.*

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Figure 130 .SECTION 2 :Through relaxation space, reclusive space, cleansing space, retreat space on the second floor, and through the swishing room and toilet area on the ground floor.
Revit model, photoshop, hand drawing by Author.

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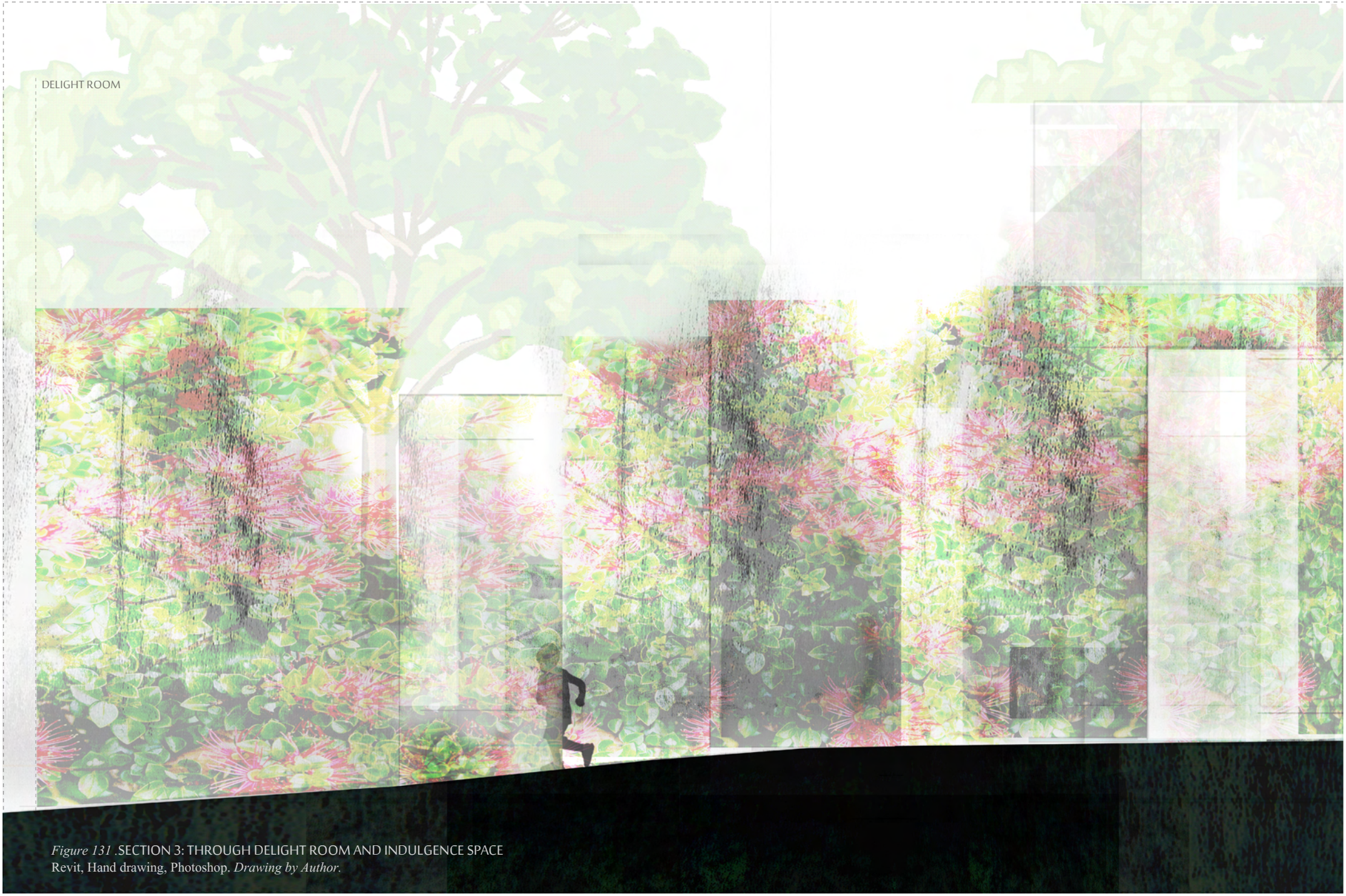


Figure 131 .SECTION 3: THROUGH DELIGHT ROOM AND INDULGENCE SPACE
Revit, Hand drawing, Photoshop. *Drawing by Author.*


INDULGENCE ROOM
indulgence room
creation space
open to outdoors
water pump
Pellaea rotundifolia
SCALE 1:50

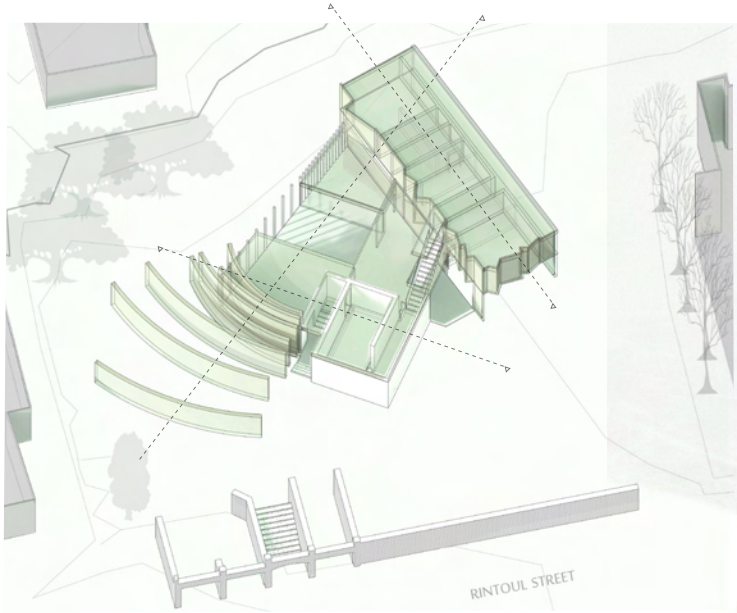
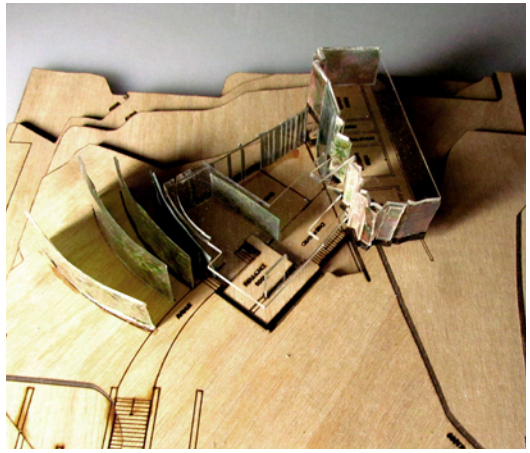


Figure 132 .REVIT MODEL OF BUILDING. *Revit Model, image enhanced in Photoshop. Image by Author.*



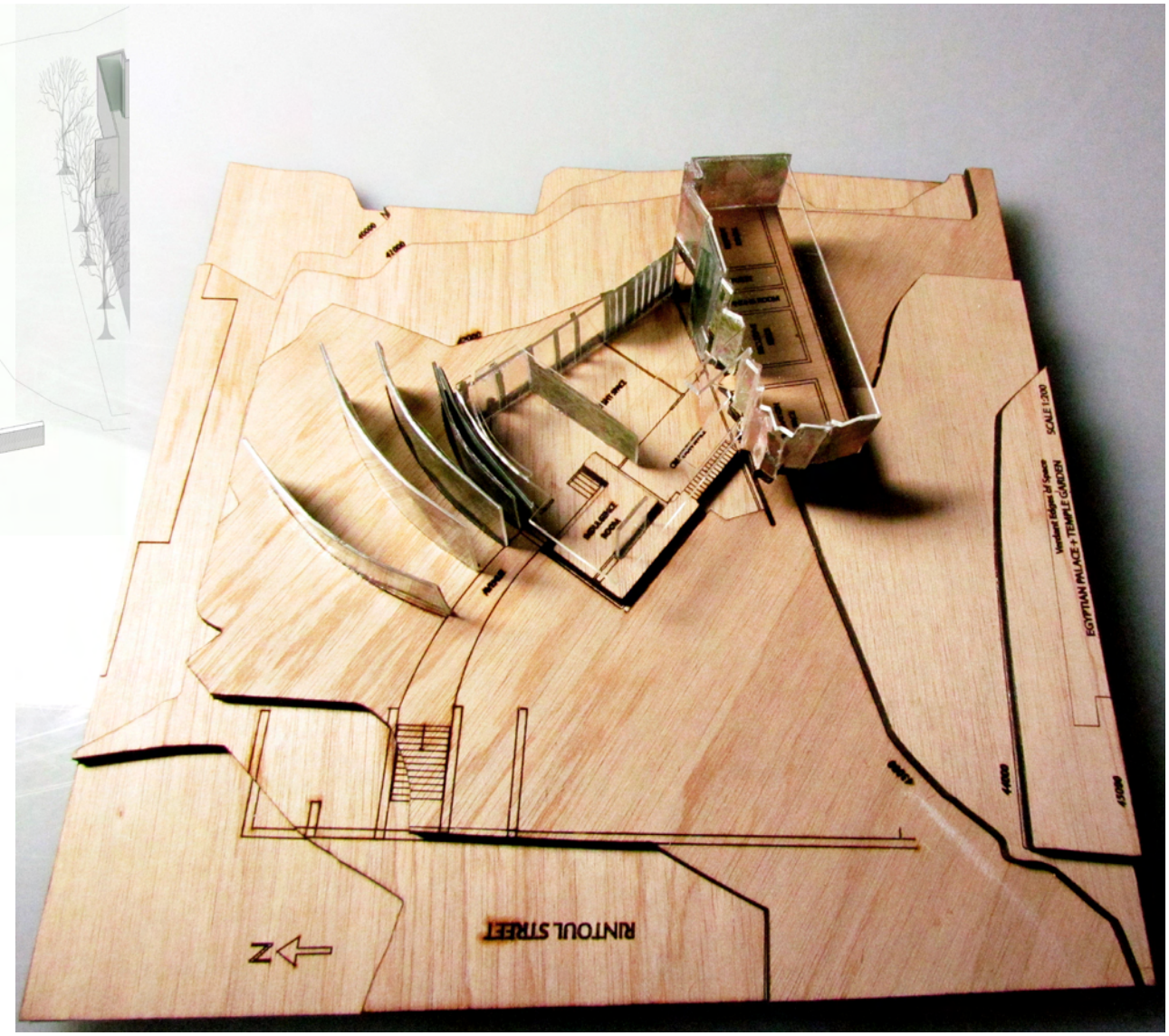


Figure 133 and 134 .VERDANT EDGES TO SPACE PHYSICAL MODEL
Laser Cut and hand modelled by Author.

Figure 131 shows the indulgence room; a space which would predominantly be used at night. The ferns implanted in the walls of the concrete interior create a uniquely lush and evocative atmosphere to dine within. Growing plants in concrete walls, is a system used in the Harmonia 57 building (see Section 4.5.6), where the lush plants are isolated on the exterior surface of the building and do not sensually influence internal space. In contrast this concept creates the planted edge internally, resulting in a radically unconventional interior space. At night, the room would rely on artificial light to illuminate the misty and moist surroundings. During the day however, variably diffused natural light would enter from the open stairwell to the right of the space; this opening would also allow rain to run down the stairs to the storage area under the floor. This water would then be used in a piped misting system directed at the walls of the space, creating a moist environment from a self sufficient supply of water. This space successfully integrates plants and architecture as the form and systems were designed specifically to support the growth of plants within the space.

These models (see Figure 132 - 134) physically explored the verdant structures designed for the house. The planted elements were designed to create comfortable, stimulating and interesting spaces through the shielding of direct sunlight. The model tested how the scale, density and forms of these elements would impact the spaces. The shadows in the delight room were changeable suggesting they would influence a vibrant environment. This can be contrasted with the typical shadows in the upstairs spaces which emphasised that replacing conventional walls with verdant walls without challenging the form or the spaces they are part of, is not fully integrating planting as part of the architecture.

This concept aimed to explore edges of space and contrasting levels of atmospheric feeling. Consequently the treatment of these boundaries has caused the house to possess similarities of a courtyard space. However instead of being confined by a solid building mass the space is enclosed by the temperate outdoor climate of Wellington.

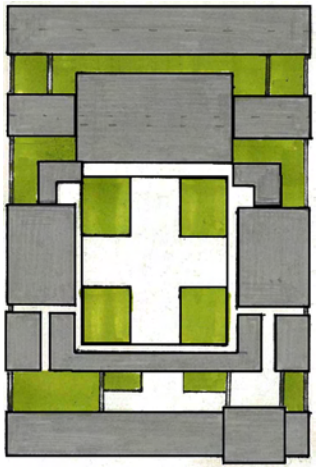


Figure 135. CHINESE FOUR SIDED COURTYARD HOUSE + GARDEN. *Diagram by Author.*

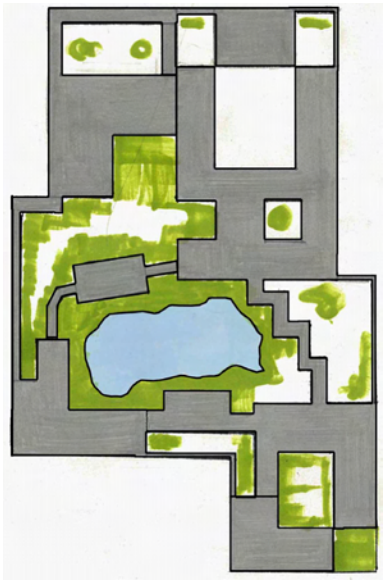


Figure 136. CHINESE SCHOLAR GARDEN. *Diagram by Author.*

8.9 HOUSE CONCEPT TWO - DIVISION

8.9.1 DIVISION (MANIPULATION OF DIMENSIONS AND MATERIALS)

This concept explores how divisions of space are created. It focuses on how the creation of an architectural element for one space also affects neighbouring spaces and areas. The entire house is viewed as a connected series of elements, which are contributing to the sensual qualities of multiple spaces. It uses Chinese and Japanese methods of creating gardens as scenes. The design did not seek to create a literal scene, instead it sought to consider the use of verdant elements for how they will be perceived and viewed by inhabitants of the house.

8.9.2 PLASTER MODELS

The plaster model in Figure 137 demonstrates the contrast between interior and exterior space. It is a simple exploration of how different conditions can be emphasised, through the use of opposing features adjacent to one another. Figure 138 expresses the manipulation of depth and illusions which occurred in Chinese gardens; it exemplifies how perceived space dimensions can be distorted through the placement of elements (in this case a void) and forms which make the depth of the model appear much deeper than it actually is. The ability of Chinese gardens to construct pleasant space within an enclosed surrounding, caused this concept house to focus inwardly and create a house which is private and purely for the occupants' experience. This design aims to challenge the conventional construction of a New Zealand house through the use of the courtyard typology which emphasises and sensualises divisions, and manipulates the relationship and interaction between spaces.

