BEE POSITIVE

Design For Awareness

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ABSTRACT

This thesis aims to create a museum dedicated to awareness, research, and education, in an attempt to preserve the declining bee population. It focuses on the Native Bees of New Zealand in conjunction with introduced bees. The architectural design intention for the bee museum aims to encapsulate the life and biology of the bee through an informative experience of current issues, by delving into the current world in which bees exist, as well as an ephemeral architectural expression based on organic elements occurring in nature. The aim is to adhere to an emotional as well as a cognitive human response for the sake of forming an empathetic connection between the occupier and the architectural subject.

This has the potential to aid the bee population through a captivating and informative design, raising further awareness as to what the issue is and how it can potentially be resolved through public initiative. The promotion of bee conservation in New Zealand may have a prospective ecological impact on a national scale and may subsequently have the potential to work as an example for other countries in their approach to this global concern.

INTRODUCTION

This thesis looks at ways in which an architectural design can be developed for the sake of awareness regarding the value of bees, with a strong emphasis on native New Zealand bees and the issue of their decline. This is because native bees, which are of great value to native flora, have fallen under the radar, eclipsed by the honey bees and their direct effectiveness in honey and honey product production.

As per the project planning phase (section 1) – features and requirements are narrowed down to direct the later stages of development for the Bee Museum design. These requirements fit within two categories – emotional and pragmatic. These two categories are used as a guide for and as part of design experiments – One, Two and Three, the core of which depends on whether they are part of a pragmatic or emotional process. Whilst processes such as spatial delegation/circulation and responsible design implementation are within the pragmatic column, aesthetic qualities such as organic inspiration and symbolic attributes are part of the emotional column (in section 1.3). Bee selection (in section 2) is a vital part of the pre-design stage, attaining parameters for hosting bee life upon the building site. For the site selection and analysis, - there are several considerations put in place (in section 3). An assessment of early building sites is carried out and contextual characteristics for a suitable building ground are determined. Specific site limitations are addressed through previous examples and the prior bee selection process. The spatial qualities of the building (addressed in section 4) raise the question of how human occupancy can be shared with plants and insects whilst simultaneously working to enhance the design.

Proper spatial delegation is discussed with particular consideration to native plant life and how it can be a key player in design development, whilst adhering to the idea of both human and bee occupancy.

A plan for responsible and ethical design practice is developed, in an attempt to observe the environmental message which the design itself aims to communicate. Proceeding to searching for a design language (in section 5); attention to elements of symbolism, organic inspiration and a potential influence of bee flight paths serve as key elements to impacting design form. Several experiments are carried out to find a strong aesthetic influence. Strengths and weaknesses to these experiments are subsequently discussed in order to add clarity to the later iterative progress. The design development phase (in section 6) is about generating specific design approaches, with prior pre-design deliberation in mind. Strengths and weaknesses are assessed post each design development and taken into consideration upon the next design iteration (throughout section 6), varying from small to significant changes in approach and implementation. Responsible design elements and variables are examined and described (in section 8) as part of final design deliberation, linking back to the scope of responsible design requirements laid out in Section 4. The final stage of the thesis is a final look at the finished design (described in section 9), giving a rendition of its architectural image and function. A critical reflection of the finalized design is discussed in the conclusion, with a better understanding of what has worked in developing this thesis and what hasn't, pertaining to its original intention of raising awareness of bee impact and preservation.

THESIS QUESTION

How can an architectural design provide an educational experience for its visitors, motivating public involvement in the bee conservation initiative?

BACKGROUND

For the last decade the population of bees has been declining at an unprecedented rate (Kerr, 2015). This has consequently influenced an ecological issue, as 35 % of global crops are dependent on pollination services by both wild and kept bees (Klein, 2007). However, as a particular association to New Zealand, the data suggests that it is the native bees that in turn are also suffering due to the overcompensating nature of the honey industry, which poses its place within the market as a product of a wholesome production process (Interview 1: Beekeeper1). New Zealand's has 28 different, 27 of which are endemic, which pollinate flowers, but do not produce honey. They cannot be farmed in hives in the same way that honeybees can and require the resources within their native environments in order to survive. Arguably, in its pursuit of keeping bees as a commercial symbol of a necessary symbiotic and honey producing life form with a means to serve the environment, there is a probability that certain honey corporations expand to the point of nudging out the native bees of New Zealand, with introduced honey bees (Interview 1: Beekeeper1).

Surveys, such as the MPI and Landcare Bee Colony Loss Surveys (of 2018), have found that the most commonly reported reasons for general bee deaths are suspected to be the Varroa Destructor (mite) infestation, which started in 2001. The Varroa Destructor is a deadly ectoparasite that attaches itself to the bee and feeds on it, causing disease and infection, eventually causing the bee to die. According to the MPI Survey - losses due to the Varroa mite, insecticides or plant toxins, as well as other pests and pathogens are difficult to diagnose, hence the caveat 'suspected' (Brown, 2017). Next to the issue of the Varroa Destructor, are factors of starvation caused by bad weather, killer wasps, and problems such as queens disappearing

from a hive or not laying eggs.

It has therefore been determined that in order to attain more information about native bees, it is important to understand the factors affecting their introduced counter parts, seeing as how they share many aspects in common in terms of diet and foraging habits (Donovan, 1980). Thus, what affects the introduced honey bee is likely to affect the native bee; whether it is pesticide sprays, the Varroa mite or wasp attacks, the native and non-native bee categories seem to suffer evenly across the board. The native bee population has also been argued to have been largely devastated (Donovan, 2007), partially due to larger bee species having larger pollen requirements than the typically smaller native species. This may correspondingly point toward food limitation as a key factor driving wild bee loss (Scheper, Reemer, & Kats, 2014).

Most beekeepers now treat their hives with chemicals at a cost of around \$25-\$30 per hive, plus labour and transportation (Fricker, 2003). However, the issue persists for native bees as they are unable to be treated in the wild (Beekeeper-1, 2019). Furthermore, as of late 2009 some beekeepers in the Auckland area began reporting signs of Varroa becoming resistant to synthetic parathyroid treatments (Inglis, 2010), which could mean that it may be even more resistant moving into the wild. This brings us to the kind of native impact this may entail upon contact with native bees, who are likely not equipped to fend off the Varroa mite. It was argued by Fountain back in 1991 - that the native New Zealand environment is under threat (Fountain, 1991). With consideration to this, the Varroa mite may arguably add an extra complication to the already vulnerable New Zealand wilderness. Fauna and flora are dependent on one another to have a sustainable lifecycle (Fang, 1997). Thus, if one perishes due to introduced external parasites or circumstances, the other may suffer similar consequences. This includes native plants which may be dependent on native bees and vis-à-vis.

Keeping track of native ecology is therefore part of bee preservation, and thus is to be considered as part of this thesis' design process.

The architectural statement of this thesis argues that if the public is made aware not only of the current peril of native New Zealand bees and bees in general, but of their significance to the environment, it may invite incentive for the sake of bettering the situation through every mindful individual taking one step at a time: E.g. Using less pesticides or requesting less pesticides be used in our current agricultural climate, planting more native foraging plants in the wild and contributing more foraging plants to private gardens and backyards.

THE STATUS QUO

In order for the design to be successful it has to pull in its audience through its architectural language. To attain this kind of influence, it should successfully communicate the current situation pertaining to the ever-declining bee numbers around the world, as well as the native bee decline on a national scale.

Ngaire Hart who has extensively studied the native bees of the Whangarei Region had presented in her PHD thesis that native bee numbers were already decreasing by as much as 60% over the year of 2006-2007. Yet, this has not been addressed and is lacking in community involvement (Hart, 2007). This beckons the question as to whether the lack of attention to these circumstances can change at this stage, and whether or not it may be too late. Native bees are referred to as keystone pollinators; this means that if they die out, it is unpredictable as to what kind of further plant losses and ongoing national impact this would entail (Hart, 2007).

LITERATURE REVIEW

The literature review covers two distinct areas equally essential for this research by design thesis. First, it explores the problems regarding bee population decline, investigating the origins, solutions, and main factors that are causing this issue.

Secondly, the literature review explores how architects have designed for awareness in different projects and what strategies they have used. This part of the literature review is respectively important for the selection of case studies pertaining to the method by which this design can be made possible.

In the first part of this section, the key findings are presented and key authors and research are highlighted, with all readings summarized in a table (table 1) at the end of this section.

Topic of Concern – Bee Decline

According to Klein, 2002, 35 % of global crops are dependent on pollination services by both wild and kept bees. (Kremen, Williams and Thorp 2002) have stated that continued degradation of the agro-natural landscape will subsequently destroy pollination services as bees continue to die out. They argued that conservation and restoration of the natural bee habitat is potentially the most viable and economic method to reduce the need for continuous honey bee reproduction. This method would be a viable solution to sustain crops and natural ecology (Kremen, 2002) without having to exploit the honey bee in a corporate economic cycle.

It has been put forward by Newstrom-Lloyd (2013) that if non-native bees compete with native pollinators for floral resources, they could adversely affect native pollinator abundance and

diversity (Newstrom-Loyde, 2013). This could mean that the current decline of a multitude of New Zealand native plants may be directly correlated to the decline in their pollinators/pollination services. However, Donovan (1980, 2007) has stated that in New Zealand the issue is largely theoretical because feral/native honey bee colonies have been decimated by the Varroa mite, which initially arrived in Auckland in 2000 and rapidly spread throughout the North Island (Donovan 2007; Goodwin and Taylor 2007). In the Netherlands, it has been found that the decline of preferred host plant species was one of two main factors associated with their native bee decline (Scheper, Reemer, & Kats, 2014)

What would happen if bees disappear?

In their book – “The Business of Bees: An Integrated Approach to Bee Decline and Corporate Responsibility” Jill and Barry Atkins strongly imply that the absence of bees could entail an ecosystem collapse and catastrophe on a global scale. Their findings show that economic and nutritional significance would inevitably suffer if bee decline continues (Jill Atkins, 2016).

Whilst the devastation of native bees would mean a shift in native ecological balance (Newstrom-Lloyd 2013), the deterioration of native bees would be detrimental to natural national resources within New Zealand as well as almost anywhere else which has endemic bees specifically evolved to their environmental conditions and resources.

Newstrom-Loyed states that a mixture of diverse, - both managed and unmanaged pollinators may have a synergetic effect on crops, as shown in the California almonds (Brittain, 2013), suggesting that

equal utilisation of managed and unmanaged pollinators can have a distinct advantage.

This literature review suggests the importance of keeping a balanced population of bees, both native and non-native. Although this is an environmental problem, as indicated above, it seems not yet fully perceived by most of the population. From the findings in the literature review, it has become clear that an increase in awareness of the issue related with the reduction of the native and general bee population should be pinnacle.

PRE-DESIGN INFLUENCE

Considering that (as previously mentioned) New Zealand is home to an estimated 28 native species of bees (27 of which are endemic), with another 14 types of introduced species (Donovan B. , 2007), this aspect is of extreme importance in pre-design deliberation. This is because it impacts the way in which the architectural site is used, as well as the design considerations for practical use; e.g. bee pods, green-walls or textural qualities within the design as an implementation for active foraging or bee living use.

MEMORIAL ARCHITECTURE

Architecture can commonly serve as a memorial for someone or something that has been and gone. The word ‘memorial’ itself is about the memory and paying tribute to that memory. But what if a memorial wasn’t just about remembering that which has gone or been lost, but remembering that which is current, before it has a chance to pass?

Perhaps such an architectural memorial can have a practical resilience along with the memory and the empathy that it shapes within human mindfulness. In his discussion specific to mortuary space Inês de Carvalho Figueiredo discusses drawing up a space for reflection and allowing for travel between the past, present and future (Figueiredo, 2013). Theoretically, this same ‘travel’ or thought process can be applicable to current existence, particularly in this case, as it is the kind of existence that has come to be vulnerable in today’s climate.