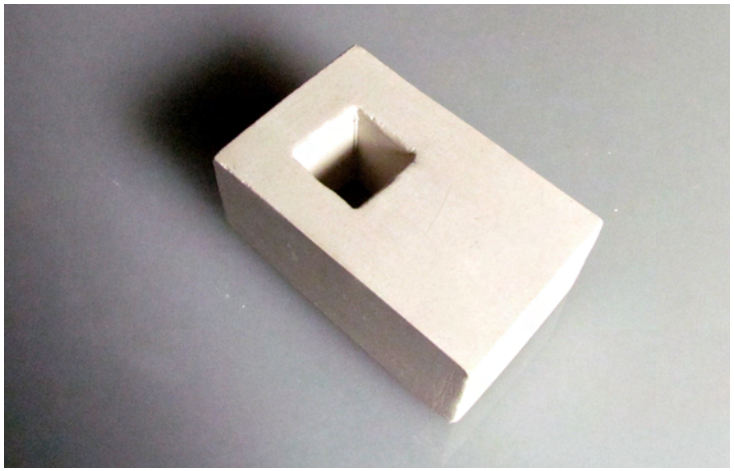
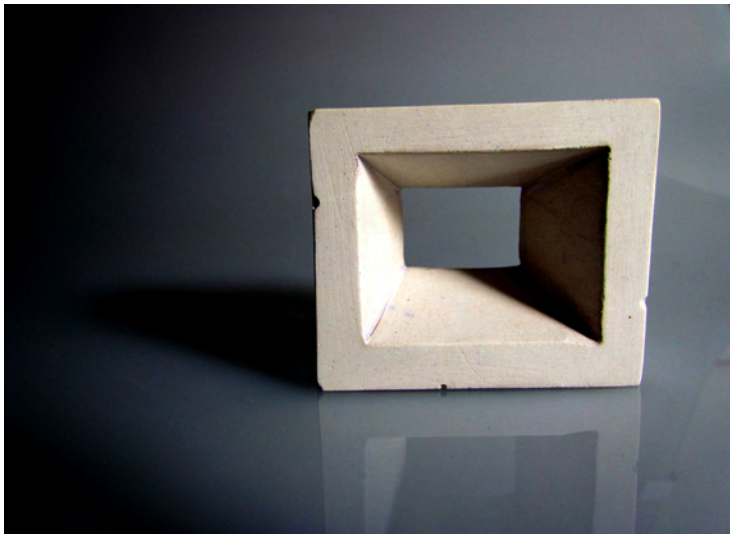
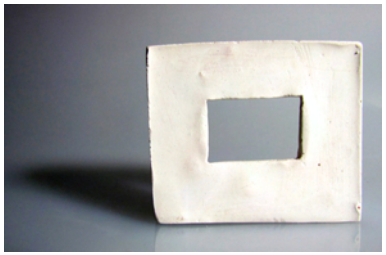


Figure 137. IMAGES OF CHINESE COURTYARD MODEL
Plaster of Paris. *Model by Author.*





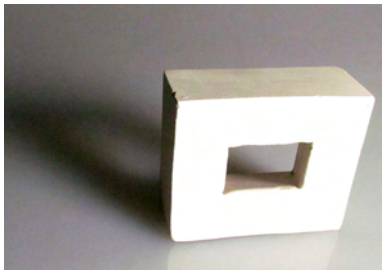


Figure 138. IMAGES OF CHINESE SCHOLAR GARDEN MODEL
Plaster of Paris. *Model by Author.*

8.9.3 HOUSE DESIGN

The plan of the house is influenced by the layout principles of traditional Chinese courtyard houses (see Section 3.3.2). Correspondingly the relaxation space is located in the most desired, north facing position to the rear of the house. The retreat room and reclusive space are located to the right and left of the living area which is in the centre of the plan. The creation space is positioned to the north of this. Instead of locating the windows at the edges of the building footprint (as is typical in New Zealand buildings) all of the spaces gain light from openings, windows and screens facing inwards towards the central space. Each room in the plan is physically disconnected from one another, providing space in between to integrate verdant elements.

Figure 139 .PLAN VERDANT DIVISION OF SPACE SCALE 1:250
Drawing by Author.

Figure 140. SECTION 1: Through Indulgence Room, Contemplation Space, Creation Space, Delight Room And Relaxation Space. *Revit, Photoshop, hand drawing by Author.*

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The longitudinal section (see Figure 140) shows the variation of materiality and the connections between different spaces in the house. Towards the southern end of the house, the design challenges typical spaces and integrates planting with architecture in a sensual way. In the delight room a series of stepped planters create the roof / wall. The form allows diffuse light to enter the space though the gaps between the horizontal planters, illuminating the plants and creating a radiant atmosphere to the end of an otherwise enclosed space. This provides aesthetic benefits for both the delight room and the relaxation space which looks out onto the slope. Division of the relaxation space uses semi-transparent living walls. Layering planted walls of different densities provides varied levels of privacy, shelter and light intensity to the space. The multiple walls provide areas of openness in the room's thoroughfare and visual enclosure in the changing area and sleeping space (see Figure 142).

Towards the Northern end of the space the house is less successful, experiencing similar problems to house concept one, where typically formed semi-transparent walls became the only sense creating part of the space.

The cleansing space in this concept integrates the need plants have for water and the ability of plants to purify waste water produced by humans when showering. A trellis supports native and exotic clematis species (see Figures 141, 142 and 143) which screen the space from the street whilst creating a unique un-sealed environment to cleanse within. Planter beds containing the clematis roots are elevated off the shower floor, visually continuing the floor into the stepped gardens to the west. The floor of the shower slopes away from the trellis, draining water into a cooling chamber under the floor and then into a series of planted beds. This system of grey water treatment was influenced by the phyto-purification bathroom concept (see Section 4.3.5) and has been explored in further detail in the refined house design (see Section 9.3.3). Within the isolated shower space the intimate distance between plant and human would be pleasant, providing inhabitants with a functional place to think enhanced by the beauty of the plants.

Figure 141. SECTION 2: Through Cleansing Room And Relaxation Space.
Revit, Photoshop, Hand drawing by Author.

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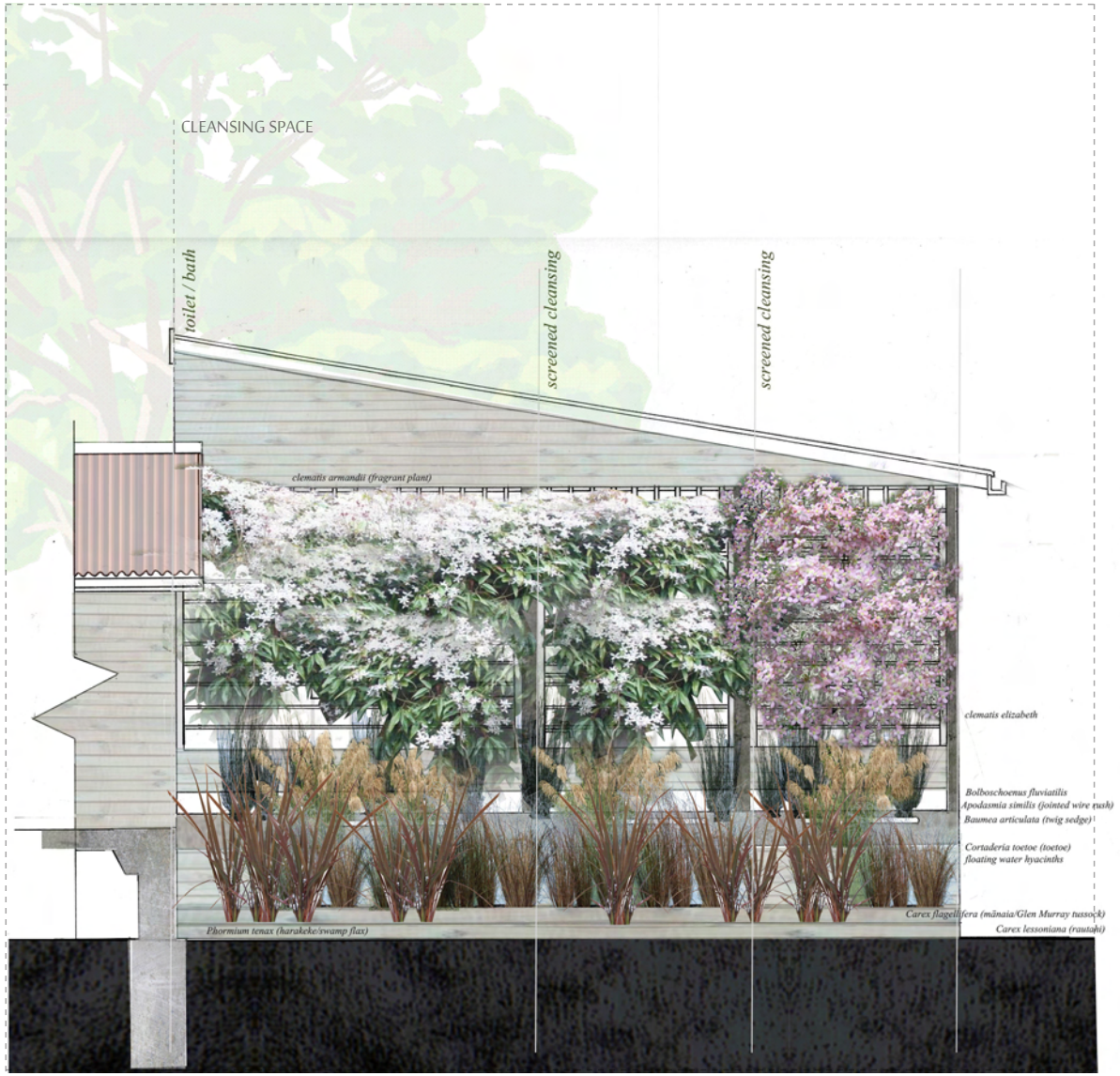
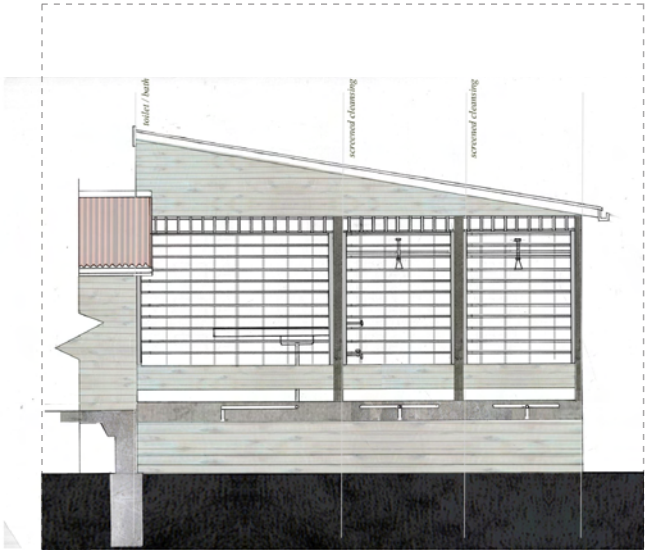


SCALE 1:50



SCALE 1:100

Figure 142. SECTION 3: Cleansing Room Verdant Screen And Greywater Biofiltration.
Revit, Photoshop, Hand drawing by Author.

Figure 143. Right. SECTION 3 STRUCTURE - showing supportive trellis.
Revit, Photoshop, Hand drawing by Author.

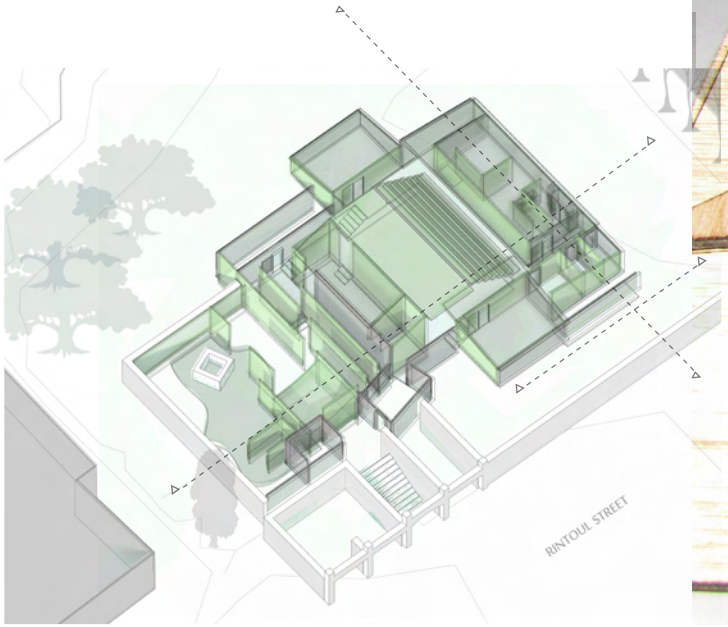


Figure 144. COMPUTER MODEL 3D VISUALISATION.
Revit and Photoshop. Model by Author.

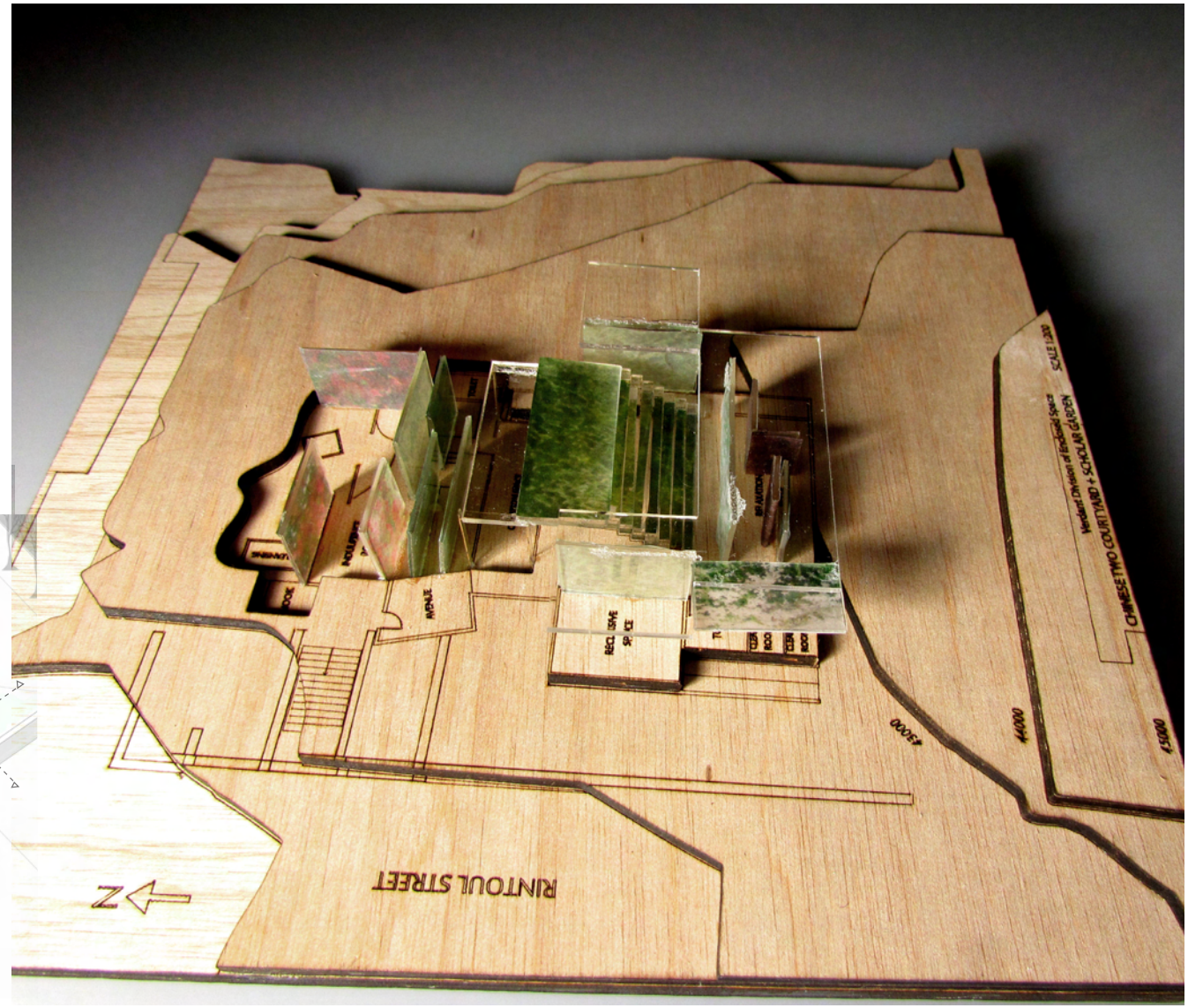


Figure 145. VERDANT DIVISION OF SPACE PHYSICAL MODEL.
Laser Cut and hand modelled by Author.

When constructing these models (see Figures 144 and 145) the designed divisions between each space were able to be physically analysed. Spaces where the verdant elements were integral components and the spaces where they appeared added on could be readily identified and contrasted. The model also highlighted that actual voids between the northern spaces in the house (between the indulgence room and the creation space, and the creation space and delight room), may have provided possibilities for more innovative and integrated divisions to occur; as opposed to a typically formed verdant wall becoming the division between the spaces.

This concept was designed as a succession of spaces, where each space is only partially visible from the previous one; allowing each space to be a thought of as a constructed scene. The concept explored how the spaces within a house can be divided, and also explored the typical division between inside and outside. It utilised philosophies and ideals from historical gardens that exhibited manipulated dimensions and materials in their designs, to offer alternative methods for sensitising the crossover of different spaces. Divisions which interact with both of the spaces they edge, in different ways, were found to be the most interesting and unique. This principle is incorporated into the refined house concept in Chapter 9.

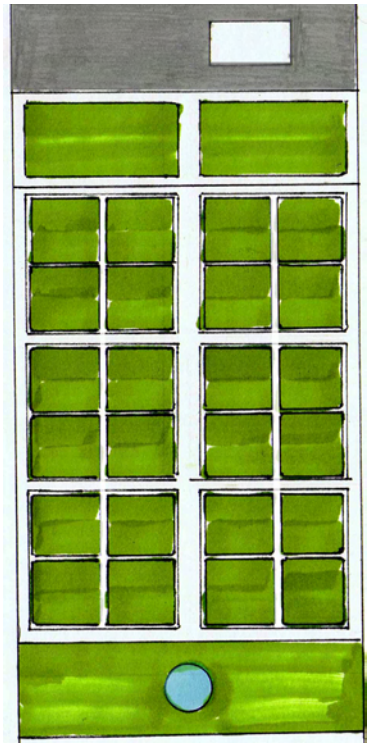


Figure 146. RENAISSANCE GARDEN.
Diagram by Author.