Memorial architecture has been found to have an emotional effect on its occupiers/visitors. The key is to find the essence of the subject matter and to re-create it using techniques and approaches found by established architects, such as Etienne-Louis Boullée and the modern memorial take of Gonzalo Mardones’ Memorial 9 (Fig. 1).

Figure 1 - M9 Memorial / Gonzalo Mardones V Arquitectos (Saieh, 2011)

Additionally, there is a disposition to look at metaphorical significance within the historically disconsolate, naturally ravaged and degenerated or disaster-stricken architecture (as a form of memorial in itself, without the need of further design intervention) – as a potential guide to finding deeper meaning through free, vulnerable and supposedly disjointed design.

Figure 2 – Jean-Marie Tjibaou Cultural Centre (Wilson, 2016)

MUSEUM – ARCHITECTURAL CONNECTION TO ITS CONTEXT

Looking at Renzo Piano’s Jean-Marie Tjibaou Cultural Centre in New Caledonia (Fig. 2 and 3) and how it manifests cultural, historical and pragmatic elements, it can be observed that as an architect who took his connection between design and location very seriously, Piano integrated materials and form to be reminiscent of sails as much as they were reminiscent of local hut design, whilst utilizing traditional materials and methods of construction (as further discussed in the following case study section) (Jodidio, 2012).

Figure 3 – Panoramic view of Tjibaou Cultural Centre (Eustaquio, 2012)

LITERATURE AND PRECEDENCE FOR ARCHITECTURAL PROJECTS, WHICH HAVE INCREASED AWARENESS

The structure of the marine museum can serve as an appropriate example of the kind of place that has an impact on cultural and social awareness: Important factors and drawbacks that exist within the marine world would apply to the Bee Museum in current gaps of awareness, as well as limited availability of independent issue-specific information, similar to that of the marine realm (Fletcher, 2008).

The National Maritime Museum located in the UK (Fig. 4, 5 & 6) - is raising political and public concern for, and involvement with, the marine environment, for the sake of promoting public awareness about ocean life and the importance of their conservation and sustainable development. One of its major recent initiatives under the name ‘Planet Ocean’ is a long-term programme that allows the Museum to bring together and showcase the past, present and future of the oceans (Fletcher, 2008). This kind of division of the informative experience between past, present and future can potentially take the museum visitors on a journey whilst providing them with an ultimate greater picture, further immersing them into its subject matter.

This is a strong precedent for how a museum with concern for conservation (such as the Bee Museum) can function to raise awareness and public involvement.

The National Maritime Museum maintains itself in the public eye by hosting public events as well as exhibits. This too, can be applied as a form of reaching awareness - by consistently serving the public whilst using the building’s subject as a backdrop, (perhaps similar to that of a sponsorship campaign). The lesson that can be taken from this – is that a museum on any subject matter needs to be practical in its use, with a multi-functional platform as a means of further serving the public. Conversely, if it only stays within the realm within which it initially established itself, it may be pigeonholed, under-utilized and therefore under-appreciated.

Figure 4 - Maritime Museum (Hosilva, 2015)

Figure 6 - National Maritime Museum (Bortes, 2008)

Figure 5 - National Maritime Museum (Croft, 2009)

DESIGN AND RESEARCH SCOPE OF APPLICATION

1. In accordance with Newstrom-Loyed’s argument of mixing wild and kept bees for different types of crops and plants - the implementation of diverse - both managed and unmanaged pollinators could show synergetic effects on their surroundings first hand, and may be a strong backdrop within and around the museum as part of the design.
2. Fletcher’s description of the Maritime Museum defining its displays within the realms of past, present and future would serve as an excellent approach in a strategically compartmentalising user experience. This could be done in a different way, but with a similar structure. E.g. The concept of time could be applicable in a different way, such as ‘Life, Devastation and Rebirth through Conservation’, or something of that line of thought. This would ultimately have a direct impact on Design circulation, thus the interior and exterior delegation of structure and spatial quality.
3. Another vital point in Fletcher’s article addresses the multi-functional elements of the design, which again are important to the design objective of attracting the public eye. Varying public spaces with malleable potential would hence need to be adhered to.
4. Finally, Klein and Kremen, Williams and Thorp all drive the point of how crops would be affected by the degradation of bees: This practical analogy and prediction of what may come

of the issue at hand, can be seen to have an association with death; - Dying of bees means dying of plants, means worse health for humans, also increasing the likelihood of early fatality. When stakes are raised to this level, the attention to the issue arguably has a higher likelihood to grow. This means attention can be drawn to this darker matter through symbolic or non-symbolic emphasis on vulnerability and mortality. This can be symbolically expressed in breaking up the stronger structural lines of the design, by introducing vulnerable and/ or organic elements into it. It can also be expressed directly through its internal content and display, which may not be part of the building design itself, but may influence how it is spatially constructed. (Kremen, 2002)

AUTHORS	PUBLICATION	TOPIC	INFORMATION LEARNED
Klein, A. (2007). (Kremen, 2002) (Hart, 2007) (Brown, 2017) (Fricker, 2003)	Importance of pollinators in changing landscapes for world crops. The Royal Society Journal, 305-311. Crop pollination from native bees at risk from agricultural intensification Industrious Native Bees: A Case Study in Whangarei Report on the 2017 New Zealand Colony Loss Survey Plight of the Bumblebee	Bee Decline and its influence	- Bees are a major source of pollination services. If the bees die out it will impact our agriculture and likely the native wilderness and ecology.
(Donovan, 1980) (Newstrom-Loyde, 2013) (Early, 2007)	Interactions between wild and kept bees Pollination in New Zealand 'Wasps and bees - Native bees', Te Ara - the Encyclopedia of New Zealand	Native and Non-Native Bee Interactions (- For design integration)	- There is no malice or aggression between native and non-native bees which makes both of them easy to design for as they can be introduced into the museum environment side-by-side. - Native and non-native bees can live side by side without harming each other's livelihood, as long as there is an even balance between bee numbers and resources.

Table 1 – Literature Review (Lubomudrov, 2019)

AUTHORS	PUBLICATION	TOPIC	INFORMATION LEARNED
(Fletcher, 2008)	Public awareness of marine environmental issues in the UK.	Designing for Awareness	- A good museum can be malleable and have the potential to encompass a multitude of displays, installations and events.
(Figueiredo, 2013)	From Cemetery to Memory		- A place of solitude can have an influence on someone's thinking on a deeper level. Thus clear space can be useful within an otherwise packed museum space.
(Zhu, 2010)	An Emotional Expression of Memorial Architecture		- The architectural language does not need to be literal in its reference to its subject.
(Freedberg & Gallese, 2007)	Motion, Emotion and Empathy in Aesthetic Experience		
(Fang, 1997)	Development of species diversity in the restoration process of establishing a tropical man-made forest ecosystem in China		- The design can work as an example by creating an environment which is friendly to the bees way of life
(La Bastide, 2017)	This Solar Funnel Technology Allows Plants to Thrive Deep Underground		- New technology to aid environmental responsibility can be useful to an architectural design, as it enhances it and builds public interest
(Rogers, 2011)	(Post)Modern Monuments: 20 Worthy Architectural Memorials		
(Jodidio, 2012)	Piano	Contextual Utilization	- Contextual awareness is vital to a building which means to serve its environment. For this reason it is important to keep the culture, location and subject of the museum in fair correspondence with one another.
(Nieves, 2016)	5 Outstanding Examples of Sustainable Design Around the World		- The very environment which serves as the building's setting can potentially aid its material use for pragmatic purposes.
(Fraser, 1972)	Design in the Built Environment		

Table 1 (Cont.) – Literature Review (Lubomudrov, 2019)

AUTHORS	PUBLICATION	TOPIC	INFORMATION LEARNED
(Fang, 1997)	Forest Ecology and Management	Environmental Responsibility	- This aspect is crucial to the majority of design decisions, discussing techniques by which to aid the surrounding environment – both within and around the building.
(Tabb, 2019)	Elemental Architecture : Temperaments of Sustainability		- A certain quality of responsible design needs to be standard in order to adhere to its subjects own message. Thus, checking current codes within NZ to understand building possibilities is a vital step in the design process.
(Alcorn, 2010)	The Authority of Sustainable Building		
(BRANZ, 2018)	Passive solar design, Sustainable Construction		
(Porirua City Council, 2009)	Porirua City Council Tree and Vegetation Policy - For Council Land		
(Jashari-Kajtazi, 2016)	An insight into Green/ Ecological Architecture and Natural building		

Table 1 (Cont.) – Literature Review (Lubomudrov, 2019)

CASE STUDIES

CONTEXTUAL MUSEUM ARCHITECTURE

THE JEAN-MARIE TJIBAOU CULTURAL CENTRE

The building as designed by Renzo Piano is able to convey divergent metaphors subject to individual perception, giving the design a unique and malleable association with its visitors (Fig. 2 and 3). However, arguably one of the strongest approaches to the design of the New Caledonia Cultural Centre – is that Piano utilizes traditional materials and methods of construction, which do not ignore the natural elements, instead highlight and integrate them with the building. (Jashari-Kajtazi, 2016) As such, Piano demonstrates compassion towards the New Caledonian environment, by utilizing it rather than disregarding its contextual influence. For these reasons, this approach is an admirable precedent - with consideration to public health as well as habitat-support. (Jashari-Kajtazi, 2016)

THE SHANGHAI NATURAL HISTORY MUSEUM

Designed by Ralph Johnson of Perkins+Will - the Shanghai Natural History Museum (Fig. 7 and 8) is another constructive example for the purpose of this project, considering that it has a similar aim; to tie in the natural environment and global ideas of sustainability along with

Figure 7: Shanghai Natural History Museum (Believer, 2015)

its subject (- Chinese history). It manifests its idea of green elements into effect through the design of an “intelligent building skin” that reduces solar gain whilst maintaining a consistently comfortable interior temperature. (Nieves, 2016)

Figure 8: The exterior of the Shanghai Natural History Museum (Guiggyt, 2017)

REFLECTION

The design precedents discussed in this section - possess elements of direct correlation to this thesis, such as incorporating natural light, exterior (and some interior) vegetation and maintaining a close-relationship to their surroundings as an integral part of their design foundation.

MEMORIAL ARCHITECTURE

DANIEL LIBESKIND’S ADDITION TO THE JEWISH MUSEUM

Memorial architecture being atmospherically focused, can work as the kind of exhibition building with an emphasis on its emotional language. An example of this design approach can be observed in Daniel Libeskind’s addition to the Jewish Museum in Berlin (Fig. 9, 10, 11 and 12): Based on an abstracted Star of David, this interactive section of the museum pulls the visitor through various spaces that architecturally manifest the emotions and conceptions of fear, isolation and hope (Dogan, 2012).

Figure 9 - Jewish Museum, Berlin (SPDP, 2006)

Figure 10 - Libeskind, Jewish Museum, Berlin (Chwe, 2004)

The architect utilized empty spaces, towering voids, dead ends and selective daylight to give the building space and its structures an emotional identity (Rogers, 2011). The devastation between this example and this thesis project is incomparable: Nevertheless, the architectural tools and the way in which they are used within the structural language of the Jewish Museum - are an excellent example

of how a design can speak to its occupier on an emotive level. In the case of the Bee Museum, emotional identity is a primary tool to elicit empathy; therefore it is theoretically important to observe previous evocative designs regardless of their differing (or darker) subject matter.

Figure 11 – The Jewish Museum Berlin (Thayer, 2008)

Figure 12 – Garden of Exile Jewish Museum (Craig Nagy, 2005)

ETIENNE-LOUIS BOULLÉE’S - ISAAC NEWTON MEMORIAL

It can be argued that the reason for Etienne-Louis Boullée’s - Isaac Newton memorial’s success is because the architecture avoided a direct praise in its adoration to Newton. Instead this monument makes use of the world’s model - huge sphere of space, in order to explain, commemorate and celebrate Newton’s memory (Zhu, 2010).