8.10 HOUSE CONCEPT THREE - WITHIN

8.10.1 WITHIN (FORMAL STATEMENT)

This concept utilises the within typology to experiment with how the strong gridded layout and divisions of the Renaissance garden can be used to contain space using enclosing verdant elements. The house is influenced by the principles of the formal space gardens. It aimed to create feelings of enticement and anticipation for those exploring the house; just as formal gardens did.

8.10.2 PLASTER MODEL

The plaster model in Figure 147 explores the logic and repetition of the Renaissance garden spaces. The three stacked forms of the model are the same but placed at different heights, expressing principles of movement; a feature that was integral to the sequential designs of renaissance gardens. The gradual and prescribed movement through renaissance gardens is translated into the design of this concept, where habitation takes place within the gridded verdant elements. This emphasises that the spaces have been created within a larger frame work, instead of the spaces dictating the layout.

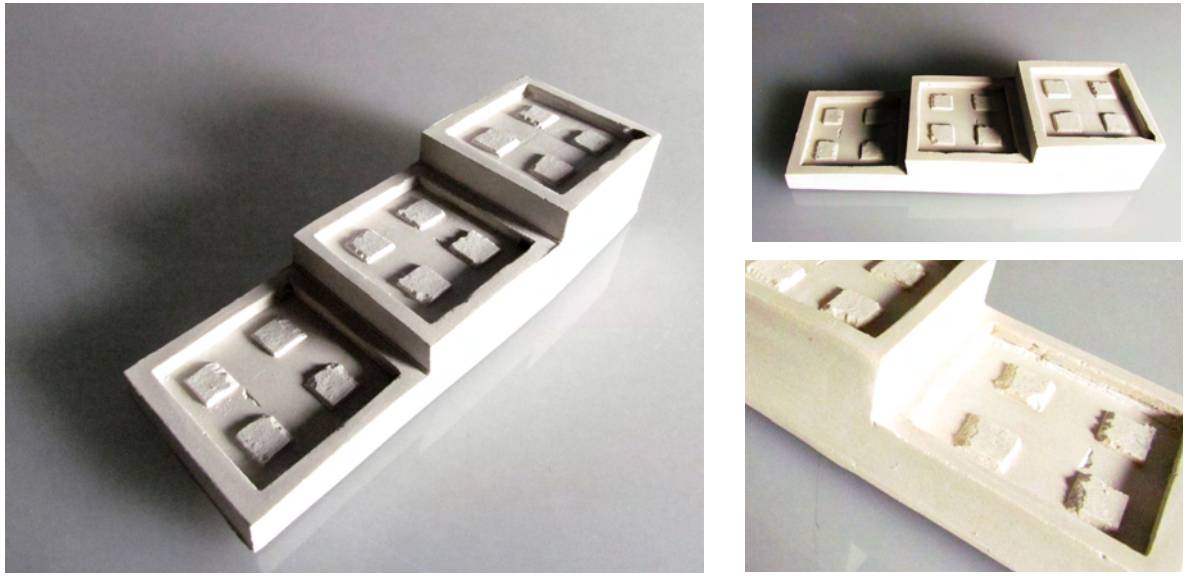


Figure 147. IMAGES OF RENAISSANCE GARDEN MODEL.
Plaster of Paris. *Model by Author.*

8.10.3 HOUSE DESIGN

The house layout is reminiscent of an Italian Renaissance garden plan, due to its structured layout and the separation of different spaces with opposing uses. The house is designed to create its own natural views and spaces within the architecture; considering garden qualities to be essential to every architectural space. The plan has a main axis which leads onto the site, perpendicular to the street.

The sections on the following page show the layout of the house. Entering the building from street level, movement through the house would be a progression through the varied spaces which only become visible when standing perpendicular to them; similar to movement through a renaissance garden where the various spaces are only exposed as you reach them. The only space in the house which is not formed by verdant walls is the essence space (see Figure 149); located towards the centre of the main axis. The space can be completely opened with four sets of double doors, or used enclosed for occupation during extreme weather conditions. Figure 150 shows the building's consideration of the site's typography and existing garages. The retreat room is located at ground level inside an old garage and is shielded from the street by a dense reddish green wall of *Berberis x ottawensis*. This verdant wall would provide changeable light and pleasant colours to the interior space, whilst creating an interesting street frontage. Similarly, the walls of the cleansing room and contemplation space would be visible from the street, providing interest to the passersby without revealing what is behind; keeping an element of mystery about the space.

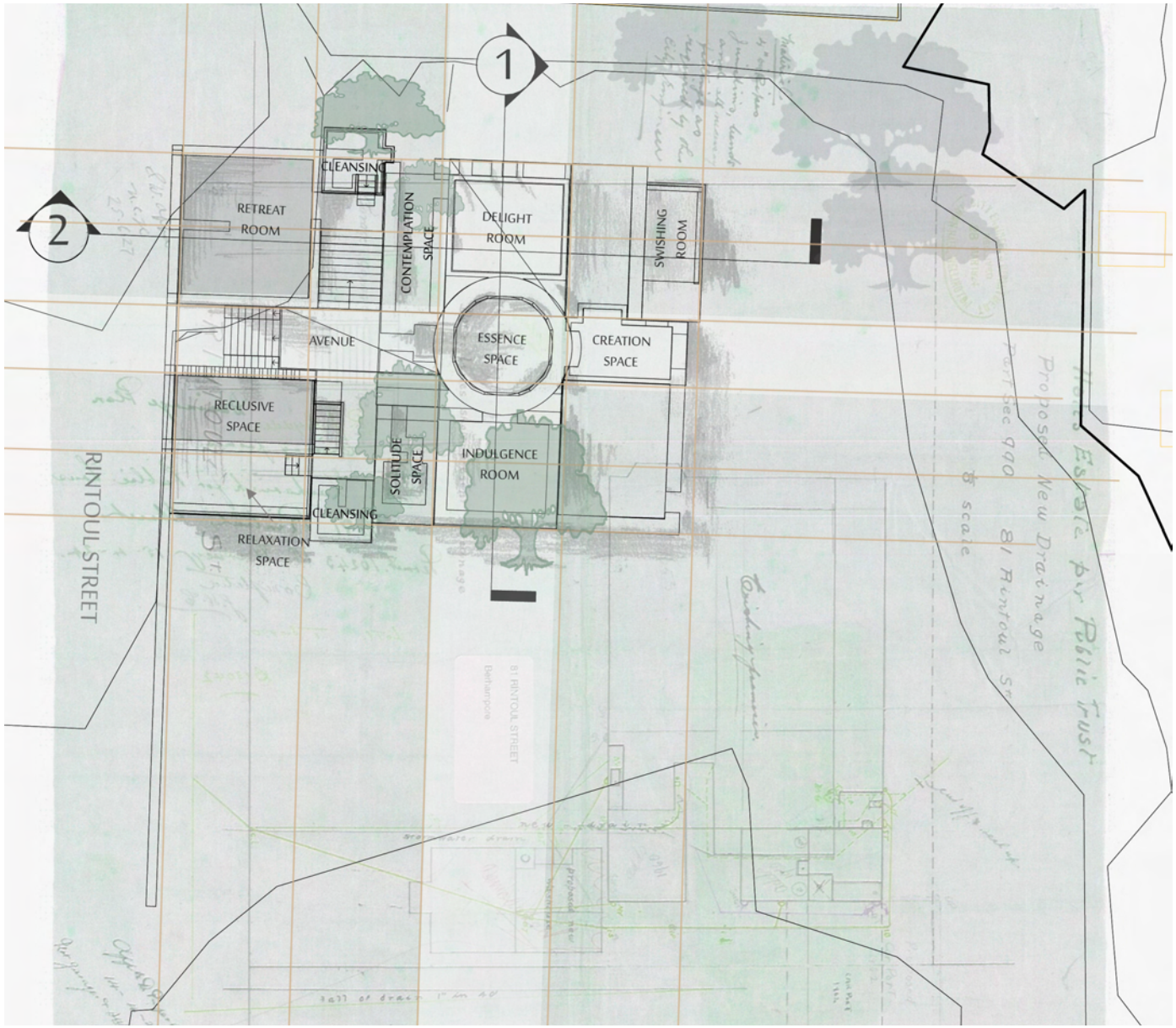


Figure 148. PLAN WITHIN THE VERDANT EDGES SCALE 1:250
Drawing by Author.

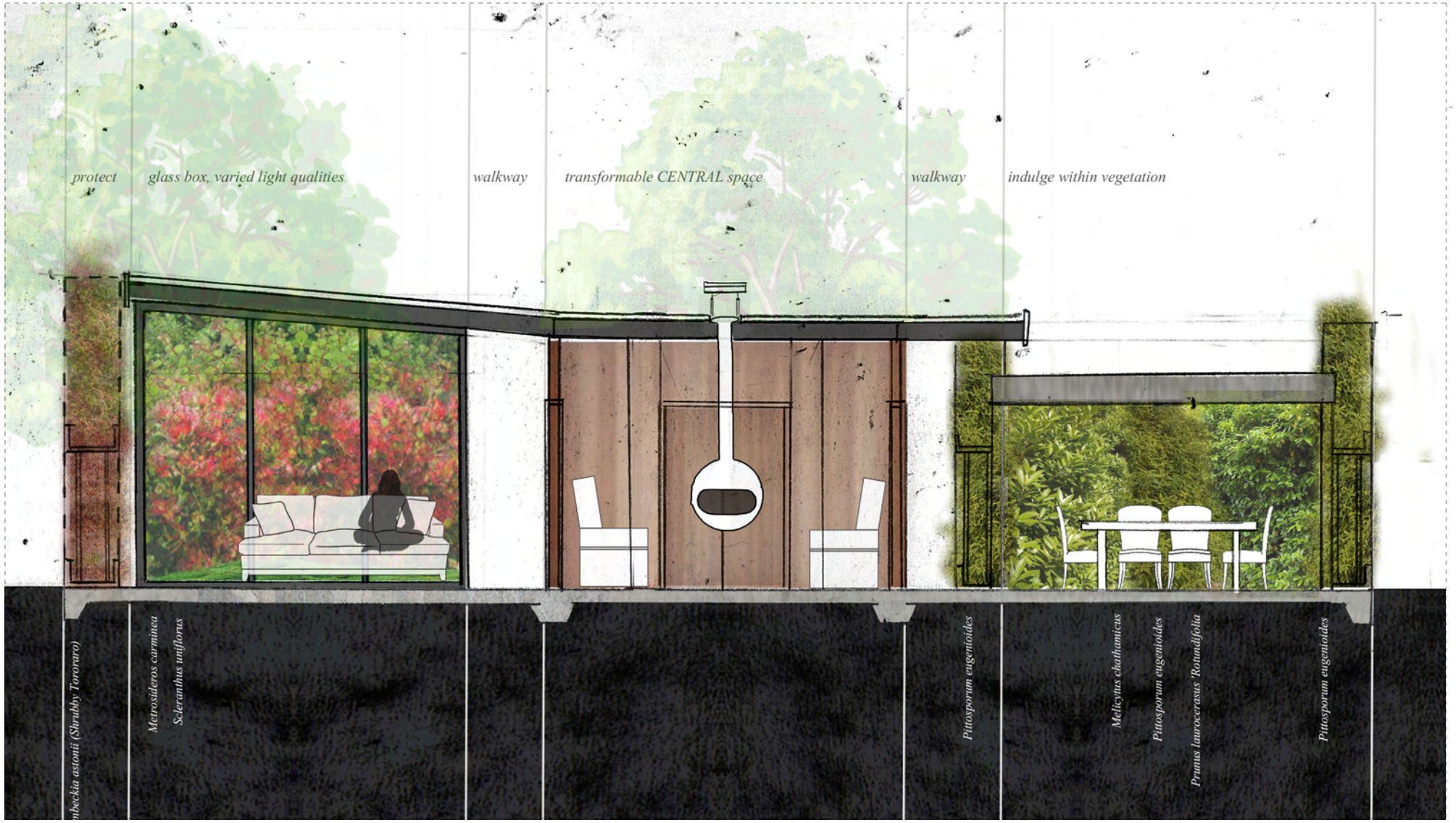


Figure 149. SECTION 1: through delight room, essence space and indulgence room. *Drawing by Author.*

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Figure 150. SECTION 2: through retreat room, cleansing room, contemplation space, delight room and swishing room. *Drawing by Author.*

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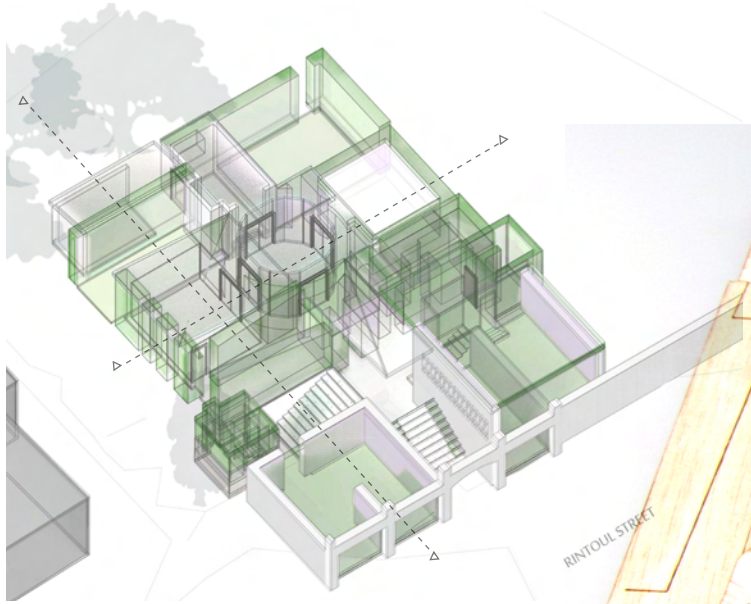


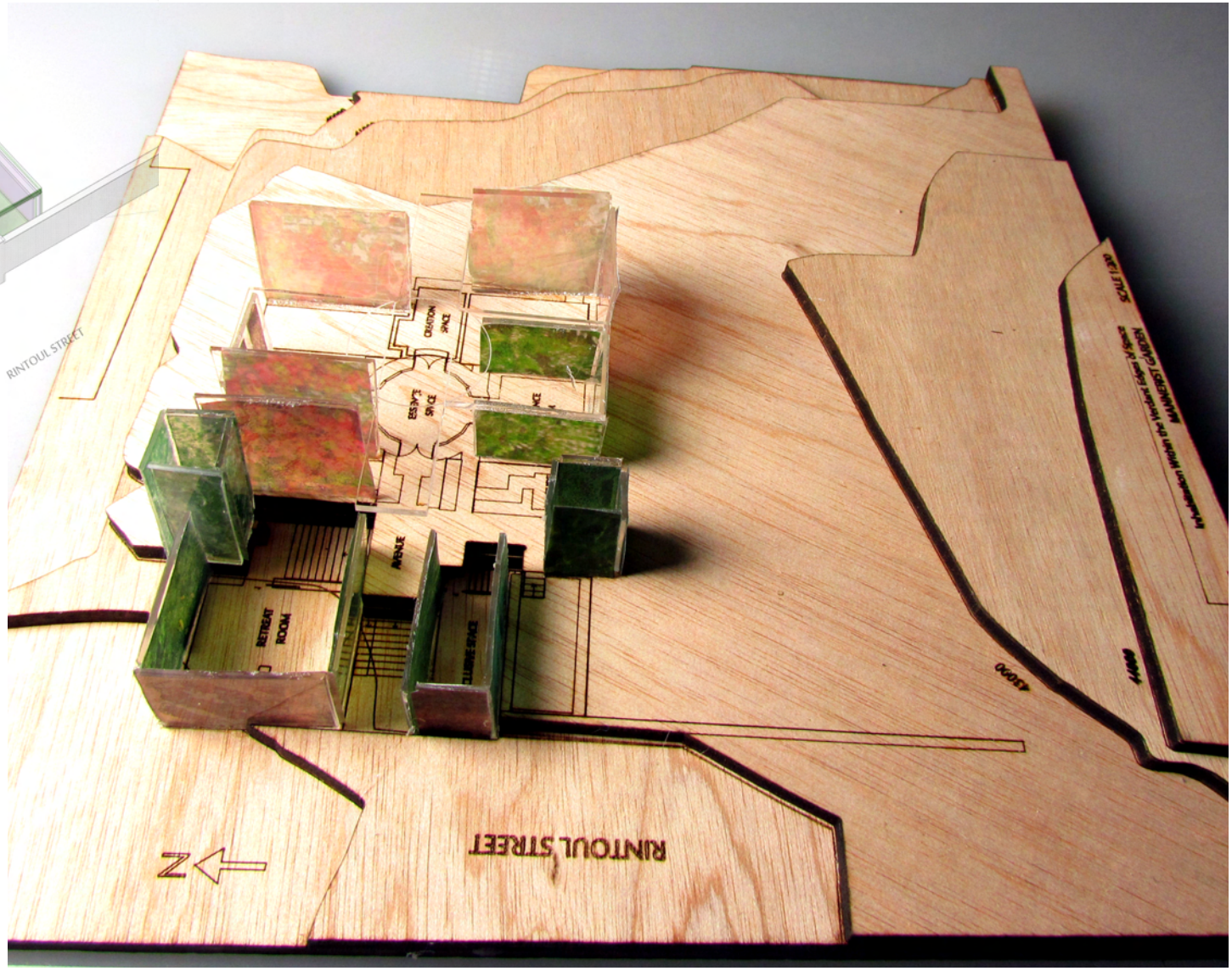


Figure 151. Above Left. COMPUTER MODEL 3D VISUALISATION. Revit and Photoshop. Image by Author.
Figure 152. Left. WITHIN THE VERDANT EDGES PHYSICAL MODEL - afternoon.
Figure 153. Above. Ibid - midday. *Laser Cut and hand modelled by Author.*

The models in Figures 152 and 153 show the layout of spaces in the house, including the unobstructed central axis through the building. Also demonstrated are the effects that light would have on the spaces created within the verdant forms. During the day inhabitation would be within lush illuminated areas, in contrast to the night, where artificial lighting would illuminate the building itself.