When the visitors would find themselves in the midst of the space (shown in Fig. 13), the immense spatial quality around them would make them feel encapsulated in its vast greatness and arguably associate it back to the genius behind the found laws of the universe (Zhu, 2010). Although, the subject of the laws of physics

used here as part of this architectural case study is very different to the one explored in this thesis, it is a successful example of drawing attention to the influence of someone (or something) with an encompassed interaction between science and emotion, much like this thesis encapsulates the science of biology and architecture within its natural environmental integration and ephemeral language in order to capture an emotional response.

Figure 13 - Étienne-Louis Boullée: Project for an Isaac-Newton-Memorial. View by night. Scan from: "Klassizismus und Romantik. 1750-1848

CHERNOBYL, UKRAINE

When looking at the significance of memorial architecture, it can be argued that metaphorical significance within the historically disconsolate, naturally ravaged and degenerated and/or disaster-stricken architecture can be seen as a memorial in itself, without the necessity of design intervention. As a further example, when looking at a place and what makes it significant in our memory, one could argue that the leftover architecture and interior spaces within Chernobyl may serve as a large memorial site to its sad history. Here, it can be argued that there is no need for a professionally

thought-out memorial, because its desolate streets and abandoned houses in the midst of overtaking dried-out shrubs - communicate the haunting reality of what happened in this place much better than any 'man-made' piece of memorial expression (Fig. 13, 14 & 15). Thus, such an occurrence (regardless of whether natural or induced by man-kind) is capable of forming as its own conceptual entity. (Veen, 2012)

Figure 14 – Chernobyl ferrous wheel (Jacoer 2018)

Figure 15 – Chernobyl, (Jacoer 2016)

Figure 16 – Chernobyl Prypyat Ukraine (Jacoer 2018)

Observing the ominous freedom that a man-made or a natural disaster can have within how it shapes the outlook of a place or a thing – can potentially have an immense role when looking to design a man-made ode to something which is in jeopardy.

REFLECTION

From this precedence, it seems that granting oneself certain personal freedom with form experimentation could be the closest an architect may come to finding that instinctual, natural, emotional and thought-provoking expression through one-self. It has been argued that there is a conceptual overuse of literal metaphor for the use of translating difficult concepts into a built form, (Veen, 2012) at times making it over-baring in its message. Although the Bee Museum design would need to have some symbolism establishing what it stands for, especially when directed at younger building users (- children and teenagers). This does not mean that its realistic message needs to necessarily be hammered into those who choose to listen and observe. The building user needs be given the benefit of the doubt and not undermined in terms of their intellectual abilities to connect the dots, leaving enough space for thought without an over-baring compensation of information.

The images (14, 15 and 16) show a desolate wasteland which looks as though it was once bubbling with life. This is important to the Bee Museum design, as it shows an example of how to show life without having to show it, (though from a darker perspective). Showing an essence of life can potentially be a strong anchor for a viewer to become immersed in a particular world/environment, in turn finding a connection with this world's subjects.

It can be observed in both historic and modern memorial architecture, that it is not so much the functional use of space that signifies their essence, but the lack thereof. The spatial emptiness creates room for contemplation, perhaps further allowing the occupier to observe more within the minimalism of the space. Although this aspect is not as specific to the intent of the Bee Museum and Research Centre, it is a strong statement to have as part of a space within the building. Having an empty (or semi-empty) space can create contrast and impact between itself and other museum spaces, allowing for a more stimulating journey.

IN MEMORY OF NOW – DESIGN APPLICATION

The way in which the concept of memorial architecture as previously discussed can be integrated into the Bee Museum design, is through the use of 'non-functional' empty and serene spaces.

Alongside the exhibition spaces and viewing platforms, there need to be elements designed to allow for moments of pause and quiet contemplation, as well as contrasting spaces of light and dark. Utilizing and manipulation of natural light is essential not only for lighting up exhibition spaces, but for establishing spaces for pause and thought. The use of native flora (as deliberated in Section 2) can be utilized as part of darker spaces going from gradually lit to near pitch black. By this method, the museum could be established as not just a mere place of leisure and entertainment, which in part it absolutely is. However, given its subject matter it should arguably speak beyond its alluring artful spaces, fun adventures and visual effects.

1. PROJECT PLAN

1.1 WHAT THE BEE MUSEUM AND SCIENCE CENTRE NEEDS TO FEATURE

As per the literature review and case study – it is established that the Bee Museum requires a multifunctional platform, - meaning that it needs to host a number of events and workshops as a venue. The information gathered from the literature review has been decoded and processed in order to inform this design decision. The four compartments (in table 2) which the design covers are directly influenced by the knowledge assembled during the study of the subject matter within the National Maritime Museum; as it is established, the museum rooms and displays need to be compartmentalised in accordance to categories of subject matter - in order to influence function and program. The compartmentalized subject matter needs to speak of the core subject and message that the bee museum wants to directly communicate, such as - the world of bees, their current decline and devastation, the world without bees, and what can be done to help them (as further explained on the following page). The interconnection between these 4 compartments provides an interesting architectural opportunity. Their almost seamless relation provides a narrative that has been used in the final design (in section 7). The user therefore experiences the building following a narrative path determined by the architect, for which the knowledge came from the academic literature available, such as Rogers’ Post Modern Monuments (Rogers, 2011) and Zhu’s Emotional Expression of Architecture (Zhu, 2010).

COMPARTMENT 1 – AN INTRODUCTION TO THE FASCINATING WORLD OF BEES
Featuring displays and installations intimately signifying the beauty and value of the bee world, through the use of life-size immersive installations and fascinating facts through real life displays and interactive technology.
Featuring: <ul style="list-style-type: none">• Visitor gallery featuring various bee exhibits displaying biological and lifestyle attributes.• A kid’s space – small interactive play area.
COMPARTMENT 2 – CURRENT DECLINE AND DEVASTATION
The second devised space of the Bee Museum would be dedicated to the current decline, devastation and mistreatment of different bee species, and how this will affect us in the future.
Featuring: <ul style="list-style-type: none">• Visitor gallery featuring short documentary spaces in the form of a 360° large monitor room, a photo and art gallery space, as well as monitor displays of recent research and discoveries.
COMPARTMENT 3 – A WORLD WITHOUT BEES AND WHY THEY ARE IMPORTANT
This area expands on the effects of limited numbers of bees through to bee extinction, by showing what a world without bees may look like.
Featuring: <ul style="list-style-type: none">• Visual documentary spaces, monitor displays and an art gallery• Laboratory for study, research and evaluation concerning bee biology, life risks, innovative solutions and observation.• A workshop/social function space• Movable walls for practical readjustment in accordance to events and varying display options
COMPARTMENT 4 – WHAT CAN BE DONE TO HELP THE BEES
This area will be dedicated to a bright and hopeful future, where people can participate in and assist the bettering of the current bee environment.
Featuring: <ul style="list-style-type: none">• A small gallery space• A kid’s space - for arts, books, toys and play.• A café and gift shop• A foraging plant and flower shop• Movable walls for practical readjustment in accordance to events and varying display options
MUSEUM GREEN AREAS
<ul style="list-style-type: none">• A secluded green area between the upper and lower floors of the building, accommodating for a short trail through peaceful green spaces and bee observation.• Smaller green spaces within some internal parts of the building

Table 2 – Compartmental Design (Lubomudrov, 2019)

1.2 DESIGN REQUIREMENTS

The aim in this section is to firstly define initial design requirements for the museum - dedicated to native bee awareness and research. It needs to thereby fit within the design objectives specified bellow.

What are these objectives?

Be informative

Inspire empathy

Stimulate curiosity

Have a practical and beneficial native and introduced bee (and foraging-plant) environment (as will be discussed in further depth through Sections 2 and 3)

Have an engaging spatial aesthetic

1.3 EMOTIONAL & PRAGMATIC
ELEMENTAL DIVISION

The requirements for achieving the objectives (listed on this page) are divided into two sections: The *Emotional* and *Pragmatic* (Table 3).

EMOTIONAL
An essential part of the methodology is to create a design language that looks into artistic and architectural expression encompassing emotion and interpretive information, along with a resilient and thought-provoking message. The emotion-based section of the methodology is chosen to be more encompassing of the aesthetic design;
<ul style="list-style-type: none">Memorial architecture in particular has been found to have this effect on its occupiers/visitors (Zhu, 2010); which is why this is part of the early research discussed in the Section 4 pre-design phase. The key is to find the essence of the subject matter and to re-create it using techniques and approaches found by established architects, such as Etienne-Louis Boullée and the modern memorial take of Gonzalo Mardones’ Memorial 9.
<ul style="list-style-type: none">‘Bee symbolism’ and spatial expression is incorporated (as part of Experiment 1 and 2) encompassing the dynamically visual elements to provoke and captivate attention. This also involves such instances as bee flight paths (explored in Experiment 1), the structure of bee wings and bee anatomy, as well as the naturally tactile qualities of the honeycomb (explored in Experiment 2).
<ul style="list-style-type: none">Natural biological occurrences in hives and fauna are observed for the sake of understanding the environment which the architecture needs to partially embody (- further discussed in Experiment 2).

PRAGMATIC
The pragmatic aspects of the design apply to the pre-design stages: They are included in the design methodology because they determine the first steps of design development, including where and how the building is positioned on site and how it is likely to look. The site itself is a key component in determining these major aspects of the final design. It is therefore included in the pragmatic section.
<ul style="list-style-type: none">Precedence with a particular focus on responsible design is necessary in accumulating a stronger understanding of how the surrounding environment (of the chosen site) can be utilized. This correspondingly involves looking at responsible design methods that have the potential to utilize aspects of the site - such as sun and/or wind and rain with the intention to generate energy and water. Material source certification is another important aspect in adhering to this design approach.
<ul style="list-style-type: none">Since the subject of the design has a distinctive focus on bees, the initial design steps are to choose what kind of bees/native bees the design will be for, as this will make an impact on the kind of space, accommodation and foraging plants (further discussed in section 2). In conjunction with bee selection, foraging plants are likewise determined, since they in turn impact how the site is developed. This is to determine major parts of building circulation in accordance to plant space.
<ul style="list-style-type: none">The design involves more than one building. For this reason the way in which the chosen site is studied, measured and organized will be essential to their spacing and circulation from one building to another. The site initially needs to fit the needed profile e.g. medium to soft density soil, a minimum area of 400m2, be close to a green area - like a park or bush, etc. Although this can be seen as a part of the site study rather than design methodology, it is included in this section due to its direct impact on design as well as on the plants that are chosen for the site (- as the larger plants/trees would be heavily dependent on space and soil type).

Table 3 – Emotional and Pragmatic Delegation (Lubomudrov, 2019)

The strategies for the requirements specified (to the left) are chosen because they all have their contribution to the overall scheme of research by design. They each cater to the final design objective, as the bullet-pointed list below narrowly defines.

1.4 SCOPE OF REQUIREMENTS

- Bee selection - determining the utilities and site plants needed, in turn influencing the design/appearance.
- Site Study - ensuring its suitability for the determined design essentials, impacting design as well as site circulation.
- Responsible Architectural Design Precedence – increases understanding of environmentally responsible design based on previous practices.
- Memorial architecture research - helps to understand how to attain spatial meaning and atmosphere.
- Natural Bio-occurrence - offers a way by which to re-create an organic aesthetic mimicking that of the bee world.
- Bee symbolism - serves to closer engage the subject of bees.

Hence, for this research project, these tools will provide a solid groundwork on which to attain a clear and concise design development with the intention of a worthy final product.

1.5 METHODOLOGY

This section of the thesis deals with selected methods, parameters and strategies engaged for research by design (as shown in Fig. 17). The nature of architectural design processes is dependent on problem solving strategies (Lawson, 1979) in relation to subject matter, as defined in Lawson’s research on Cognitive Strategies in Architectural Design. It is arguably often driven by an empirically intuitive process, involving various tangible and intangible influences, (Sethi, 2015).

As broad as the intersection of bee preservation and architecture is, in this section, it is focused down to a number of strategic approaches involving conventional and semi-unconventional processes (Lucas, 2016). Conventional processes such as drawings and models have been an integral part of the classical design approach serving as the primary tool of vision manifestation. Said ‘conventional’ processes are the paramount tool for finding the architectural design language explored in section 5 for this design project, as it is the one that is able to most closely identify potential visual elements that can captivate a viewer’s attention and emotion, based on both a pragmatic and intuitive research by design process.

Parts of design development overlap and work together in achieving the next stage of the design process. Unlike Fraser’s B.A.S.I.C methodology in his book - Design in the Built Environment, 1972, which consists of 5 linear steps; Briefing, Analysis, Synthesis, Implementation and Communication (Fraser, 1972), this methodology has an overlap between Analysis and Synthesis. Although this methodology is not entirely linear, it does not adhere

to Snyder's cycle structure either. The cycle structure involves the same steps in a repetitive cycle and a yes or no branch upon the final step of communication, - whether to keep the final design or repeat the step-by-step process all over again for a better result (Snyder, 1979). Although the methodology for this thesis involves some repetition, unlike cyclical methodology it primarily consists of investigative branches/parts involving multiple ideas, eventually meeting or breaking off to influence the final result. This falls within the former mentioned (as part of the introduction) experiments 1, 2 and 3 (Fig. 17). Each experiment plays the role of an investigative branch in order to determine whether it progresses through to another branch extending from it (further influencing the design) or if it breaks off to start a new experiment. Each step in this design process is based on selective research involving options of ideas and solutions (Lucas, 2016), most closely replicating a methodology or design as a goal-directed search process (Kalay, 1985).

Figure 17 – Methodology (Lubomudrov, 2019)

2. BEE SELECTION - DESIGN IMPACT

This section explores how certain types of bee species may influence the design based on their needs and vulnerabilities. The information gathered can be applied to certain site and building characteristics that may otherwise be designed solely for human use and comfort.

2.1 PRE-DESIGN QUESTIONS

Assessment for Potential Bee Species Overlap

Because it is important for educational and research purposes - the museum and sanctuary grounds aim to host a number of native and introduced bees.

Upon designing the museum and managing the site with the chosen bee species as observational examples, initial determinations are made with consideration to these varying types of bees.

- Individual necessities
- Territory
- Food specific to particular species
- Nesting grounds

Most importantly it is further discussed whether native and/or introduced bees clash over territory and/or certain types of food. - Previous biological study points to limited animosity and territoriality amongst native New Zealand bees, as they are solitary, apart from three native bee species which have a basic social structure, a bit like the introduced honeybee and bumblebee. The rest are not bound to a colony, thus without the need to protect a large honey-containing nest from predators and most often constructing solitary nests close together with no boundary-imposing tendencies (Early, 2007).

The contrast between certain types of bees can serve as a way for visitors to learn about what makes these differing species unique

to one another, as well as understand their contribution to the varying agricultural and native environment. On the other hand, these unique bee distinctions may also serve to their demise (within the scope of the Bee Museum design) dependent on the degree of niche differentiation, as well as whether colony overlap is peaceful or aggressive.

Although, when looking at most native bees, it can be found that they are non-aggressive towards humans as much as they are non-aggressive towards each other (Hart, 2007). With this in mind, the objective would be to incorporate and home as many bees as possible (if they can be found, or are not yet completely decimated) as a significant priority to the purpose of this museum and bee sanctuary. Because of this, the initial building and site design steps will be focused on several native and introduced bees for the building site and surrounding sanctuary to host. As a way of identifying a peaceful bee overlap, a number of non-aggressive bees from previously shared territories are chosen in section 2.2, based on Donovans’ foraging and site overlap analysis, as e.g. - observing requirements of ground nesting bumble bees, honey bees, native bees and alkali bees for nest sites differing so greatly that no probability of competition exists (Donovan, 1980).

2.2 BEE SELECTION

As discussed above, bee selection is dependent on their nature and manageability, as well as what they offer to the museum’s knowledge-building platform. The following native species are

shown to be an optimum choice for the design, with constructive factors for their suitability stated in the description:

The table below does not show all 28 species of New Zealand. Instead it shows the bees chosen for the site based on their non-territorial nature and foraging food preferences.

There are 18 types of Leioproctus bees that are native to New Zealand. It is therefore a major representative of the national native bee, possessing a striking resemblance to the honey bee, with just a minor difference in size approximating at 5–12 millimetres long (Early, 2007). They are known for digging nest holes in the ground, and may at times give the impression of a colony due to covering a nesting area riddled with individual bee holes. A small pile of soil is the usual sign of solitary nest tunnels (Early, 2007). Such aspects of bee-made environments could potentially impact and inspire key elements of the design, - integrated as functional or symbolic design elements. They are therfore an essential part to the research by design process.

NATIVE BEES			
Native Bee Family	Leioproctus	Hyaleus	Lasioglossum
Species	• Boltoni Cockerell	• (Prosopisteron) agilis (Smith)	• Austrevylaeus Mataroa
	• Huakiwi	• (Prosopisteron)	• Genus Euryglossina Cockerell
		• Matamoko	
	• Pango	• Euryglossina Cockerell	
	• Imitates Smith	• Genus Hyleoides Smith	
	• Waipounamu		
	• Kanapuu		

Table 4 – Native Bee Selection (Lubomudrov, 2019) (Donovan B. , 2007)

2.3 NATIVE FORAGING PLANTS DATA
COLLECTION, ASSESSMENT & SELECTION

Similarly to the research of bee behaviours and environments, the plant food which is consumed by each particular type of bee will be integrated into the landscape and architecture of the site. For this reason, the types of foraging foods necessary to the chosen native bees are listed for further development and understanding of their potential impact on the final design and its site. Both scientific and laymen plant names have been subsequently listed as reference points to anchor building and site development. This aspect of the pre-design stage functions as a point to work from due to its substantial role within the architecture, influenced by the essential recourses necessary for native bee accommodation.

Tables have been comprised (on the following page and appendix) to determine which plants should be introduced to the site, with priority to plants that are most in demand by a majority of native bees.

This data is collected from Donovan’s research on Fauna of New Zealand and **Cerulean’s Plant Conservation Network (Donovan B. , 2007; Cerulean, 2019).**

(LEIOPROCTUS) BOLTONI COCKERELL - ASSOCIATIVE NATIVE FOOD/HOST PLANT		
Foraging Plant Food – Scientific Name/Category	Foraging Plant Food – Laymen Name	Plant Status
Campanulaceae - Wahlenbergia pygmaea	North Island harebell	Not Threatened
Fabaceae - Carmichaelia	Pink Broom	Nationally threatened
Hemerocallidaceae - Phormium tenax	Flax, Harakeke, Korari (maori name for inflorescence)	Not Threatened
Laxmanniaceae - Cordyline australis	Cabbage Tree, Ti Kouka, Palm Lilly	Not Threatened
Myrtaceae - Kunzea ericoides - Leptospermum scoparium - Kunzea Leptospermum - Lophomyrtus obcordata - Metrosideros excels - Rata	Kanuka Manuka, Kahikatoa Kānuka, White Tea-Tree or Burgan Rohutu Pohutukawa Rata	Nationally Threatened At national risk Threatened - Nationally Vulnerable Threatened-Nationally Critical Threatened – Nationally Vulnerable At Risk - Naturally Uncommon
Plantaginaceae - Hebe traversii	Hebe	Not Threatened
Polygonaceae - Muehlenbeckia complexa	Small-leaved Pohuehue, Scrub Pohuehue, Wire Vine	Not threatened
Thymelaeaceae - Pimelea traversii	Boreus	Threatened Nationally Vulnerable

Table 5 – Native Bee Foraging Foods (Lubomudrov,2019)

SITE PLANTS

Confirmed Vegetation to be planted around the site and within building premises

• Corokia buddleioides	• Weeping Tree Broom	• Kanuka	• Creeping Willow Herb
• Manuka	• Trailing Rosemary	• Tenax Flax/Korari	• Pahutakawa
• Tea Tree	• Harakeke	• Palm Lily Creeping willowherb	• Cabbage Tree
• Kowhai	• Wahlenbergia	• Rata	• Scarlet Mistletoe/ Korukoru
• Hebe (several types)	• Red Mistletoe, Pikirangi	• Forget-me-not	
	• Pohuehue	• Cordiline Australis	

Note: Not all plants on the list are included in Fig. 18

Native plants are to be incorporated between museum structures and potentially influence said structures, seeing as how even a single flowering Kanuka tree can provide foraging food for hundreds to thousands of native bees nesting within its vicinity (Hart, 2007).

Correspondingly, this same method by which the foraging trees and plants are placed determines bee flight paths and interaction with their surrounding structures. It is important to keep this in mind when considering the fairly vast area of the museum and how its occupation impacts the flight paths and subsequently the lifestyle of its bees. This component can in turn have a strong influence on design deliberation and execution (which will be addressed in Section 6).

18 - Confirmed Site Vegetation (Lubomudrov, 2019)

2.4 FINAL CONSIDERATIONS FOR BEE HOSTING

It is important to remember that New Zealand's native bee species do pollinate flowers, but do not produce honey. They also can't be farmed in hives the same way honeybees can. This means that they require different - native environments in order to have all the required resources. They don't always look like bees, nor can be displayed in a similar fashion to honey bees, seeing as how they do not conform to a hive, but rather, they make nests in the ground or in barks of trees etc. (Donovan B. , 2007). Thus, the grounds for native bees will not be developed in the same way as those for honey bees, and may be less engaging for observational purposes.

Ecosystem observation hives and nests will therefore need to be applied to the site very delicately, along with an in depth explanation of how and why each of these hives or nests work.

2.5 IMPACT ON SITE TERRITORY

Following the complete assessment of appropriate bees to host upon site, there is a measurement of site territory with consideration to how it may be divided post-deliberation to territorial requirements.

Typically, 50m² per solitary bee species type (adding up to almost an acre) may be required. Much of this is based on guesswork, seeing as how there is no direct source which determines whether certain native bees may be territorial, and thus far the only stipulation from

given sources - is that native bees are non-aggressive (Donovan B. ,2007), and theoretically appear to be as non-aggressive toward humans as they are towards each other. This is where site suitability and availability may become complicated, due to the dependency on the types and amount of bee species the museum design intends to incorporate into its site. Furthermore, due to bee food requirements, - the spatial foundation of the site, its soil type and exterior elements all aim to impact sustainable plant growth.

3. SITE

After an exploration of multiple potential sites, the one deemed to have the most suitable environment for this thesis and its design requirements is the Raiha Street logging site (located at 6-8 Raiha St, Porirua, New Zealand).

Several possible sites have been considered prior to this site, which have been proven to be ineffective, primarily due to their locations. One is firmly placed within the Porirua green belt for which the council has very specific plans concerning its use and revival (Community, 2014) , whilst the other is placed considerably closer to the town centre and does not allow for enough green space development due its spatial and contextual limitations. Both of these initially considered sites have also proven to have an abundance of practical complications further discussed below (in Section 3.1). Nevertheless, having to address these issues post an in depth site analysis has helped narrowly determine what works and what doesn't when it comes to an environment for specific design potential and usability.