This concept was heavily reliant on the use of semi-transparent green walls and facades which make up the entire building's form. These walls were integral to defining entire spaces for habitation whilst also creating sensual spaces. The use of verdant walls to define and contain space would show human control over nature as well as making the spaces beautiful to inhabitants; two principles important to the construction of Italian Renaissance gardens. While the spaces within this concept are interesting and successfully incorporated as part of the architecture, the verdant architectural forms could be challenged further to result in more varied, and unique, shadows and spaces.

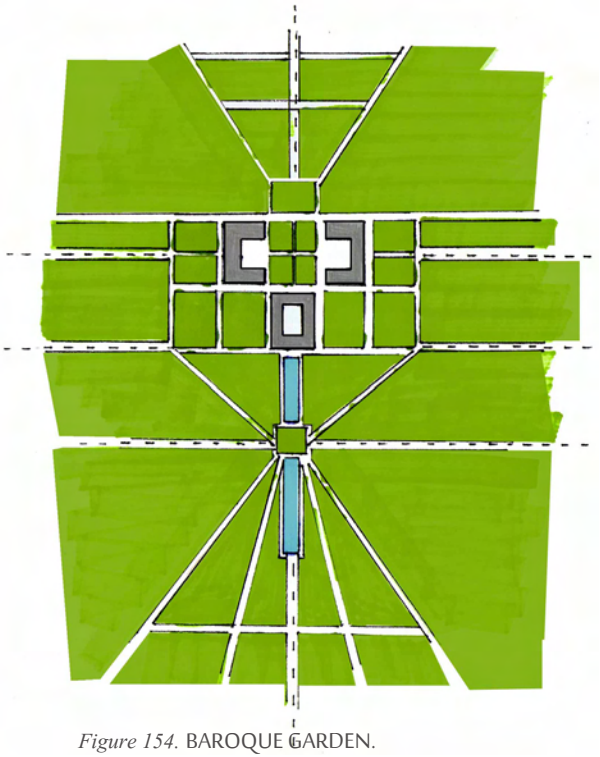


Figure 154. BAROQUE GARDEN.
Diagram by Author.

8.11 HOUSE CONCEPT FOUR - FRAME

8.11.1 FRAME (FORMAL STATEMENT)

Concept four uses the frame typology to create spaces which are uniquely presented to inhabitants through the use of striking verdant forms. It questions how everyday spaces could be made more exciting and dramatic, utilising the merits of Baroque gardens (see Figure 154) to present this idea in the design.

8.11.2 PLASTER RENDER

This render was created to visualise the three dimensional form of the baroque garden. Figure 155 shows an emphasised widening of the central line of symmetry which prevents the space from appearing to be reduced in size when viewed in perspective. It expresses the symmetry of the garden and the constructed sight lines through the many sectors. This feature allowed Baroque gardens to remain highly connected spaces despite their vast scale. The concept aims to transform typical components within a house into extravagantly designed verdant elements, with the intention of enhancing the surroundings where household activities occur.

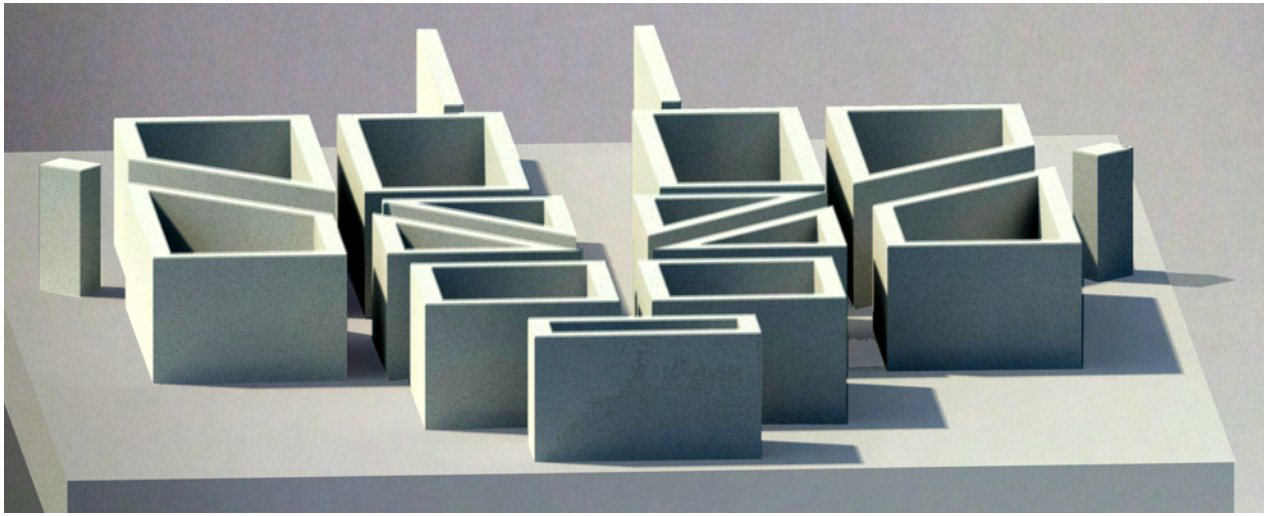


Figure 155. IMAGE OF BAROQUE GARDEN MODEL.
Revit Render. *Image by Author*

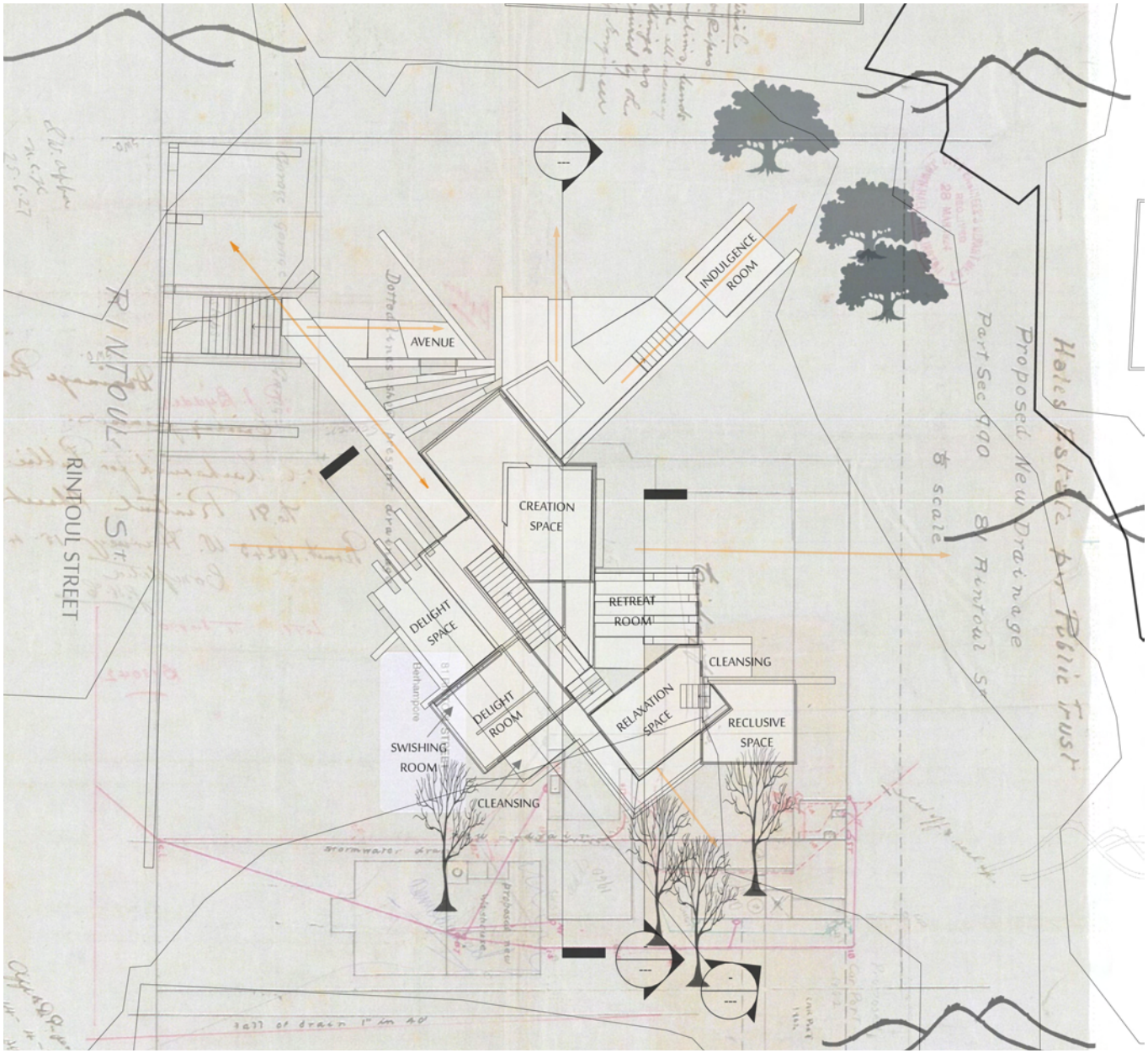


Figure 156. PLAN VERDANT FRAMING OF SPACE.
Drawing by Author.

SCALE 1:250

8.11.3 HOUSE DESIGN

This house is designed as an arrangement of varied spaces which are all connected to a central axis. The spaces are each angled according to a line of sight either directed at a tree within the site, or to the distant hills. Each space aims to dramatise its utilitarian use, by framing and increasing typical scale or form of building components. The building encourages movement, through the use of many angled elements, repeated forms and multiple views through the spaces.

An avenue leads onto the site from the street, this path travels past an enticing diagonal view into the house, referencing the constructed views used in baroque garden spaces (see Section 3.5.3). Entry to the house (see Figure 157) is perpendicular to this avenue; a series of four verdant archways frame the entrance, using gradually increasing void sizes towards the internal space. Once inside the house there are multiple directions to take. Straight ahead a semi-transparent living facade is lush with herbs situated behind sliding glass windows, this verdant element borders the open plan kitchen space. To the northeast of the building a verdant corridor directs inhabitants to the indulgence room, which is framed by two large semi-transparent walls directed at the large trees at the corner of the site. This space is grand and of an exaggerated scale. It would be a sheltered and secluded area to dine within.

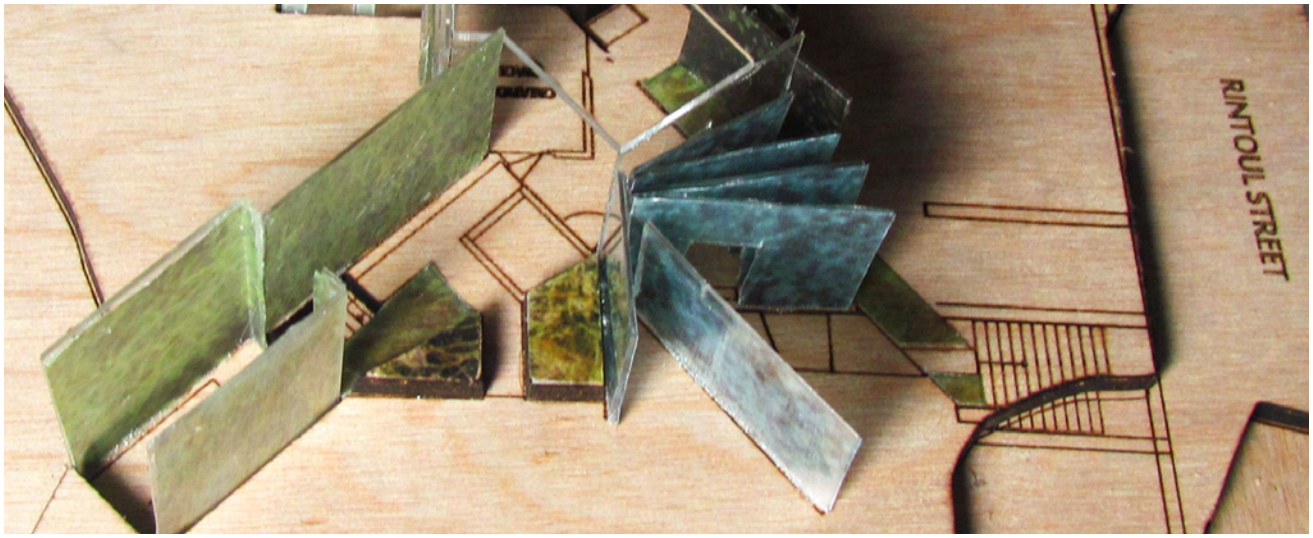
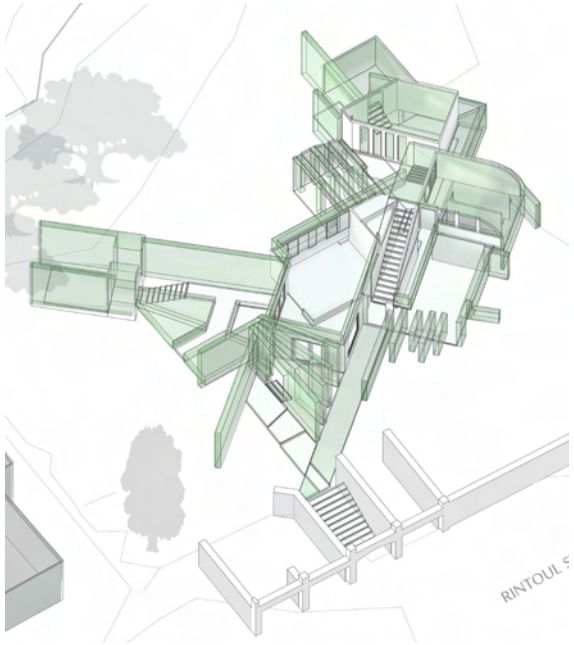
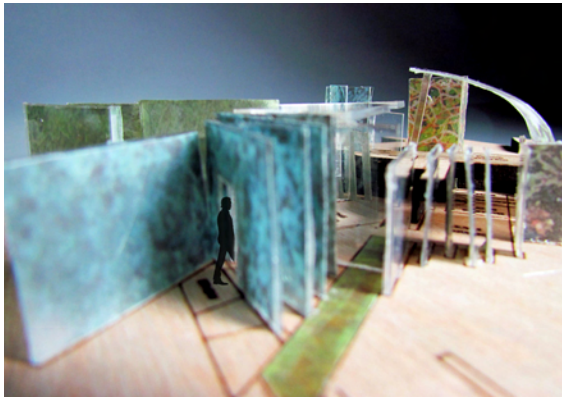