3.1 EARLY SITES

TAKAPUWHAHIA, PORIRUA, NEW ZEALAND (FIG. 19)

This site is an excellent place for a potential bee museum as it has the outdoors and the plant sustenance for the bees which the museum intends to host. It is also based in a good location, where it's not too close to central Porirua, but is close enough to be within walking distance, not far from the bustling public centre and to the brink of the Takapuahwhi native bush area.

However, being part of the Porirua green belt with a Te Awarua o Porirua Harbour and river conservation initiative in place Harbour and river conservation initiative in place, (Community, 2014) it does not work as a site on which a large structure could be built. This is because a large structure and the building process itself may disturb the fish and pollute the harbour and river water, halting conservation progress. After the first review, and an in depth discussion with my reviewers concerning these issues, the decision was made to keep searching for a site which would be more appropriate and responsible.

Figure 19 – Takapuwhahia Site, Porirua, New Zealand (Lubomudrov, 2019)

CORNER OF JOHN SENNET AND HERRIOT DRIVE, PORIRUA, NEW ZEALAND (FIG. 20)

This site is considered next, as it is also based fairly close to central Porirua, and visible from the main road, which means that it would be accessible and within view, as part of the central Porirua landscape. However, the issues with this site are even more evident, given the lack of wilderness needed to harbour and take care of hosted bees. Additionally, even though the site is over 7000m2 there is not enough space to plant foraging foods, once the approximate number of host bees are considered given how many native (28) and non-native (14) species there are to deliberate.

Figure 20 - Corner of John Sennet and Herriot Drive Site, Porirua, New Zealand (Lubomudrov, 2019)

THOUGHTS BASED ON INITIAL SITE STUDY

It would be ideal to find a site which already has a native New Zealand wilderness nearby. Being within visual view is no longer a priority, seeing as how there are a number of Museums in New Zealand which are out of the way, yet don't lack popularity - such as the Southward Car Museum in Paraparaumu, or the Fiordland Vintage Machinery Museum.

3.2 SITE PRECAUTIONS AND CONSIDERATIONS

A very important aspect to site assessment for this architectural design - is whether or not it can be hospitable not only to structure and human occupation, but equally for bee residents. As there are several elements in modern day urban living that may be contradictory to bee health and safety within urban, industrial and suburban areas, there are a multitude of factors to consider prior to settling on a chosen site:

- Fast travelling vehicles
- Insect predators
- 1080 Poison (- a metabolic poison used for pest control in New Zealand)
- Light Pollution
- Fume Pollution
- Lack of community awareness (friendly signs and adverts may help with this)
- Completely unsheltered sites (to extreme weather conditions)
- Polluted, infertile or overly dense soil may be problematic for growth of vegetation. In most instances this issue may be manageable through the application of proper native plantation practices, soil compensation, mulch and a variation of botanical services (Meurk, 2012); however, it would be ideal to find a ground that naturally possesses good substance for plant growth, as well as natural-sanctuary park potential.

3.3 SITE CHARACTERISTICS

RAIHA STREET, PORIRUA, NEW ZEALAND (FIG. 21)

Overall, the site and the bush track have a great deal of potential with consideration to the Impact on Site Territory questions raised in Section 2.4. Not only can it be suitable to territorial parameters and requirements for the sake of native bee maintenance, but its forestry and bush areas may benefit and cater to the native and introduced bee habitat, which in turn may benefit from their pollination services.

Furthermore, the vast bush area surrounding the site is currently being rehabilitated by the Porirua Council's tree planting community known as Aotea Conservation Volunteers. This could mean that the native planting goals centred as part of the Bee Museum design can align with the Porirua Council's initiative for native bush rehabilitation and conservation (Porirua City Council, 2009).

Looking back at Section 2.3 - Native Foraging Plants Data Collection, Assessment & Selection, which specifies the necessity for the building structure to adapt to and work with the foraging plants introduced into the site, as well as the location itself (specified above); It indicates the various pros and cons of site placement between an industrial and green area - signalling an opportunity for the building to closely work with its environment. This in turn - is partially influenced by precedential practices discussed in section 4.

Firstly, there are environmental factors, and secondly, there are physical factors of the site to be taken into consideration: Primarily, the angle of the site's slope, which may have an effect on the final design. This aspect can either be utilized or overcome, dependant on design aim.

Therefore, it is important to have a solid groundwork for this kind of architectural design to be introduced to the lands own shapes and curves, where it could either compliment it, or alternatively work along-side it, utilizing the landscape. This aspect of the design will be addressed in section 6 upon stronger design deliberation.

6-8 RAIHA STREET, PORIRUA, NEW ZEALAND - MARKED IN RED (FIG. 21)

Figure 21 - 6-8 Raiha Street Site, Porirua, New Zealand (Lubomudrov, 2019)

4. SPATIAL QUALITIES

This section addresses the question of how human occupancy can be shared with plants and insects to help enhance the design, making it favorable for all inhabitants. It presents ideas of responsible architecture, red list materials and aesthetic concepts.

4.1 PLANTING THE ROOT FOR A RESPONSIBLE BUILDING PLAN

The way in which the bee museum will meet the standards of responsible architecture in building and practice:

- The roof of the main building and subsequent walkway pavilions will use solar panels as a primary source of power.
- The landscaping in and around the premises of the building will serve to integrate to the native environment as a manmade facility can.
- Utilization of natural light through the use of opaque/semi-transparent roof panels and larger tinted windows for the sake of heat and harsh sun-light control.
- Natural Ventilation through the use of schematically placed windows and openings, also utilizing natural air produced by surrounding vegetation.
- Natural glues and non-toxic treatment substances are to be used, with source checking.
- Source checked, naturally durable and non-toxic materials are to be employed for the building.
- Recycled grey water is necessary (especially when used for large amounts of plant irrigation) in order to lower unnecessary water consumption

- The building will be elevated off the ground allowing for some light to penetrate under the building (- further discussed in Section 4.3). Thus flora would be able to continue growing (even under the building) where there usually would not be enough light to sustain plant life.

With the future of the natural environment becoming increasingly vulnerable, it is at this stage, important to aid this environment through research of non-toxic materials, and proper native planting incentives and practices.

The project to develop native species diversity as part of the restoration process of a tropical forest ecosystem in China - has shown that soil fertility, plant species diversity and the diversity of birds and microbes appear to mutually facilitate one another (Fang, 1997). This indicates that assisting the growth of a natural habitat would not be the same as growing a garden or maintaining a greenhouse. It would involve soil assessment, germination analysis and light delegation (Fountain, 1991).

4. 2 RED LIST MATERIALS

This section lists materials of high toxicity, which cannot be used as part of the Bee Museum building, as it attempts to provide a non-toxic environment for all life within and around it (- established in accordance to the Living Building Challenge):

• Alkylphenols	• Halogenated Flame Retardants (HFRs)
• Asbestos	• Lead (added)
• Bisphenol A (BPA)	• Mercury
• Cadmium	• Polychlorinated Biphenyls (PCBs)
• Chlorinated Polyethylene and Chlorosulfonated Polyethylene	• Perfluorinated Compounds (PFCs)
• Chlorobenzenes	• Phthalates
• Chlorofluorocarbons (CFCs) and Hydrochlorofluorocarbons (HCFCs)	• Polyvinyl Chloride (PVC)
• Chloroprene (Neoprene)	• Polyvinylidene Chloride (PVDC)
• Chromium VI	• Short Chain Chlorinated Paraffins
• Chlorinated Polyvinyl Chloride (CPVC)	• Wood treatments containing Creosote, Arsenic or Pentachlorophenol
• Formaldehyde (added)	• Volatile Organic Compounds (VOCs) in wet-applied products
•	(Living Buidling Challenge, 2019)

4.3 EARLY RESPONSIBLE & AESTHETIC DESIGN IDEAS & DELIBERATION

In the initial stage of the design, the building is structurally elevated off the ground for the sake of preserving airflow and the foraging vegetation at ground level. This would also preserve the visual/eye-level connection with the green park area located behind the museum, giving it a lighter and more contextually integrated look. However, once this elevated design is complete, there is also great potential to utilize the space underneath the building. This would be done not for the sake of utilizing extra space for solely human use, but for the further integration of man-made wilderness as a means to serve bee purposes.

With consideration to both ephemeral and ecological aspects of this design, the use of the site needs to be resourceful as well as light in its portrayal and function. Utilizing the use of natural light, space and structure – the roof of the building would allow for light to travel directly through parts of the skylights and large windows to illuminate the artwork on the upper floor, whilst utilizing the semi-dark mystery of the underground floor in order to submerge its occupier into its environment and technology.

When it comes to a park under a building, an underground precedent of LowLine lab in New York City has a strong influence on the kind of technology for maintaining a green environment (La Bastide, 2017). The technology to redirect daylight through the use of solar light tubes is the most appropriate for certain internal and outer areas of the building which do not receive enough daylight exposure.

Raad Studio, - the company behind NYC's Lowline has initiated new solar technology under the name Invasive Regeneration, created by James Ramsey and Dan Bartsch. This technology uses a system of finer optic cables and mirrors to lure the sunlight toward an underground level (La Bastide, 2017) that enables garden growth underground. It is known as Invasive Regeneration, which utilizes a solar funnel installed at street level, functioning as an expansion of the process used to create Lowline, - a subterranean park in New York city.

To support plant growth beneath the building, absorptive light panels (as those used at the Lowline subterranean park) are installed as a source of light manipulation (Fig. 22).

Figure 22 – Solar Panels Lighting Under Bee Museum Building (Lubomudrov, 2019)

5. DESIGN LANGUAGE

This section delves into how a unique and interesting design can be found through organically occurring influences in nature, and how they can be developed through iterative experimentation. As previously discussed (in Methodology), this involves iterative experimentation consisting of 3 different experiments to understand where they lead the design. Strengths and weaknesses to experimental influence are discussed and re-conceptualized further into the process, supplementing found weaknesses with a pragmatic approach in the final design stage (in section 6).

5.1 SYMBOLISM AND INSPIRATION

There are a multitude of elements within the bee world to consider as a focus of inspiration. Such elements may consist of internal and external factors, such as the bees hive/borrow or the bee itself. Other elements could include - flight paths, movement or grazing patterns of bees, as well as the types of places they visit, or potentially their unique anatomy.

As opposed to focusing on hive/honeycomb elements - as it has been done a multitude of times - the following experiments primarily focus on the bee's flight and everything to do with it. This choice is due to the idea that a bee's flight is arguably when it's at its most lively and productive as well as at its most vulnerable; when it has a chance to stray, get hit by a car or be chased by predators. This liveliness combined with vulnerability is exactly where there is potential to establish a connection between the bee and the observer, as well as introduce an element of adventure into the architecture without necessarily being literal.

5.2 FLIGHT PATH INFLUENCE & SKETCHING - EXPERIMENT 1 (FIG. 23)

When it comes to most building design practices, it seems that landscaping is often one of the last stages in the design process even though it may remain in view of consideration throughout said design processes. In the case of this thesis, it seems that the design approach has been slightly altered from a traditional building design process. This experiment employs a working-backwards design system for the sake of making the bee environment its priority, in turn impacting its design through the early involvement of this environment.

Upon studying a bee flight path, it may appear random, even though in actuality it is methodical and deliberate, commonly navigating through an established pathway - based on reference points and a navigational motor routine (Menzel, et al., 2004). It is by mimicking this movement, that some of the ephemeral and structural elements will be developed. The very idea of the flight path can in itself parallel forms of the architecture. Such an approach could add an extra layer of hidden depth to the design, if fittingly executed. The conceptual flight paths following the plant paths can in turn serve to break the traditional architectural grid, escaping a commonly pre-determined disposition toward a rigid architectural narrative (as is further explored in Section 6.5 - Experiment 3).

STRENGTH

With this approach, the architectural language can be purposely disrupted by that which may appear invisible to a conscious perception, subtly communicating its design intention. This means that what may seem to be skin deep in a myriad of physical shapes and textures can have an ephemeral quality for the sake of depicting the world of the subject which it speaks of.