Figure 157. TO HOUSE FROM STREET. *Laser Cut and hand modelled by Author.*





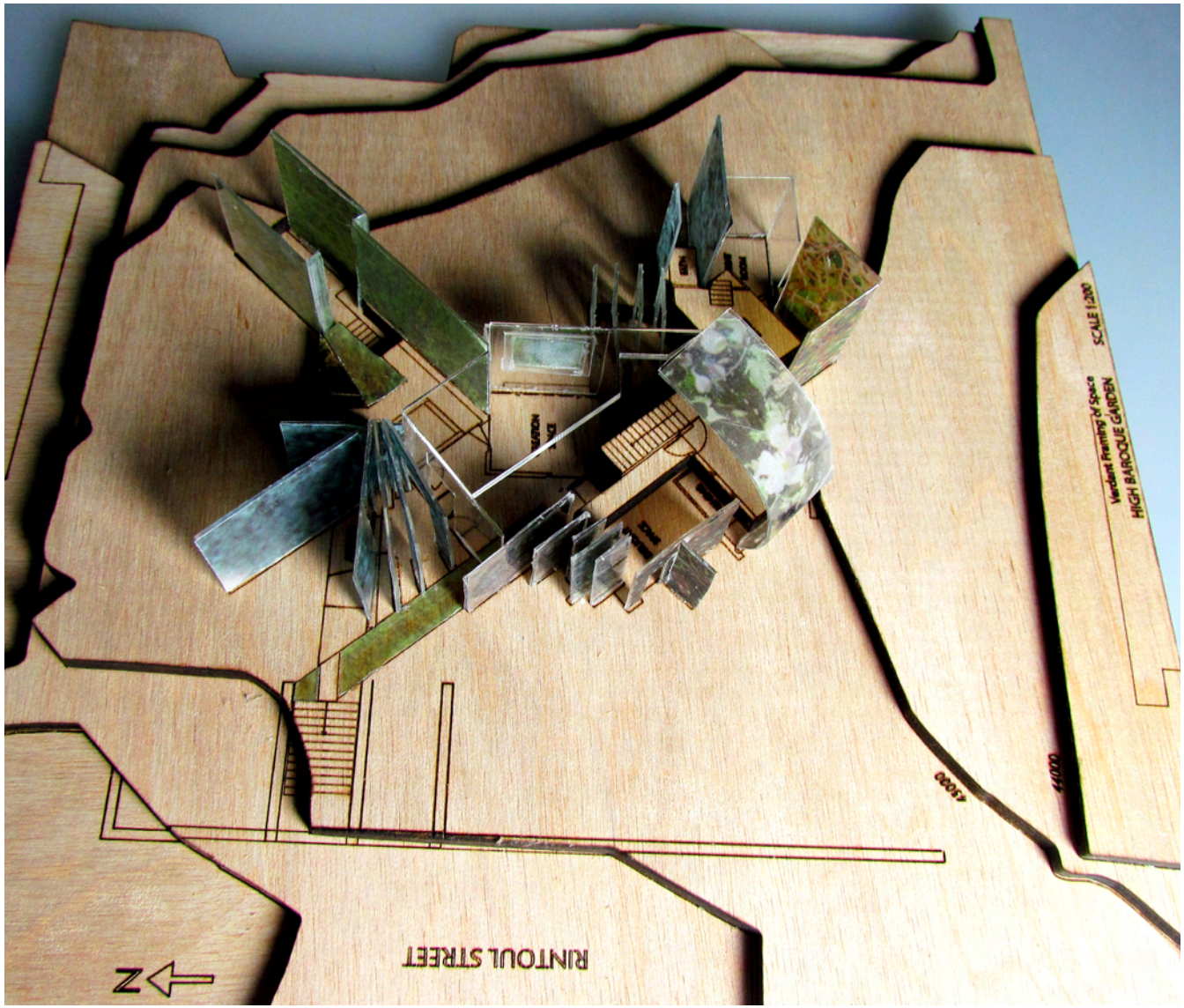


Figure 158. Above Left. COMPUTER MODEL 3D VISUALISATION. Revit and Photoshop. Image by Author.
Figure 159. Left. FRAMES AT ENTRANCE TO HOUSE.
Figure 160. Above. VERDANT FRAMING OF SPACE PHYSICAL MODEL. *Laser Cut and hand modelled by Author.*

To the east of the space, the relaxation room, retreat room and reclusive space are each orientated towards different views. For example the retreat room has a series of frames which penetrate and divide the space into two areas with contradictory views. In one area within the repeated frames the view is focussed to the north-east, while the other looks perpendicularly through these frames to the south-east. The thickness of these frames is manipulated as such as the views would only be available from certain points.

Utilising a physical model (see Figure 159) was useful for this concept house as it was a visualisation of the many statement elements used in the building. The model shows the incorporation of ornamental verdant elements and the blurred distinction between inside and outside. The concept was successful in challenging the physical form of verdant elements, treating them as they were considered in the creation of French Baroque gardens; as architectural forms.

8.12 DISCUSSION

The concepts in this chapter utilised principles of historic gardens to provide the designs with sensual opulence which is often lacking in present day verdant architecture. Each concept focused on creating verdant elements with regard to one typology of building component. The designs resulted in a number of realisations. Firstly that planted components should not be verdant replicas of conventional building components within conventional spaces. These elements should be challenged either through a change of shape, layering or the repetition of elements. Secondly that physical separation between spaces allows varied interaction with the verdant element in the two surrounding spaces. Finally the designs showed that expressive verdant forms, while not functionally essential, create splendid and interesting spaces. These realisations are incorporated in the design of the refined concept house (see Chapter 9).

Figure 161. Right. GROUND PLAN OF VERDANT HOME - SCALE 1:100. *Image by Author*

chapter nine:

REFINED VERDANT HOME

9.1 INTRODUCTION

The refined design shown in this chapter has been completed to an increased level of resolution. The verdant technologies used to construct the house have been integrated with traditional building materials, resulting in a building which could comfortably support daily living functions with minimal lifestyle changes. It is predominately a development of Concept House two, but it also integrates successful ideas from the other three concepts. Resulting in the creation of a refined house design which incorporates spatial principles from multiple gardens, and the four verdant element typologies. This chapter will discuss the functional aspects and verdant technologies used in each space, before describing the sensual qualities provided throughout the *Verdant Home.*

9.1.1 SITE USE

The refined house was designed to be bounded by its site; creating predominately inwardly facing spaces. The site (see Figure 163) has not been completely filled as the design was focused on integrating the house with garden. Therefore, landscaping the site was outside the scope of this thesis and was accordingly not considered. The building incorporates the subtle changes in topography which exist on the site to create architecture fitting to the natural landform, and utilises many of New Zealand native plants, benefitting the promotion of a variety of species.

9.1.2 GREEN ROOFS

Intensive green roofs (see Section 4.2.4 and Figure 162) have been used on the stepped roofs of the delight room and the flat roof of the reclusive space. The 350 mm depth of growing medium used on these roofs allows native shrubs and grasses to be grown. To retain as much natural rainfall as possible a standing water system is incorporated into the roofs; where a water retention layer stores water under the substrate. In periods of little rain a manual watering system can be used to fill this retention layer. In the retreat room, the steep gradient of the intensive green roof means it would need to be a specially constructed intensive roof to ensure the soils stability, whilst enabling shrubs and grasses to be grown.

Visibly inaccessible extensive roofs are used on the creation space, contemplation space and swishing room. These roofs are low maintenance and are integrated purely for the environmental and functional benefits they provide.

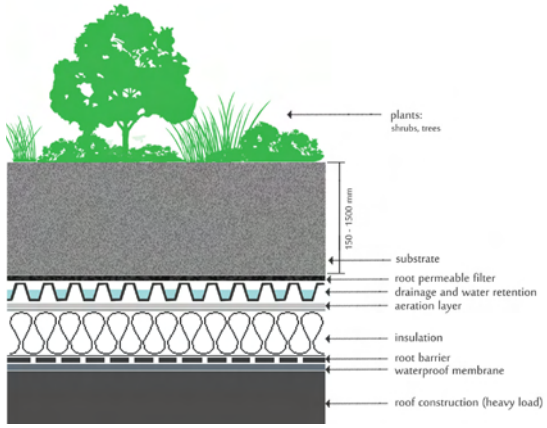
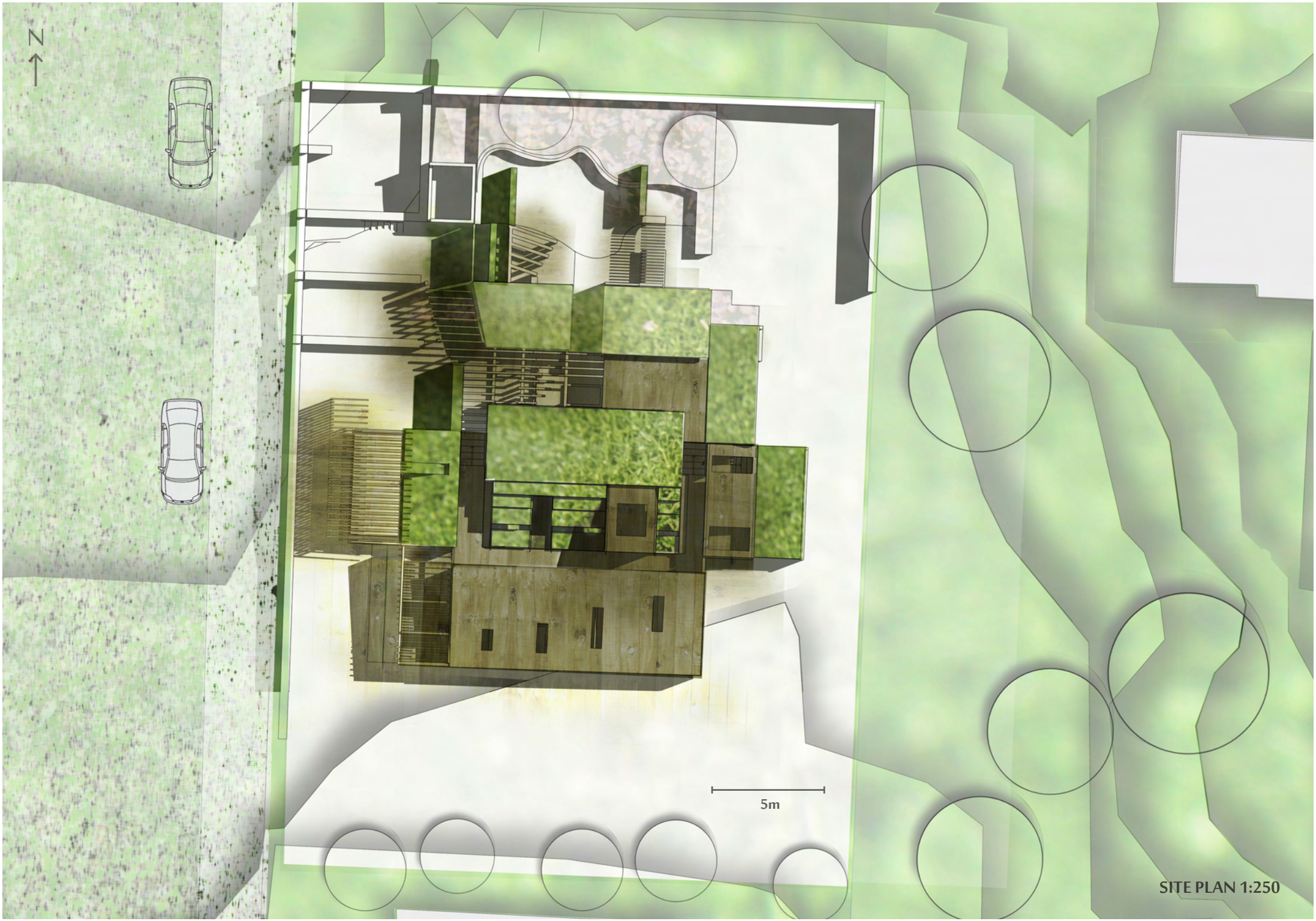


Figure 162. INTENSIVE GREEN ROOF DIAGRAM
Figure 163. Right. ROOF PLAN 1:250. *Images by Author.*



SITE PLAN 1:250

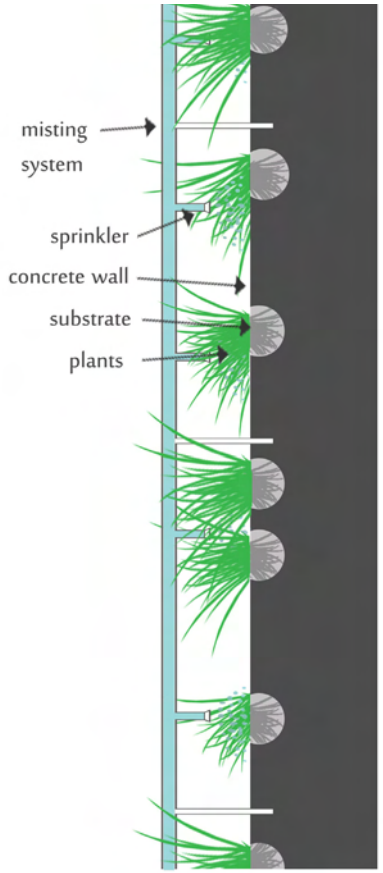


Figure 164. CONCRETE VOIDS LIVING WALL. - used in the indulgence room. *Diagram by Author.*

Figure 165. Right. GROUND PLAN 1:200. *Image by Author.*

9.2 LAYOUT

The house would be a sensual and changeable environment to live within, due to the varied form, size, colour, planting, materials and environmental conditions of each space. The connection of the non-hermetic building to the external environment would result in internal conditions that relate to outdoor conditions providing inhabitants with a beneficial connection to nature (Chartered Institution of Building Services Engineers, 2006, pp. 1-16). Each space is designed to have different sensual qualities, either through the use of verdant edges, divisions, frames or enclosing verdant elements (see Figure 164). The layout of the space is similar to that of a Chinese courtyard house, also used in house concept two (see Section 8.9). The spaces are all physically separated, meaning each room has four external edges, these edges, along with additional divisions, incorporate verdant elements to create sensual spaces within the areas they enclose.

9.2.1 INDULGENCE ROOM

The indulgence room design was taken from concept house one and is designed to be a less damp but still evocative space in this house. It contains one complete concrete wall embedded with growing ferns and two half walls (see Figure 164). Diffuse light would enter the space from the delight room windows providing the ferns with light; however artificial light would also be needed to support the plant growth. The floor near the edges of the walls slopes to prevent water from the misting system used to water the walls from pooling on the floor surface. The indulgence room is a thoroughfare space which would act as an area of dimness between the kitchen, avenue and delight room.


LONGITUDINAL SECTION FOUR
TRANSVERSE SECTION ONE
TRANSVERSE SECTION TWO
TRANSVERSE SECTION THREE
SHED
CONTEMPLATION SPACE
AVENUE
CREATION SPACE
SWISHING ROOM
INDULGENCE ROOM
DELIGHT ROOM
RETREAT ROOM
RECLUSIVE SPACE
TOILET +CLEANSING SPACE
CLEANSING SPACE
CLEANSING SPACE
RELAXATION SPACE
Hebe 'Orphan Annie' (S1)
Hebe 'barnettii' (S1)
Hebe pimeleoides 'Quicksilver' (S1)
Hebe 'Mary Antoinette (S1)
metrosideros carmonia (S2)
pseudowintera colorata (S1)
assorted vegetables
muelembeckia astonia (S1)
Clematis paniculata (S4)
Acaena inermis 'Purpurea'
blechnum fillforme
luzuriaga parviflora
pratia angulata
Hebe Armstrongii (S1)
Scindapsus Aureus (S4)
Mosstile Flooring
5m
GROUND PLAN 1:200

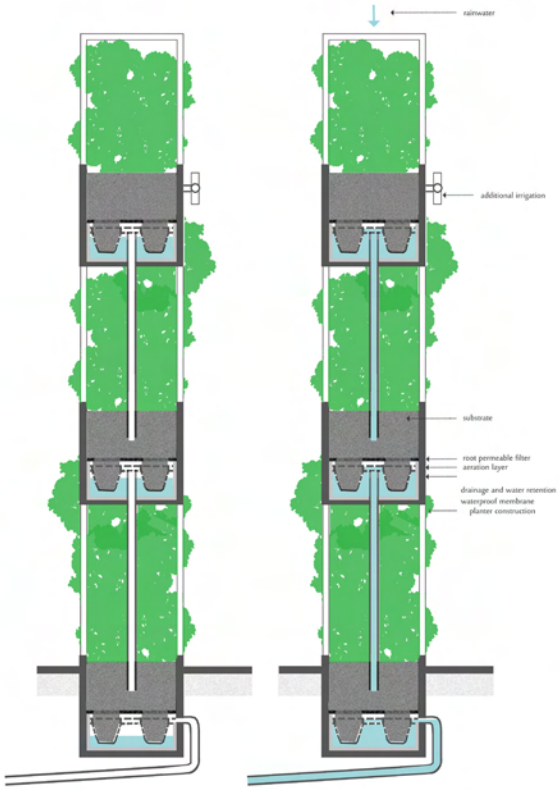


Figure 166. SEMI-TRANSPARENT LIVING WALL - HORIZONTAL GROWING SUBSTRATES - used contemplation space, creation space, retreat room and relaxation space. *Diagram by Author.*

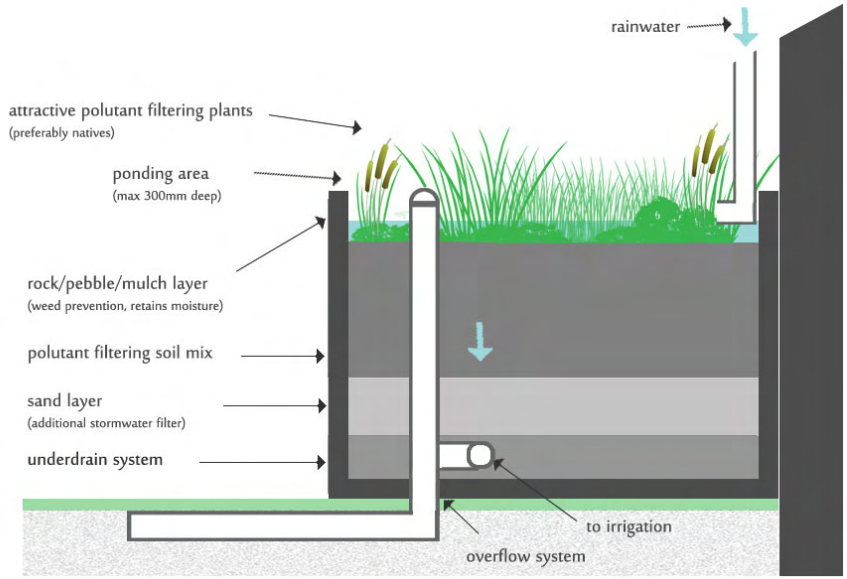


Figure 167. STORM WATER PLANTER - used in the creation space, swishing room. *Diagram by Author.*

9.2.2 AVENUE

As the entry to the house the avenue (see Figure 168) has semi-transparent living walls (see Figure 166) of *Hebe pimeleoides* and *Muelembeckia astonia* which shield the house from the street as well as a series of frames along the avenue which direct visitors to the entry.

9.2.3 CONTEMPLATION SPACE

The contemplation space (see Figure 168) provides protection from the elements as it is enclosed by a pergola-like outdoor structure, covered by a green roof. Frames, as tested in Chinese scholar gardens, have been used to manipulate the space's connection to other parts of the house, making areas feel enclosed whilst in actuality they are open. Semi-transparent living walls (see Figure 166) of *Metrosiderous carminia* and *Pseundowintera Colorata* have been used within some of the architectural frames; enhancing sensual qualities. The space is intended to be used as an outdoor area for contemplation, dining and living, which could be considered as having similar uses to the New Zealand deck.

9.2.4 CREATION SPACE

The creation space (see Figure 168) has herb troughs and vegetable beds that are watered by rain water from the roof above. Constructed to grow adjacent to the windows, the herbs and vegetables can be picked from inside the space, sensually integrating smells, colours and textures with practical use as was seen in Greek court houses and Medieval cloister gardens (see Section 3.4). Functionally, these verdant components are beneficial as they produce food in close proximity to the house. They utilise the principles of the flow-through storm water planter (see Figure 167 and Section 4.3.2). Water runs from the roof through into the planters, where it travels through the rock, pebble, soil and sand layers before flowing on to the next bed. The stacked layers of herbs planted to the west of the creation space would form an illuminated living wall of varied textures.

Opening the northern sliding window and door enlarges the creation space area. The continuous bench stretches out under a trellis structure covered in *Clematis paniculata* which subtly defines the space.

Figure 168. SECTION ONE - TRANSVERSE
Image by Author.


CONTEMPLATION SPACE
CREATION SPACE
SWISHING ROOM
DRIER
WASH

9.2.5 RECLUSIVE SPACE

The reclusive space green roof (see Figure 169) is steeply angled and forms a non-enclosing privacy barrier; whilst providing attractive planting for the occupant/s of the retreat room to view. To the left of this roof a glass sleeping area is enclosed by two *Clematis paniculata* covered trellis structures, these provide delightful light to the sleeping space whilst also providing privacy from the street. On the wall edging the avenue, small rotatable green walls / roofs planted with *Acaena inermis 'purpurea'* are used to create a permeable boundary between the communal avenue and the semi private study space. When open, the views out through these components could be manipulated depending on what angle they were placed on; whilst also providing ventilation for the space. To close they would be simply rotated around the horizontal axis into wall position and then locked shut by small sliding panels on each segment.

Figure 169. SECTION TWO - TRANSVERSE
Image by Author.


DELIGHT ROOM
RETREAT ROOM

9.2.6 RETREAT

Utilising similar principles to the horizontally rotating components used in the reclusive space, the retreat room contains pocket planted panels (see Figure 172); these rotate around vertical poles to open or enclose space. When sleeping in the retreat room (see Figure 169) with the shutters open, one would look out to the *Pratia angulata* covered panels, orientated however the user likes. Looking over top of the recreation and study area one would not see any mess or objects below, creating a sanctuary within the retreat room. The downwards view through the space would have a background of grass, removing views to context outside the site.

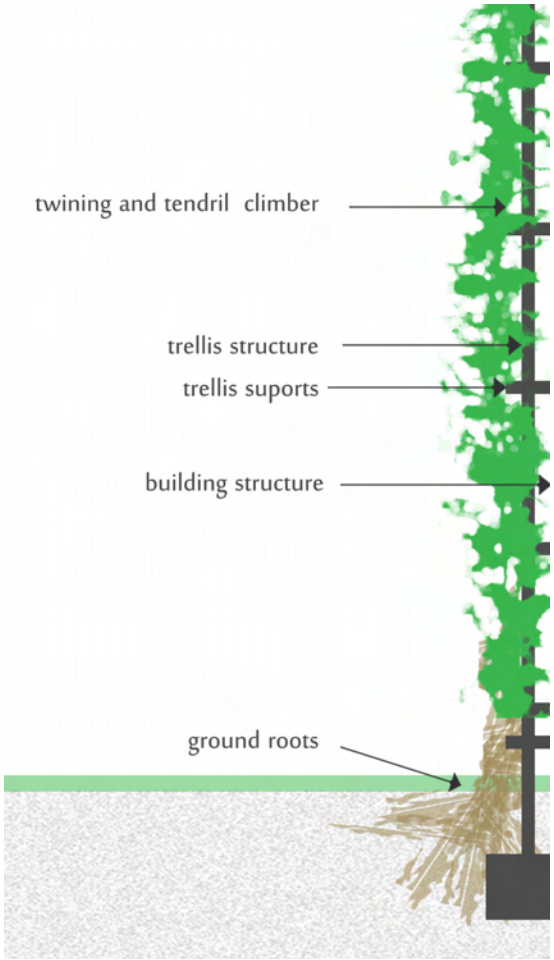


Figure 170. SEMI-TRANSPARENT LIVING WALL - TRELLIS STRUCTURE - used in avenue, delight room, relaxation space and cleansing room.*Diagram by Author.*

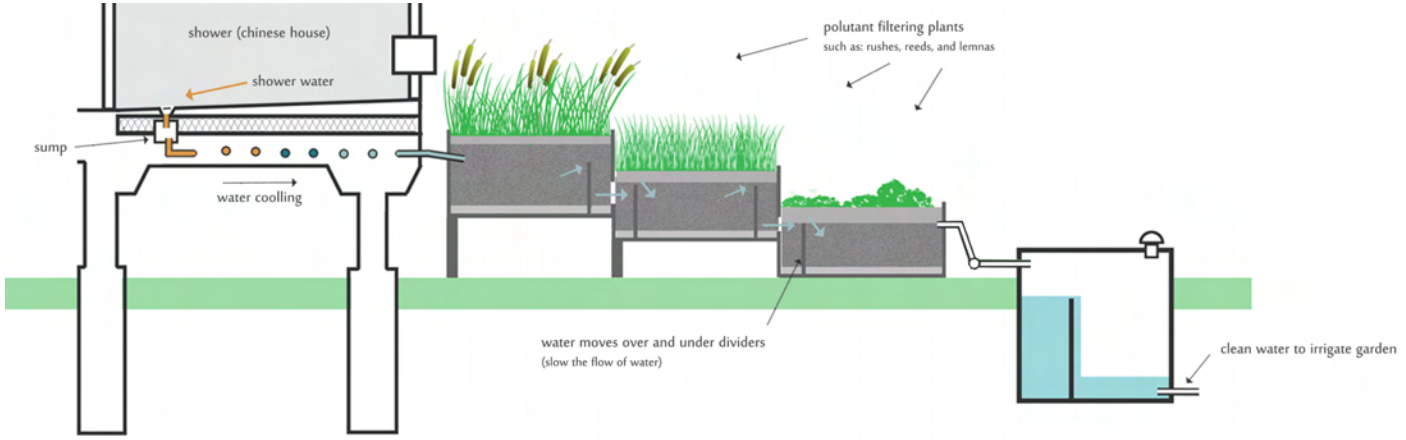


Figure 171. STEPPED GREYWATER BIOFILTRATION - used in the cleansing rooms. *Diagram by Author.*

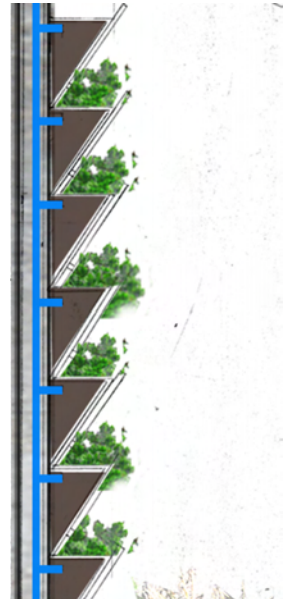


Figure 172. LIVING WALL POCKETS - used in the delight room and retreat room. *Drawing by Author.*

9.2.7 CLEANSING ROOM

The grey water bio filtration system discussed in Section 4.3.3 (see Figure 171) has been used to treat water in the cleansing room spaces (see Figure 173). Water from the shower is drained along the subtly angled floor into the drain, where the water settles for a short time before over flowing into the cooling chamber (the cooling chamber is embedded within a piece of concrete separated with insulation from the warm concrete of the shower floor). The water then flows through a series of planted beds, where pollutants and organic materials are broken down. Treated water is then stored before being used to water other areas of the verdant house. This planting forms an attractive area for occupants of the shower and the reclusive room to look out to; filling the area right up to the boundary.

9.2.8 RELAXATION SPACE

The relaxation space (see Figure 173) is designed to be a place of leisure as well as an area for the functional activities of a bedroom to occur. Because of the varied uses of the space it is designed to have diverse levels of privacy throughout. Minimal layering of trellis structured semi-transparent walls of *Clematis paniculata* provide an exposed thoroughfare and powder area, while multiple layers of semi-transparent walls of *Hebe pimeleoides* create private sleeping and changing areas.

Figure 173. SECTION THREE - TRANSVERSE
Image by Author.

RELAXATION SPACE

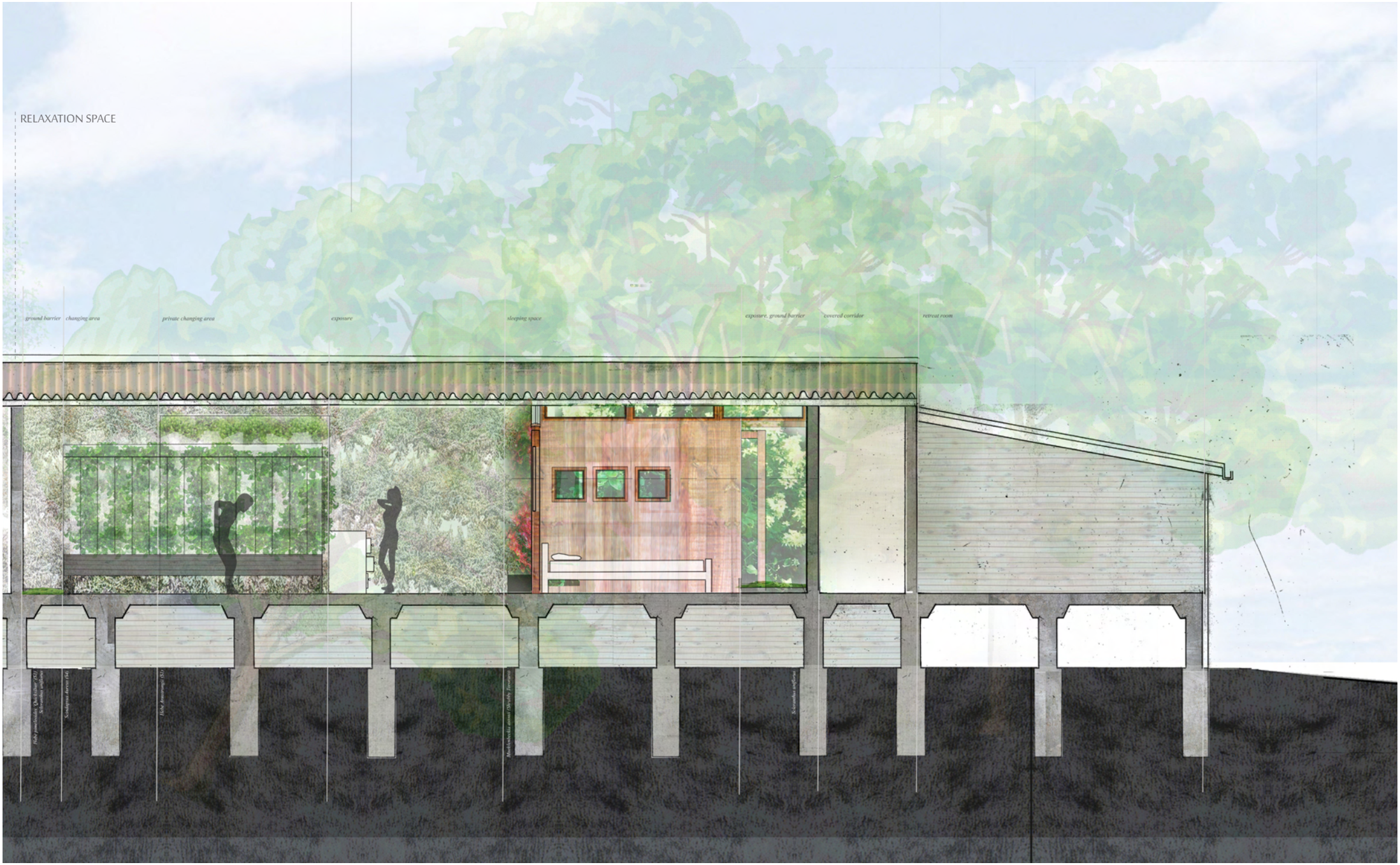
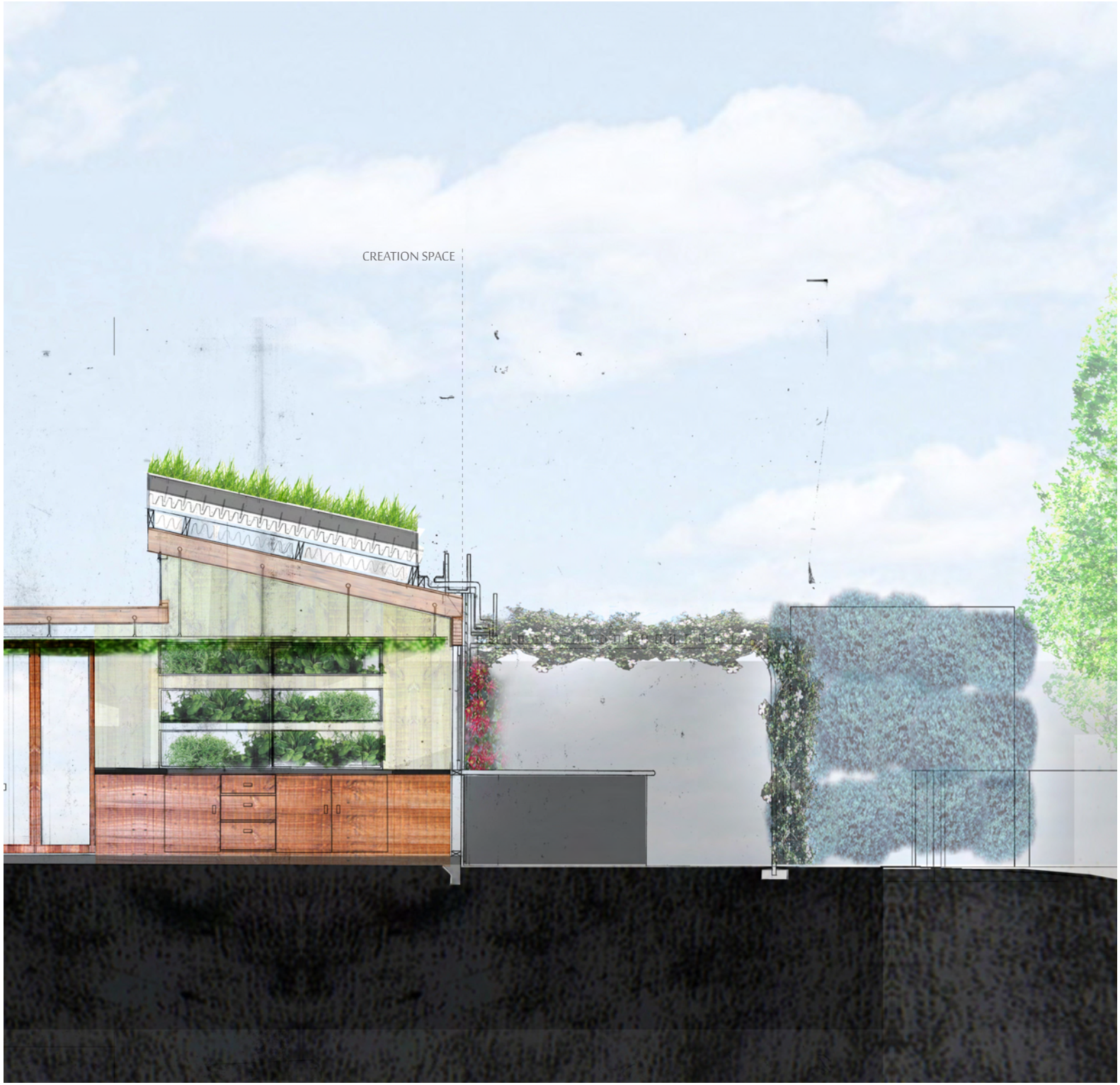


Figure 174. SECTION FOUR - LONGITUDINAL
Image by Author.