WEAKNESS

An issue with this experiment is that the plants are often approached as barriers to work around, rather than assets to work with. Due to this aspect, the design progress can become disoriented and constrained if it leans too much on this experimental direction.

Native Plants Introduced

Clear Site

Plants & bees Introduced

Figure 23 – Experiment One, Flight Path Exploration and Development (Lubomudrov, 2019)

5.3 NATURAL ENVIRONMENTAL INFLUENCE AND EPHEMERAL QUALITIES – EXPERIMENT 2

The world of the bees is a mysterious one. Hence, the best method by which to encompass a viewer/occupier can be through the eyes of a bee, integrating the viewer into its world as though they were one of the hives own.

Light and shadow can be seen as qualities that have the potential to breathe life into a building. These qualities can be utilized through the use of dislocated movements within the structure. More specifically, parts of the roof and the façade can be developed to mimic organic forms latching onto and breaking off from one another, much like they would in a natural setting. The way in which a hive latches onto its tree, a solitary bee nest is formed in the crack of old bark, or the structural aerodynamic nature of the bee wing – can play an influence on an ephemeral design approach.

TEXTURAL QUALITIES

The images shown (in Fig. 24) are sketches and photos - created upon observing different forms of potential native bee environments such as tree stumps, bark and dried up old wood. This is used as a potential part of design development – to see if these environmental elements can have any impact on a building design with consideration to façade as well as hypothetical inspiration for circulation.

Textural qualities are then looked at for application to the found form. As part of Experiment 2, the textural qualities and materials used are the finishing component in establishing the architectures natural and ephemeral point of view.

Figure 24 – Organic Form Exploration and Development (Lubomudrov, 2019)

Figure 25 – Textural Qualities Exploration (Lubomudrov, 2019)

Qualities which occur naturally within nature can either be extremely sturdy or immensely vulnerable, which seems to be part of what makes them fascinating. The hard and soft textures can thus help signify this contrast, similarly to how they can signify the vulnerability of the bee.

One particular structural and textural influence is found within the bee wing. It is practical, yet fragile, and the ephemeral qualities it possesses can be applied with the empathetic depiction of the architectural statement to portray a sense of delicate vulnerability. In order to find a strong depiction for the façade of the building, the bee wing is in turn combined with the initial experiment of honeycomb voronoi manipulation (Fig 27).

Figure 26 – Experiment Two, Bee Wing Ephemeral Exploration (Lubomudrov, 2019)

Figure 27 – Symbolic Manipulation (Lubomudrov, 2019)

STRENGTH

This part of the experiment phase serves as the final layer of the physical ephemeral design. It is quite literally and external shell, providing both practical use for bee interaction with its natural materials and installations - including bee houses and plant pods, as well as a visually pleasing element to correspond with its organic environment.

WEAKNESS

Because this experiment is focused on physical qualities, it may lead to the development of a superficial design, with not enough functional/pragmatic merit: This is a concern, because a museum made to serve humans and bees would need to work in a way where it can benefit both.

6. DESIGN DEVELOPMENT: ISSUES, SUCCESSES AND INFLUENCE

DESIGN PREMISE:

The first premise is to design more than one building. This is so that the public can move between spaces in the form of green corridors, allowing them to be immersed within the natural bee environment.

The second premise is to allow for the building to function as more than a museum and to have several spaces catering to different types of venues (as discussed in the project planning stage – Section 1).

Figure 28 – Design One (Lubomudrov, 2019)

6.1 DESIGN ONE (FIG. 28)

The very first design is the initial step in elevating the building. Its structure aims to accommodate rooftop hives and a café across a green over-bridge to another green-roof building. This aspect is an element to responsible design, aside from some potentially incorporated solar panels as part of the honeycomb overhang. The façade integrates the organic texture of a bee wing (as was explored in Experiment 2). Upon the second review for which this initial building is designed, there have been a number of notes and critiques made by the reviewers (listed in the table on the following page), which will be addressed in the second stage of the design process (in Section 6.2).

Strengths	Weaknesses
Appearance	
<ul style="list-style-type: none">- Interesting modernist language- Contrasts and stands out amidst its green park backdrop	<ul style="list-style-type: none">- Harsh concrete appearance comes off heavy and imposing upon its surroundings- Does not capture the essence of its subject matter- Honeycomb overhang may appear too literal
Structure	
<ul style="list-style-type: none">- Structural promise; enough mass to integrate structural walls. The stairwells and elevators leading from one floor to another are placed to allow for a floor and ceiling diaphragm, which would be useful as seismic precaution.	<ul style="list-style-type: none">- Honeycomb overhang has no structural integrity in that it is not yet developed in a way where it has points to stand on. Although it is timber and fairly light weight, this may infer problems during wind events, without proper anchorage.
Functional Elements	
<ul style="list-style-type: none">- Circulation- Good thermal mass- Earthquake prevention potential	<ul style="list-style-type: none">- Issues with spatial delegation for exhibit rooms- Entrance and exit are not yet visually evident and may be confusing to visitors/building occupiers- Lack of natural lighting- Honeycomb overhang does not provide enough shade due to its trellis like structure, having a more sculptural integrity rather than functional purpose
Responsible Design Potential:	
<ul style="list-style-type: none">- Green rooftop design- Park integration	<ul style="list-style-type: none">- Green rooftop is a sole element for green design which is not beneficial enough- Concrete facade does not yet have any organic elements to allow for natural environmental integration, such as bee pods or plant growth- Concrete structure may be easier to crack upon integrating foraging plants around or under its main cantilevering upper floor of the main building
Contextual Integration:	
<ul style="list-style-type: none">- Although the building stands out, it is not imposing on the industrial part of the neighbourhood (Raiha Street, Porirua) where it is based	<ul style="list-style-type: none">- Does not integrate well with the neighbourhood’s native bush track and landscape next to which it stands (The Colonial Knob Walkway, Raiha Street, Porirua)

Table 6 – Design One – Strengths and Weaknesses (Lubomudrov, 2019)

6.2 DESIGN TWO

The second design also consists of two buildings joined by an over-bridge pathway. The idea of this over-bridge pathway is influenced by the bee flight paths first experiment (explored in Section 5.2) and curves around native forestry planted between the two buildings. For this phase of development the building is almost entirely converted from concrete to timber - as an attempt to address the imposing and heavy qualities of the first building. The second design development also integrates the initial honeycomb overhang structure from the previous design as a roof element for one of the two adjoining buildings. This is a solution to anchoring the honeycomb element, whilst further integrating it as part of the building itself, rather than just a non-functional sculptural element.

Figure 29 – Design Two (Lubomudrov, 2019)

Strengths	Weaknesses
Appearance	
<ul style="list-style-type: none">- Light timber language- Merges nicely with most of its surroundings including the native bush backdrop- Both buildings encompass some bee symbolism with bee wings as inspiration for the first building, and the honey-comb hive in the second	<ul style="list-style-type: none">- Bee symbolism is overused and too literal in the second building- The two buildings styles do not correspond well with one another. They are contrasted, but for the wrong reasons.
Structure	
<ul style="list-style-type: none">- Some structural promise as the building is fairly light, but may need to encompass moment frames in order to be structurally viable whilst maintaining its appearance	<ul style="list-style-type: none">- V-columns under holding the floor of the building are likely not wide enough to hold weight of the building plus added weight of museum displays and installations- Whilst there are columns holding up the floor, columns for roof would need to be further deliberated if the building were to be longer than 9 metres by 4 metres wide. Although the moment frames have some potential to carry the roof, this would not be possible in a building of this size (-18m x 5m) and would need to be further realized structurally
Functional Elements	
<ul style="list-style-type: none">- Light structure – easy to stabilize- Double or triple glazing may be used for regulating temperature- Ramps imply easy accessibility- Earthquake prevention potential- Abundant in natural lighting	<ul style="list-style-type: none">- Issues with spatial delegation for exhibit rooms with the first building being too narrow- Circulation is problematic due to only one cross-over between the buildings, making the journey back through the museum useless and repetitive- Entrance and exit are not yet visually evident and may be confusing to visitors/building occupiers- Lots of natural lighting, which may lead to overheating and needs to be addressed with a balance of light and shade/coverage within the building- Number of spaces is too low to meet project plan requirements discussed in Section 1
Responsible Design Potential:	
<ul style="list-style-type: none">- Exterior green walls make parts of the façade and integral part of the natural bee environment implementation- Easy park integration- Does not take up an overwhelming amount of space saving on resources and limiting carbon footprint- Materials used for building are natural/timber-based	<ul style="list-style-type: none">- No green rooftop element (although compensated with exterior green walls) may not be enough to serve ecological or bee preservation purposes due to limited spatial occupation and arrangement- Building does not have enough under-floor space and height in order to grow and manage native plant life on the ground below
Contextual Integration:	
<ul style="list-style-type: none">- The first building stands out within its industrial part of the neighbourhood (Raiha Street, Porirua), but does so in a subtle, yet intriguing manner, without overcompensating in size or style. In other words, it appears a lot more elegant yet effortless, as opposed to when it was its early concrete stage	<ul style="list-style-type: none">- The ‘hive-roofed’/second building appears to be overdesigned in terms of its literal depiction and may be an alarming contrast to both the first building and the rest of its neighbouring context

Table 7 – Design Two – Strengths and Weaknesses (Lubomudrov, 2019)

6.3 DESIGN THREE

The third design once more consists of two buildings joined by an over-bridge pathway. At this stage of development the hive building is removed to address the contextual, spatial and literal-symbolic issues it added to the design. The first building is kept as is with some fairly minor structural adjustments involving a redesign of the v-columns to be wider and have extra supporting columns branch out at a 45° angle. Instead of the hive building, the second building is now a smaller entrance point/introductory space as a build up to the primary larger building. The larger building is slightly enhanced in size – particularly in width to be more accommodating as an exhibition space. Extra timber panels are added to the façade in order to manage overheating caused by natural light. This progressed design works as a solution to remedying some of the earlier structural, functional, contextual and aesthetic issues that were found in the previous design (- design two).

Figure 30 – Design three (Lubomudrov, 2019)

Strengths	Weaknesses
Appearance	
<ul style="list-style-type: none">- Light timber language- Merges nicely with most of its surroundings including the native bush backdrop- Both buildings encompass some bee symbolism with bee wings as inspiration- Both buildings work well together/correspond stylistically	<ul style="list-style-type: none">- Bee symbolism is overused and too literal in the second building- The two buildings styles do not correspond well with one another. They are contrasted, but for the wrong reasons.
Structure	
<ul style="list-style-type: none">- Some previous structural issues have been remedied with a stronger design in the wider branched out v-columns.- Moment frames are present for seismic stability of the floor level building	<ul style="list-style-type: none">- Because the building is now wider by 1.5 metres and longer by 2 metres, further deliberation for the building is needed with regards to floor level stability. Although the moment frames can now carry most of the roof, there may need to be several pillars installed as an extension of the v-columns to the roof crossbeams of the building
Functional Elements	
<ul style="list-style-type: none">- Light and stable structures- Double or triple glazing used for regulating temperature- Extra timber panels in façade used to regulate temperature- Multiple ramps imply easy accessibility- Earthquake prevention almost realised- Fair amount of natural lighting	<ul style="list-style-type: none">- Circulation is still problematic due to an awkward crossover involving ramps between buildings- The exit in the first building is not yet fully realised- The second building may not have enough space for what is required to do – partial exhibit and reception- There seems to be no space delegation for a café yet, even though that was part of the initial design plan- Number of overall spaces is too low to meet project plan requirements discussed in Section 1
Responsible Design Potential:	
<ul style="list-style-type: none">- Exterior green walls make parts of the façade and integral part of the natural bee environment implementation- Easy park integration- Does not take up an overwhelming amount of space saving on resources and limiting carbon footprint- Materials used for building are natural/timber-based- V-columns are now elevated 500mm to allow for growing and managing native plant life on the ground below	<ul style="list-style-type: none">- No green rooftop element (although compensated with exterior green walls) may not be enough to serve ecological or bee preservation purposes due to limited spatial occupation and arrangement
Contextual Integration:	
<ul style="list-style-type: none">- Both buildings stand out within their industrial part of the neighbourhood (Raiha Street, Porirua), but do so in a subtle, yet intriguing manner, without overcompensating in size or style. At this stage, they appear a lot more elegant yet effortless. They likewise correspond well in style to one another as opposed to the earlier design in <i>stage two</i>	

Table 8 – Design Three – Strengths and Weaknesses (Lubomudrov, 2019)

6.4 POST -DESIGN ONE, TWO AND THREE NOTES
AND FINAL THOUGHTS:

Even though clear parameters are set in the project planning phase (in Section 1) they are not as strictly applied to the design experimentation phase. At this stage, it seems that the design progress is not meeting spatial requirements, or adhering to better public access and easier flow through the building(s). Due to this issue, particularly evident in Designs Two and Three, a more radical and comprehensive approach needs to be considered in order to remedy current design issues.