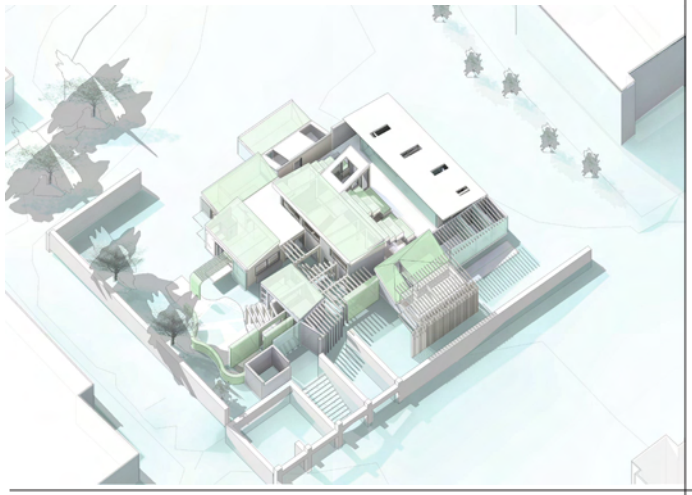


9.2.9. DELIGHT

The stepped planters used to the south of the delight room (see Figure 174) positively affect the entire space due to their form and scale. The staggered planting mediums (intensive green roof construction see Figure 162) allow light to illuminate the plants, enriching the diffuse light which enters the space to provide a calming and almost magical atmosphere. A pleasant view outwards from inside the space is provided through the gaps and onto the semi transparent wall of the relaxation space.

A pocket living wall system is used on the concrete wall of the delight room. These pockets for growing vegetation (see Figure 172) are a series of small rows of substrate, which, when layered, form a wall. A water system stores water vertically in a series of horizontal compartments which snake down between the concrete of the wall and the soil. A wick system allows the stored water to be withdrawn from storage and provided to plants when the soil becomes dry. This wall would be illuminated by direct sunlight which enters the spaces from the angled skylight above. Creating a bright area compared with the rest of the hazily lit delight space.

9 AM



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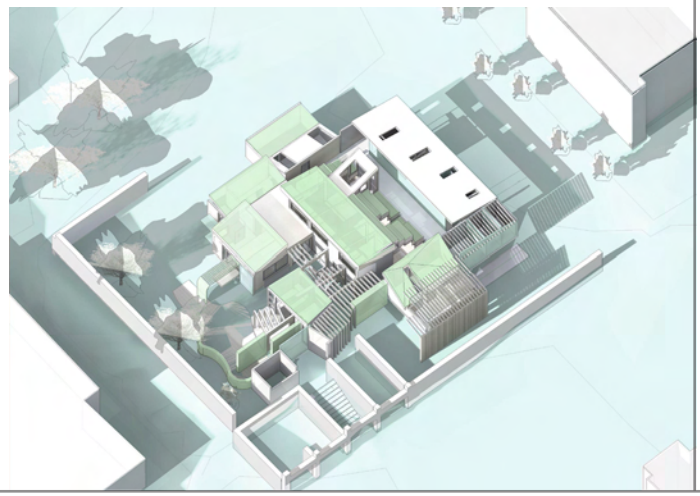

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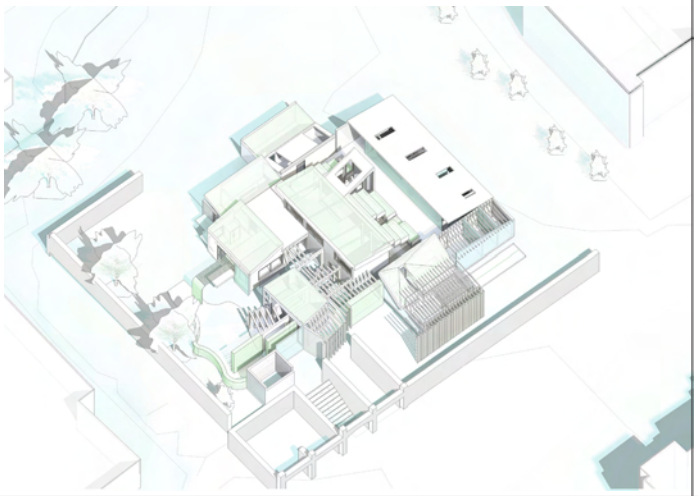

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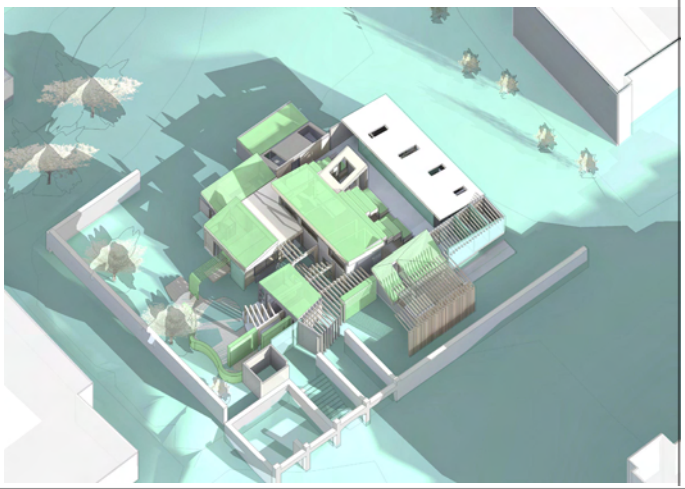
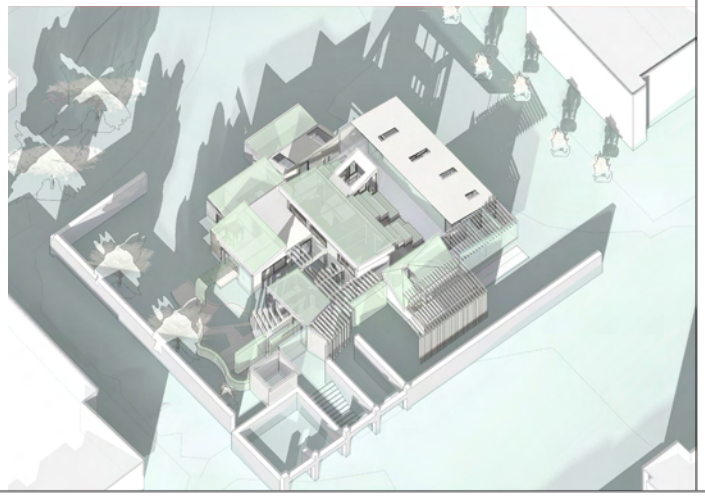


SUMMER SOLSTICE



9.3 SUNLIGHT DIAGRAMS

These sunlight diagrams visualise the amount of light which is provided to the different areas of the house in summer and winter, at four different times. As most of the verdant elements used in the house are integrated with the architecture on external edges they are reached by natural light. These diagrams show where sunlight is cast and evidence that the plants are provided with adequate light. Each of the plants used has been placed according to the conditions it prefers to grow in (see Appendix A).

WINTER SOLSTICE

Figure 175. SUN STUDIES WINTER AND SUMMER SOLSTICE. Revit analysis showing the building layout and direct sunlight on the planted areas of the building. *Image by Author.*

9.4 A JOURNEY THROUGH THE VERDANT HOME

81 Rintoul Street, Newtown, Wellington, New Zealand at 11am one summer morning.

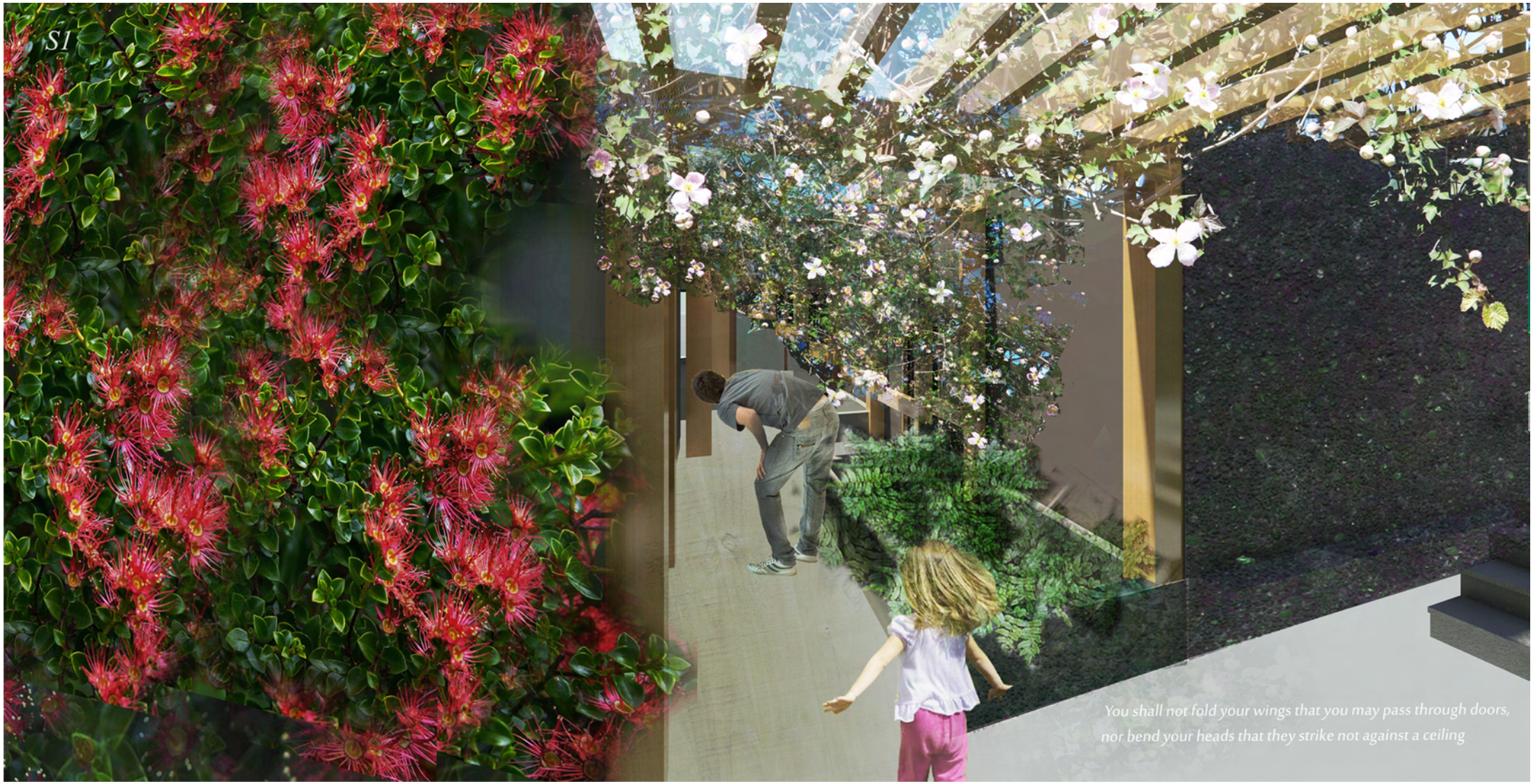


Figure 176. AVENUE FACING EAST. *Image by Author.*


" It grows in the sun and sleeps in the stillness of the night;
and it is not dreamless "
S1
S3

Figure 177. Left. CONTEMPLATION SPACE.
Image by Author.