Experimentation is used in science to tweak each experiment in the form of a kind of progression from the previous one, dependant on what the experiment is focused on (Lucas, 2016). Architecture is not much different, and may require tighter parameters for it to progress (Lucas, 2016).

It has become evident that part of the lack of functional progress is due to the aesthetic limitations of Experiments One and Two: Whilst focusing on capturing external factors which may encapsulate their subject matter, the element of logical function falls to a lower priority, when in fact it is just as important in this design, if not more so, than it's aesthetic qualities.

For the sake of remedying prior misconception of priorities – Experiment Three is implemented for the next (fourth) design stage. This experiment involves going back to the basics through the use of a grid, working with a pragmatic 2D foundation and gradually converting it into a more thoughtful 3D structure. Experiments One

and Two were primarily based within the emotional column in section 1.2 – Design Requirements. The findings in Experiment One and Two are therefore to be looked at once more and applied to the design either during or after Experiment Three.

6.5 BREAKING THE GRID – EXPERIMENT THREE
(FIG. 31 AND 32)

This experiment is added post early building stages, without negating the earlier experiments – One and Two. This means that prior experiments can be added as part of the Experiment Three development. E.g.: As deliberated in section 2 and expanded on in section 6.2 – Experiment Two, the flight paths (post planting phase) can work as part of the early stages in determining the form and circulation of the building. Whilst many buildings are arguably created based on a grid-like structure, this stage would involve starting with a practical basic shape and work to break through certain parts of its parameters through iterative sketches. This exercise may achieve a more organic flow to an otherwise rigid structure, without necessarily losing its pragmatic aspect.

Figure 31 – Experiment Three – Breaking the Grid (Lubomudrov, 2019)

Here, rather than making plants adapt to structures (as mentioned in sections 2.1 and 2.2) the idea is to allow certain parts of the structure to form around certain plants, or be indicative for circulation development.

GRID IN ELEVATION

Figure 32 – Experiment Three – Breaking the Grid (Lubomudrov, 2019)

6.5 DESIGN FOUR – FINAL DESIGN
(FIG. 33 AND 34)

Figure - 33 – Design Four/Final Design (Lubomudrov, 2019)

Strengths	Weaknesses
Appearance	
<ul style="list-style-type: none">- A play of symmetry in the front and some distortion in the back gives the building character, and addresses symbolism in a tactful way- Light timber language- Merges nicely with its surroundings including the industrial neighbourhood and the native bush backdrop- The building's work as one, encompassing some bee symbolism with bee wings as inspiration	<ul style="list-style-type: none">-
Structure	
<ul style="list-style-type: none">- Previous structural issues have been remedied with a stronger design in the wider branched out trellis v-columns.- Moment frames and columns are present for seismic stability of the floor level building- The floor is constructed as a diaphragm to cope with force in a seismic event- Underground structure is structurally treated as a car park would be, with v columns extending through the entire building and into the ground- Exterior underground walls will need of sealing to prevent water damage. Reinforced earth construction would be implemented for their construction as it can resist earthquake damage. Both rammed earth and adobe brick construction would be used to strengthen the underground level structure. These structural elements are non-combustible, strong, durable, and have a large thermal mass. (Tabb, 2019)- Large crossbeams are used to take extra load, due to the green-nature of the above surface, which includes extra load such as mud, water and small to medium sized plants	<ul style="list-style-type: none">- Further investigation is required for how a heavier native surface garden can work on top of an underground floor, and whether specific plants with shorter stemming roots need to be chosen for the surface, since roots can grow through and destroy concrete. To compensate for this, more steel may potentially need to be incorporated for the crossbeams and the roof structure of the underground floor- As per larger trees that would be planted in between the wings of the museum; there would need to be a technology put in place to stop the roots from breaking through the concrete slab and other structural elements of the underground floor. This would not involve stopping the roots from growing, but instead redirecting them.

Functional Elements	
<ul style="list-style-type: none">- Good spatial delegation with well compartmentalised exhibits and public spaces on each floor- Double glazing used for regulating temperature- Timber panels in façade work as large mechanical blinds used to regulate light and temperature- Circulation is made almost seamless through the up and down flow of ramps and elevators through the building as well as short cross bridges on the upper floors.- Earthquake prevention almost realised- Fair amount of natural lighting	<ul style="list-style-type: none">- Entrance and exit, plus reception need to be more evident when accessing the building- Amenities need to be accessible and well placed within the building circulation
Responsible Design Potential:	
<ul style="list-style-type: none">- Exterior green walls make parts of the façade and integral part of the natural bee environment implementation- Easy native plant integration- Does not take up an overwhelming amount of space saving on resources and limiting carbon footprint- Elevated for the sake of spatial delegation to aid the growth of plant life on site- V-columns are now elevated 500mm to allow for growing and managing native plant life on the ground below	<ul style="list-style-type: none">- No green rooftop element (although compensated with exterior green walls) may not be enough to serve ecological or bee preservation purposes due to limited spatial occupation and arrangement- Needs to include solar roof panels for energy production/lower energy consumption
Contextual Integration:	
<ul style="list-style-type: none">- Both buildings stand out within their industrial part of the neighbourhood (Raiha Street, Porirua), but do so in a subtle, yet intriguing manner, without overcompensating in size or style. At this stage, they appear a lot more elegant yet effortless. They likewise correspond well in style to one another as opposed to the earlier design in <i>stage two</i>	

Table 9 – Design Four/Final Design – Strengths and Weaknesses (Lubomudrov, 2019)

7. DESIGN AND MEANING

The final design has four compartments located between the first and underground floors.

Figure 34 - Final Design Program Compartmentalisation (Lubomudrov, 2019)

The circulation tells a story and takes the occupier on a journey where the building carries a particular meaning and subject matter within each of its four wings, as learned from the literature review. This is compartmentalized in such a way - to bring the occupier into the specific atmosphere of each message and purposefully contrast these atmospheres to emphasize the contrast of a world with the bees and one without them, paralleling empty spaces with occupied ones.

Although the museum's circulation serves to navigate the user through their journey, it is also of great importance that the user themselves can have control over certain aspects of this experience. This is why, through the use of hi-tech displays, the user can choose which parts of the exhibit to view and interact with and/or which order to do this in.

8. RESPONSIBLE DESIGN WITH SUSTAINABLE FUNCTIONS

Going back to the set scope of responsible design (discussed in Section 4.1), there are a multitude of elements to apply within building function in order to make it responsible and fair in complying with its own message – as respect and preservation of the natural environment.

SUMMARY OF ENERGY EFFICIENT APPLICATION

- 1. Natural light utilization for less power consumption
- 2. Natural ventilation for less power consumption
- 3. Building orientation, essential to the aspects above (1,2 and 3)
- 4. Recycled grey water management
- 5. High thermal mass for heat retention
- 6. Natural material use and source checking
- 7. Building elevation for less space occupation – dedicated to plant life
- 8. Solar panels as a primary source of power

The efficiency of the indoor climate is determined by sensible lighting, heating, cooling and ventilating systems (Shukuya, 2019). Whilst lighting is fairly regulated with balanced use of openings and covers in the building (including the underground level), the heating, cooling and natural ventilation is necessary to aid sustainable and efficient building function. The focus of the Bee Museum design is

for there to be a constant source of airflow through the building, maintaining a fresh and moisture-free indoor climate.

An important variable that needs to be kept in mind when pursuing most of the energy-saving objectives in the list – is the fluctuation in weather patterns in the Wellington region and how these fluctuations may influence these design elements. This is done through code-checking and case studies applicable to the Wellington climate.

When it specifically comes to HVC and lighting systems, the following table (10) as primarily structured and discussed by Shakuya - provides a comparison of passive and active system components along with the associated physical characteristics to be considered (Shukuya, 2019). The main considerations for this design are in the orange columns.

Objective	Passive Technology		Active Technology	
	Components	Physical Characteristics	Components	Physical Characteristics
Lighting	<ul style="list-style-type: none">• Windows• Shadings• Glass panes• Ceiling• Internal wall surfaces	<ul style="list-style-type: none">• Solar optical properties of window materials• Reflectivity of ceiling and internal wall surfaces	<ul style="list-style-type: none">• Lamps• Luminaires• Ceiling• Internal wall surfaces	<ul style="list-style-type: none">• Luminous efficacy• Optical properties of luminaires• Reflectivity of ceiling and internal wall surfaces
Heating	<ul style="list-style-type: none">• Windows• Walls• Floor• Ceiling	<ul style="list-style-type: none">• Solar optical properties of window materials• Conductivity• Radiative and convective transfer• Thermal mass• Air tightness• Permeability	<ul style="list-style-type: none">• Heat exchangers• Fans and pumps• Heat pumps• Boilers	<ul style="list-style-type: none">• Convective and radiative transfer• Conductivity• Radiation• Pressure• Friction• Efficiency
Cooling	<ul style="list-style-type: none">• Windows• Shadings• Walls• Floor• Ceiling	<ul style="list-style-type: none">• Solar optical properties of window materials• Conductivity• Radiative and convective transfer• Thermal mass• Permeability	<ul style="list-style-type: none">• Heat exchangers• Fans and pumps• Heat pumps	<ul style="list-style-type: none">• Convection• Radiation• Pressure• Friction• Efficiency
Ventilation	<ul style="list-style-type: none">• Windows• Doors• Vents	<ul style="list-style-type: none">• Wind• Buoyancy• Pressure• Water vapor• Friction	<ul style="list-style-type: none">• Fans• Ducts• Shutters	<ul style="list-style-type: none">• Pressure• Water vapor• Friction• Efficiency

Table 10 – Passive and Active Technology Responsible Design Assessment (Lubomudrov, 2019)

SOLAR PANELS AS A PRIMARY SOURCE OF POWER

Monocrystalline Silicon PV cells are the most efficient solar panels on the market. The silicon on this solar panel is made from one continuous crystal of silicon, with higher energy absorption and exertion (Coalit., 2009). Due to this complexity, it delivers much better conductive results as a photovoltaic cell (Powershop, 2019). Because in the larger panel weighs 200kg (Powershop, 2019), this would impact the weight of the roof, meaning that extra care is to be taken for structural stabilization.

DESIGN APPLICATION

Figure 35 - Final Design Plan (Lubomudrov, 2019)

NATURAL LIGHT UTILIZATION FOR LESS POWER CONSUMPTION

As a means to utilize natural light - the upper floor is primarily comprised of a light timber and glass façade.