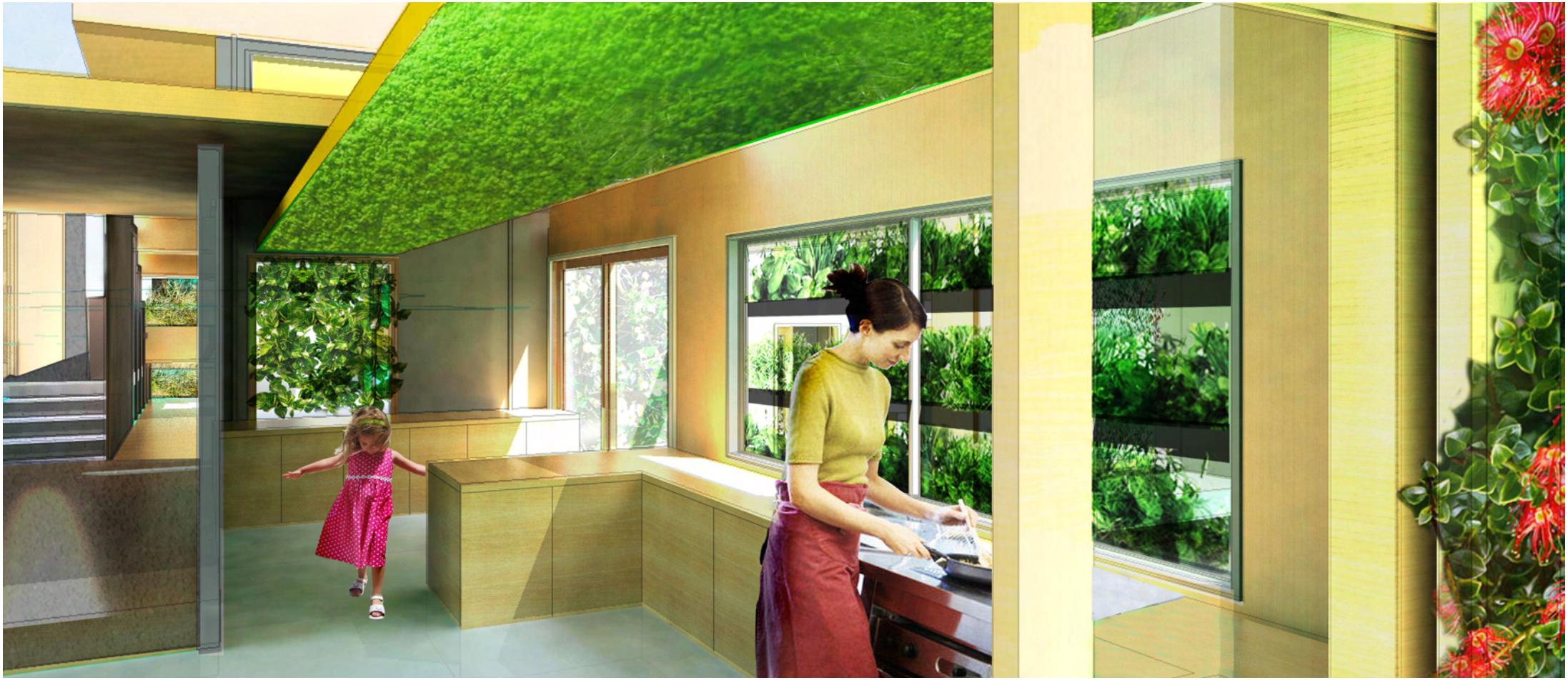


Figure 178. CREATION SPACE *Image by Author.*

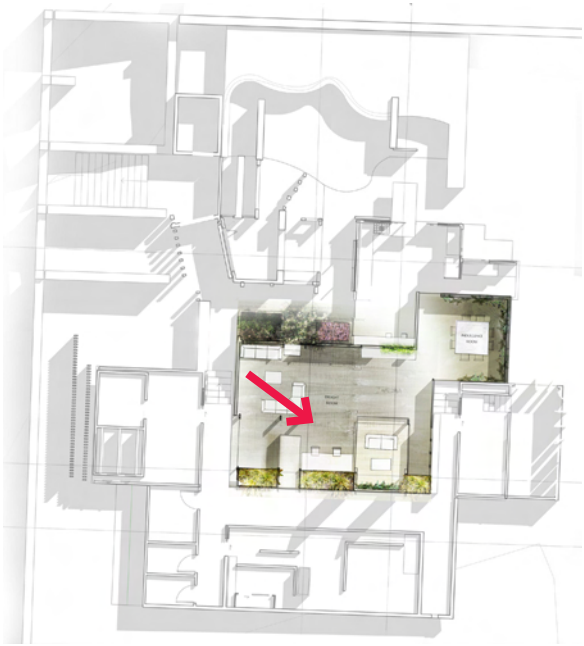


Figure 179. Right. DELIGHT ROOM. *Image by Author.*

Figure 180. RECLUSIVE SPACE. *Image by Author.*

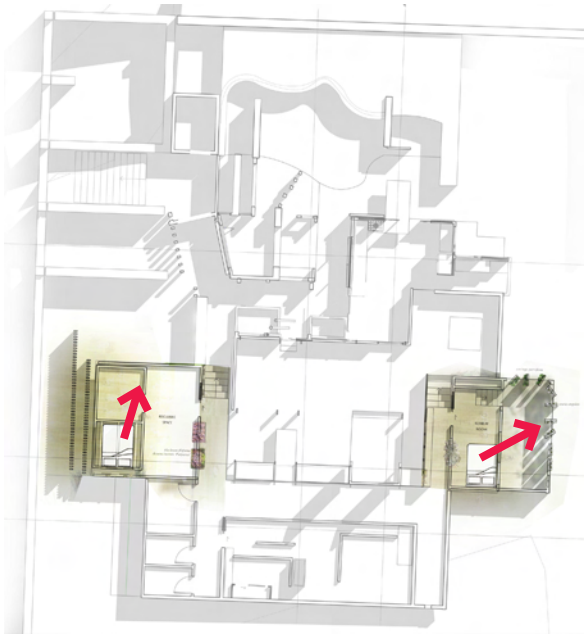


Figure 181. RETREAT ROOM. *Image by Author.*

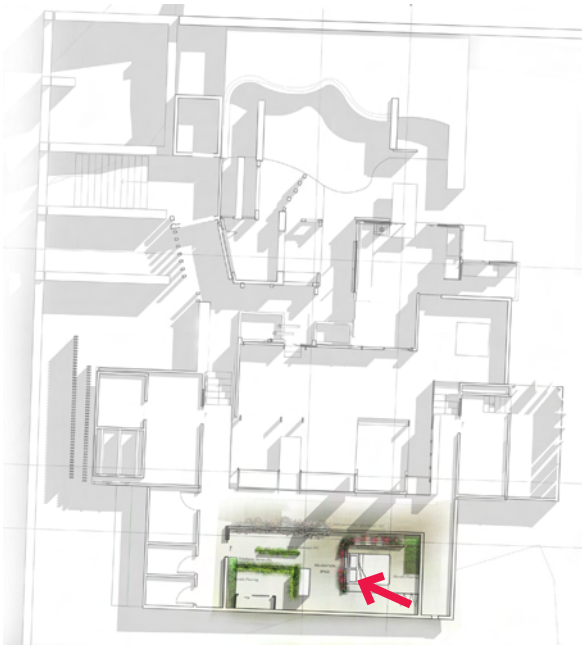


Figure 182. Right. RELAXATION SPACE. *Image by Author.*


Does not your house dream?
And dreaming, leave the city for grove or hilltop?
S4
S1

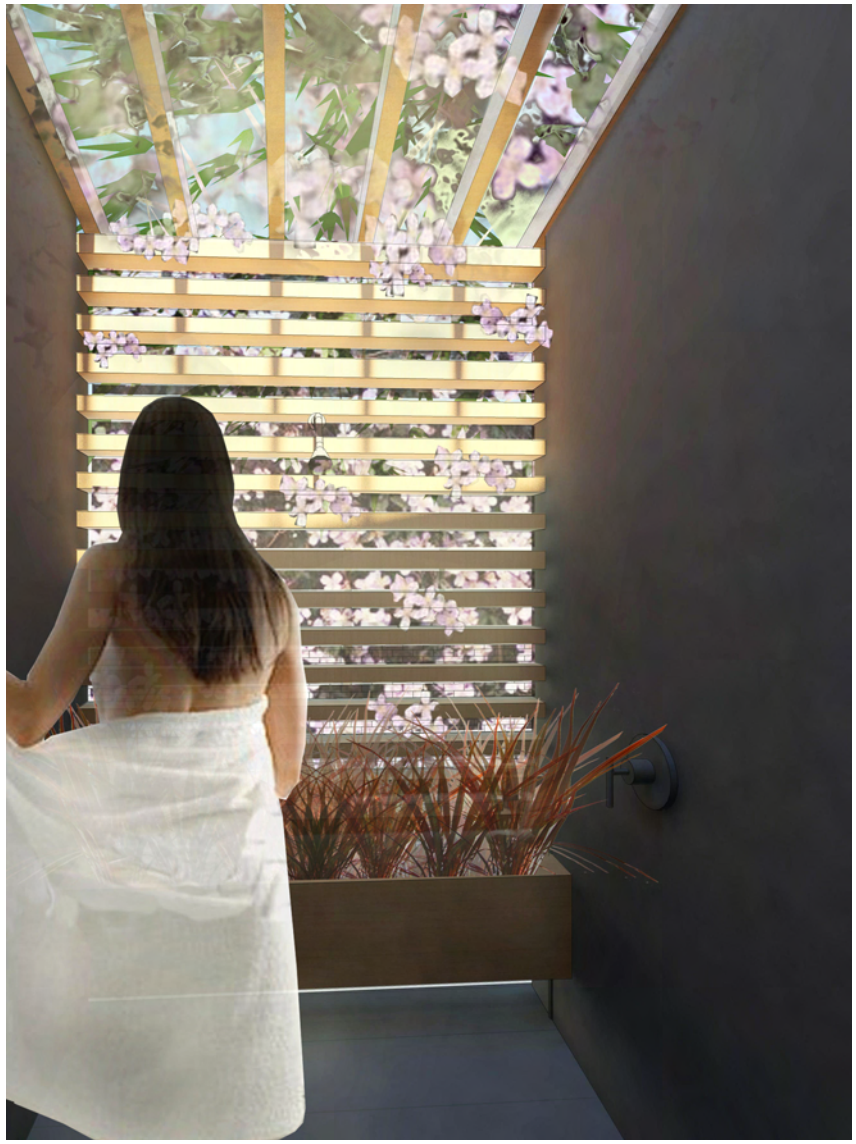


Figure 183. CLEANSING ROOM - MORNING. *Image by Author.*

Figure 184. CLEANSING ROOM - EVENING. *Image by Author.*

9.6 DISCUSSION

The refined design is a successful integration of house and planting. The spaces within would support the functions expected of a New Zealand house in unique and sensual ways. Living within the verdant house would be incredibly different to living in a house which looks out on a garden. As the verdant elements would grow and change according to the seasonal variations of the plants; changing the conditions within the house creating a greater connection between plant and human. The different spaces were designed to suit to the activities of each space, privileging the effects daylight has on verdant elements.

The design found that verdant elements used to replace a typical building component are the most successful when they challenge the expected form and therefore become more than just a planted wall or roof. For example the delight room wall / roof in the refined home design integrates both the functions of wall and roof allowing light to enter the space through the stepped growing mediums. This allows verdant elements to became part of the architecture; beneficial not only for their environmental and aesthetic qualities but also for the production of sensually evocative space.

part F : CONCLUSION

chapter ten

CONCLUSION

10.1 STATEMENT

The main purpose of this thesis was to generate ideas for verdant homes which incorporate plant life as spatially enhancing *parts of architecture.* Verdant elements incorporated in modern green buildings are often not designed with the purpose of utilising all of the benefits they are capable of providing. Many of these buildings underdevelop experiential and sensual qualities of plant enriched spaces. This research has considered the benefits of plants for humans, historical garden typologies, verdant technologies and the New Zealand context, The resulting building concepts are innovative and considerately incorporate plants with buildings to transform what would be typical residential space into sensual space.

10.2 DISCUSSION

The incorporation of living elements within architecture is a relatively contemporary idea. While it has been used on the facades of buildings for centuries , the planted architectural elements have only recently become an accepted technology within internal spaces. The use of these technologies is a constantly developing trend worldwide; due to the minimal space required and the retrofit potential, as well as the recognised mental and physical health benefits, aesthetic appeal and positive stigma around anything which is environmentally friendly or "green". When verdant elements are simply an addition to buildings they have minimal implications on the architectural structure itself; allowing them to be easily used in conventional spaces. Highly innovative living buildings such as the BIO FAB HAB building (see Section 5.3.3) do not fit within the standard requirement for a building, as they do not utilise accepted structural systems and are not hermetically sealed. Such buildings struggle to gain building consents. The building concepts within this thesis offered a middle ground solution between verdant elements as an addition to architecture and a completely living house.

New Zealanders traditionally constructed gardens around their houses on private land for utilitarian uses and recreation, however the more modern garden is predominately used for entertainment or relaxation purposes. The impending need for plants to be integrated with New Zealand's city buildings is the result of a gradual increase in population density since the 1970's (Barnett, 1995, p. 191). The population growth has resulted in more built form and less outdoor space and consequently less planted areas

Figure 185. Previous Page. MAN IN THE CABBAGE TREES. *Image by Author*

and gardens. This research sought to pre-empt architectural solutions which incorporate vegetation into plant-less residential environments; a problem New Zealand is likely to face increasingly in the future. Plants offer many exciting possibilities for integrating house and landscape in New Zealand residences: no longer excluding the external environment by isolating internal space.

The temperate climate of Wellington was an ideal site for the project due to the minimal extremes of its climate (Garnier, 1950, pp. 46, 84). Whilst the house lacks a hermetical seal, resulting in unregulated internal conditions (see Appendix B), it is assumed that people could live in the house all year round.

The verdant home design was created as a pleasurable environment, which enabled the creation of a garden as part of the architecture itself. Allowing plants to be enjoyed regularly within the largely internal modern day lifestyle was the overriding focus. The final house inexplicitly expresses similar spatial virtues to historic garden designs. This is seen in particular through the layering of shadow and repetition from the sensual gardens, the division and scene creation used in the manipulative gardens, the enticement and structure of the statement spaces and the use of sensually rich plants seen in sensually practical gardens. To achieve this focus the many techniques and technologies which allow a wide range of plants to be grown on vertical and horizontal surfaces and structures were explored; in both exterior and interior spaces. As shown in chapter 4, many of the case studies were highly successful functional and attractive green buildings, however users of the internal spaces were not receiving the psychological benefits of the external verdant covering. In the design process, it was easy to get preoccupied in the aesthetic appeal of plants and neglect to challenge the typical design of spaces. By challenging the entire spaces and typical forms, sizes and uses of typical building components in the design process, sensual internal space was produced and an inclusion of components into the architecture was realised. The design predominately utilised verdant elements at the edge of spaces allowing plants to receive direct natural light, while also filtering and sensualising light entering the corresponding internal spaces.

The building does not aim to speak of the future; rather it seeks to reflect its place, through its use of native plants and recognition of landforms and climate. The planted materials do not need to be translated from other places and their selection is appropriate for New Zealand. The scale of the design is applicable to both large and confined spaces. As the house functions inwardly, a

similar house could be created right up to the edges of a smaller site and still provide comparable spatial experiences. Similarly on a larger site the building would still be functional. An architecture that incorporates functional vegetative elements in its design would be an improved fit with New Zealand's context and identity, and would provide a natural way to live within the temperate climate and beautiful backdrop of New Zealand.

10.3 IMPLICATIONS FOR THEORY / PRACTICE

Verdant elements can influence the creation of exciting space, but this requires the culmination of both architecture and verdant technologies. As Alan de Botton has noted;

"We owe it to the field that our houses will not be the inferiors of the virgin land they have replaced. We owe it to the worms and the trees that the buildings we cover them with stand as promises of the highest and most intelligent kinds of happiness." (de Botton, 2006).

The incorporation of plants into residential spaces was important to resolve architecturally due to the potential held by verdant elements to enrich spatial qualities within buildings. The resulting house would become part of its eco system, thus contributing positively to the external environment while creating a good residential environment.

10.4 LIMITATIONS / UNANSWERED Q'S

Creating domestic space, using living elements to define the boundaries, creates a home which is part of the landscape. Due to the innovative nature of this thesis, there is insufficient information on what the environmental conditions would be when living within such a verdant house in New Zealand. While there is research on the air quality benefits and insulation qualities of vegetation on the edge of buildings, this does not equate to the properties of a passively functioning space enclosed by a wall of vegetation.

10.5 FURTHER RESEARCH

If New Zealand's residential homes were constructed as verdant homes, the life cycle of buildings would change. Instead of a new house beginning to get old, owing to the construction style or mode, a verdant house would continue to grow, change and flourish for inhabitants. This continual growth would offer a changing environment to live within; the opportunities to replant areas of the home would offer a change in colours, textures and smells. The maintenance requirements of the verdant home would be no longer entail conventional building materials to be painted and replaced; instead the house would predominately require plant maintenance. Further research could be undertaken to discover the exact internal conditions within the house, the ideal selection of New Zealand plants for use within a verdant home, the plant maintenance requirements and methods of insect proofing the home.

10.6 CONCLUSION

Any deliberate use of plants in architecture is undoubtedly beneficial. However the range of benefits provided are dependent on how the plants are incorporated. This research has found that by purposefully using historic garden design qualities to integrate verdant elements with architectural space, unique, sensual and atmospheric qualities can be created. Such benefits are unattainable without the integrated use of plants in architecture. The incorporation of verdant elements as a considered material and part of the architecture, ensures that verdant buildings contain expressive spaces, instead of merely conventional spaces, with the addition of a beautiful verdant element.

Hermetically sealed houses and industrialised cities are no longer seen as innovative. These nature-less places are increasingly recognised by society as imperfect places to live. Integrating verdant elements with domestic living spaces can supply the benefits of plants to everyday people in any location, providing contact with nature that humans intrinsically require. Verdant houses could be the modern houses of the future.

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APPENDIX A - PLANT CHARACTERISTICS

Name	Native	Height (m)	Width (m)	Maintenance	Preferred conditions	Hardy
Acaena inermis 'purpurea'	NZ	0.1	1	slow release fertiliser	full sun and well-drained, sandy soil	yes
Apodasmia similis 'Jointed wire rush'	NZ	1	1		will grow in wet or dry conditions	yes
Baumea articulata "Jointed twig rush"	NZ	1.8	2	copes with high contaminats and nutrients	will tolerate both dry soil & deep water	yes
Blechnum fluvial		0.3	0.4		damp, shady	
Blechnum wattsii	Aust	0.7	0.2		damp, shady	no
Bolboschoenus fluvialis		2.5			Requires consistent water.	no
Carex flagellifera 'glen murray tussock'		1	0.75		constantly moist to boggy soil, hot sun	yes
Clematis paniculata	NZ	9			sheltered position, shaded roots	yes
Clematis montanna 'giant star'	UK	6	0.8		sunny position fertile well drained soil	yes
Cortaderia 'Toetoe'		2.5	1		Prefers well drained but moist soil, Full or shade	yes
Hebe armstrongii	NZ	0.6	0.8	prune after flowering	sunny or partial hade	yes
Hebe barnettil	NZ	0.8	0.8	prune after flowering	easy growing	yes
Hebe mary antionnette	NZ	0.75	0.8	prune after flowering	easy growing	yes
Hebe Orphan Annie	NZ	0.3		prune after flowering	sunny or partly shaded	yes
Hebe pimeleoides quicksilver	NZ	0.5	1		Plant in moist, free-draining soil that is poor or moderately fertile. It should be in a sheltered position in full sun or light shade.	yes
Luzuriaga paviflora	Chile	0.15	0.15		shade, prefers sheltered position	yes
Metrosiderous carminia		1	1		Full sun and semi-shade, Prefers a sheltered position	no
Muelembeckia astonia		1.5	1		moist to dry, full to mid sun	yes
Phormium 'harakeke, swamp flax'	NZ	2	2		Tolerant of wet and dry	yes
Pratia angulata		0.1	2		Although it prefers a damp situation, it seems to do well in most places. Sun or semi shade	Yes
Pseundowintera Colorata	NZ	1.8	1.8		semi shade or direct sun, prefers medium levels of water, prefers shelter	
Scindapsus aureus		1		Prune they vines when the become unmanageable	not direct sunlight (used in internal spaces)	No

APPENDIX B - SPECIFIC NEEDS OF INTERNAL SPACES

Table summarised from (Chartered Institution of Building Services Engineers, 2006, pp. 1-9,11)

Room Type	Winter Operative Range		Summer Operative Range		Suggested air supply rate	Maintained illuminance (Lux)	Background noise levels
	Temp °C	Activity Level	Temp °C	Activity Level			
Bathroom	20-22	1.21	23-25	1.2	15 L/s	150	——
Bedroom	17-19	0.9	23	0.9	0.4 ACH	100	25
Hall/stairs/ landings	19-24	1.8	21-25	1.8	——	100	——
Kitchen	17-19	1.6	21-23	1.6	60 L/s	150-300	40-45
Living rooms	22-23	1.1	23-25	1.1	0.4-1 ACH	50-300	30
Toilets	19-21	1.4	21-23	1.4	> 5 ACH	100	——

In houses bedroom temperatures are noted to be more critical than those of the living area. High bedroom temperatures have been found to result in poor sleep quality and therefore poor performance the following day at work; sleep can be negatively affected at temperatures over 24°C (Chartered Institution of Building Services Engineers, 2006, pp. 1-11,13).