The underground floor receives its primary natural source of light from the semi-outdoor garden area, located between the two buildings. This side of the building floor is almost entirely comprised of glass, allowing for natural light to travel inward. The side facing the garden gets a decent amount of light, whilst the interior closest to the East wall in the East wing and West wall in the west wing has a singular sky roof garden light source of light. This is beneficial to this particular interior, since the underground level is meant to have immersive qualities delving into darker spaces for the use of technological integration e.g. interactive monitors, as well as mimicking certain types of bee environments. Nonetheless, the use of natural light is not neglected on the undergoing floor, using it as an essential source to guide people into its darker lit spaces.

EAST LEFT WING - SECTION

Figure 36 - Final Design - East Wing East Section (Lubomudrov, 2019)

NATURAL VENTILATION FOR LESS POWER CONSUMPTION

Good air circulation is paramount to a large public space with constant movement. In this design, air circulation is achieved through natural openings in the building, especially due to its exposed openings throughout and in-between the garden areas. As part of responsible design considerations, the building envelope system has openings with shutters to condition the indoor environment within a range of comfort, functioning as a passive system. (Shukuya, 2019)

DESIGN APPLICATION

Figure 37- Final Design Air Circulation Plan (Lubomudrov, 2019)

The snags that are considered for these openings are – the possibility of insects flying indoors and possibly getting hurt or being accidentally killed by visitors. Although the building is designed to aid bees, if a bee gets trapped in the internal structure there would likely be negative ramifications. Therefore, a net-automatic-door is designed to open and close between the exits and entrances of the four wings of the building. A net is also applied to the window openings, allowing for air to circulate as usual from the outdoors, while keeping insects out. Whilst simpler door openings would be ideal, this is the best way to ensure that the bee subjects of the museum are less likely to get hurt or trapped within its structure.

BUILDING ORIENTATION

An interdependent variable to producing good air circulation, natural light and temperature control is the building's orientation. Overheating and glare has to be part of design consideration when weighing up the need for differing variables in aid of these sustainable design elements.

By facing the building North it is ensured to benefit from a lower solar aspect in the winter, while external motorised shutters are implemented in the façade on the upper level to control solar penetration through the building and keep it from overheating. (BRANZ, 2018) This is a very important aspect when considering that most of the building's upper level is comprised of glass and may be vulnerable to immense heat gain if not designed for. E.g. A good form of solar heat control can be (external shutters) and external solar shading in the form of tinted double-glazed window properties.

RECYCLED GREY WATER MANAGEMENT

This is a crucial element in managing the internal and external ground floor native plant garden irrigation. It would also be used as flushing water. However, it is unclear whether grey water for the Museum public toilets is in as much demand as plant water, seeing as how the overall green area coverage adds up to over 1900m² including the building's indoor and outdoor managed native plant areas (Allen, Christian-Smith, & Palaniappan, 2010). Such a system is commonly used for agricultural purposes, paralleling the Museums objective for growing foraging plants. It is moderately low cost and requires no additional site area (Allen, Christian-Smith, & Palaniappan, 2010). Filtration systems are thus installed, redirecting waste water through the filter and to the green areas of the building.

HIGH THERMAL MASS FOR HEAT RETENTION

For the underground floor there is a significant opportunity to utilize thermal mass through the usage of adobe bricks as part of several strong load-bearing walls. The upper level is compensated with some thermal mass in the form of a large concrete slab, and several concrete walls. Because parts of the concrete slab are directly exposed to sunlight through parts of the glass façade and skylights, it should be able to absorb and store heat, then slowly release it in the evening.

NATURAL MATERIAL USE AND SOURCE CHECKING

As a means of insuring quality for responsible design, certification for sustainable sourcing of materials is to be checked.

- E.g. For materials such as timber, certification is provided by FSC (Forest Stewardship Council) or PEFC (Programme for the Endorsement of Forest Certification) (Alcorn, 2010). Radiata pine is the most commonly used timber in New Zealand, however it is not durable unless chemically treated. Chemicals used in treatment include tri-butyl tin oxide (TBTO), tri-butyl, methyl bromide, and naphthenate the fumes of which may be harmful to the flora and fauna of the building site. Along with this, formaldehyde emissions may occur as a result of the glues used in the manufacturing (Alcorn, 2010). Although it is the most affordable and widely produced timber in New Zealand, such treatment methods exclude the use of Radiata pine for the Bee Museum and an alternative timber would need to be found for building production.

As shown in the design phase (Section 7.5), - the first level of the building would have a considerable (5 metre) elevation off the ground, to ensure a productive use of space for plant and bee life.

In addition, the general implementation of green areas within the building site ranges from 40m² to 1,100m² on each floor (including ground level).

9. FINAL DESIGN OUTCOME

PLAN - ROOF

The roof is comprised of a concrete slab. The roof - as shown in plan - includes solar panels and Invasive Regeneration technology (as discussed in section 4.3) appearing in the form of solar dishes, so as to absorb a vast amount of solar rays and illuminate the ground level covered area under the first level of the building. A small green area is implemented to host native bee 'hotels' and non-native bee hives, as well as provide extra foraging foods. The skylights in the middle of both wings serve to allow for more light to penetrate the gallery areas. A curved skylight at the side of each building meets in the middle to create a liquefied effect, engaging with the larger trees between the two wings. Elevator and stairs are able to travel to rooftop.

PLAN - LEVEL ONE

The first level of the building is primary space for exhibits and venues. This is why the circulation is fairly straight forward with movable walls allowing for spatial manipulation in accordance to type of occupation. Disabled access is through the elevators located at each wing for easier movement through the building. Screens for ramps are installed for public safety (which will show up clearer in the larger scale plans). The deck allows for visitors to go outdoors and enjoy the view, while relaxing at the café. A *Bee Possitive* shop is located on the opposite side of the west wing. It includes plants, seeds and bee hotel products (as opposed to honey products). The movement from floor to floor and one wing to another is easy with ramps, cross-bridges, stairs and elevators on either side of the building wings, allowing for easy circulation. The cross-bridges are there to give visitors access to move over the native garden located in between the two buildings from one wing to another, while looking down on the view below.

PLAN - GROUND LEVEL

The garden area is located on the ground floor, between level one and the underground level. It is an essential part to the native plants provided for bee foraging. Nesting spots are also created and encouraged amidst this environment. As mentioned in the Roof Plan - this area employs Regeneration technology allowing for solar rays to be collected at roof level and travel down to illuminate the ground level native garden during the day. The light provided by this technology is reliant on the sun and therefore fades out after sunset, adhering to daylight hours. Human interaction with the garden is allowed along the small garden pathways created for that. The ramps toward the middle of the overall building lead to the first and underground floors, providing a green resting area in between.

PLAN - UNDERGROUND LEVEL

organic spaces in the right. This is the level where bee devastation and a world without bees is explored and simulated in certain areas and spaces (as discussed in section 1.1 for architectural compartmentalization). This level also possesses small green areas by allowing for parts of light to travel in through skylights to the ground level (- please refer to interior render 1, page 88). These are fairly small and do not intersect with structural elements. The centrepiece to this level is the garden in between the two wings, which is accessible on this floor and allows for seamless movement through the garden from one side of the building to another.

ON SITE

Figure 39 - Final Design - Building on Site (Lubomudrov, 2019)

SCALE: 1:3000

East Elevation

Note: The ramps do not show their surrounding screens that are installed for public safety, because they have been removed to show context and circulation. The context is very important here, as it is the part of the design where the visitors can enjoy the garden view through the glass facade when moving from level to level through the ramp access. The ramps essentially serve as a short interior bushwalk between museum spaces and are a crucial part of the experience.

SCALE: 1:200

Figure 40 - Final Design East Elevation (Lubomudrov, 2019)

South Elevation

Figure 41 - Final Design South Elevation (Lubomudrov, 2019)

SCALE: 1:200

West Section

Note: The ramp screens have been removed in section once more for better visual access as they would block the interior in section.

SCALE: 1:200

Figure 42 - Final Design West Wing - West Section (Lubomudrov, 2019)

West Wing Render

Figure 43 - Final Design West Wing - Interior Render (Lubomudrov, 2019)

Figure 44 - Final Design - Exterior Render (Night) (Lubomudrov, 2019)

Figure 45 - Final Design - Exterior Render (Day) (Lubomudrov, 2019)

Figure 46- Final Design - Interior-Exterior Garden Render (Lubomudrov, 2019)

Figure 47 - Final Design - Interior Ramp to 2nd Floor Render (Day) (Lubomudrov, 2019)

Figure 48 - Final Design - Interior Underground Floor Exhibition Space Render (Lubomudrov, 2019)

Figure 48 - Final Design - Interior Ramp to 2nd Floor Render (Day) (Lubomudrov, 2019)

Figure 49 - Final Design - Interior First Floor Exhibition Space Render (Lubomudrov, 2019)

Figure 50 - Final Design - Exterior Building Render (Day) (Lubomudrov, 2019)

The building encapsulates its subject matter in a dignified, yet non-literal manner. The circulation gives the occupier a chance to interact with its exhibits, green areas and installations in accordance to their individual preference, whilst taking them on a journey through the space. The structure is fairly large, yet it has a light structural quality, with an integration of ephemeral elements. The responsible design features and systems are integrated in a way where they are not imposing on the lightness of the overall design, but rather add character and interest to the building.

CONCLUSION

As a way of answering - how an architectural design can provide an educational experience for its visitors, and motivate public involvement in the bee conservation initiative – this thesis has explored the technique of interweaving pragmatic and emotional design elements and methods.

It has done so, through a series of research pertaining to the workings of native and introduced bee life and its environment. Precedence for increasing awareness and showing the value of the bee subject has been discussed and used in achieving an ephemeral and pragmatic function within the museum, as shown in the design of non-literal contemplation spaces as well as a malleable space/ moving walls for the use of conventions, classes and other events.

A major part of the design has been achieved with a series of drawing experiments and iterations. During this part of the design phase a number of important findings were unveiled, adding to the final progress.

One of the most prominent findings pertaining to this design is the notion that form follows function when it comes to achieving a responsible design. If the design has to encompass a larger set of variables, its aesthetic form seems to carry less priority until those variables are (at the very least partially) sorted, or calculated to fit within a particular dynamic of certain aesthetic qualities.

As a result, the complex nature of responsible design (as experienced in this thesis) entails a more in depth consideration of design aesthetic from the very beginning and should not be added as an afterthought. It is there to serve the very purpose and subject which the design stands for: It serves the bee environment, and in turn, our own.

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APPENDIX

This data is collected from Donovan’s research on Fauna of New Zealand and Cerulean’s Plant Conservation Network (Donovan B. , 2007; Cerulean, 2019).

(Leioproctus) Pango - Associative Native food/host plants		
Foraging Plant Food – Scientific Name/ Category	Foraging Plant Food – Laymen Name	Plant Status
Fabaceae – <i>Carmichaelia stevensonii</i>	- Weeping Tree Broom, Cord Broom	Threatened - Nationally Endangered
Laxmanniaceae - <i>Cordyline australis</i>	Cabbage Tree, Ti Kouka, Palm Lilly	Not Threatened
Malvaceae - <i>Hoheria</i>	Narrow-leaved Houhere	Not Threatened
Myrtaceae - <i>Kunzea ericoides</i> - <i>Leptospermum scoparium</i> - <i>Lophomyrtus</i> - <i>Metrosideros</i>	Kanuka Manuka, kahikatoa Ramarama White Flowering Rata, Akatea	Threatened - Nationally Critical At Risk – Declining Threatened - Nationally Critical Threatened - Nationally Vulnerable
Plantaginaceae – <i>Hebe traversii</i>	Hebe	Not Threatened
Ranunculaceae - <i>Clematis parviflora</i>	Unknown	Not Threatened
<i>Rousseaceae</i> - <i>Carpodetus serratus</i>	Putaputaweta, Marbleleaf	Not Threatened

(Leioproctus) Huakiwi - Associative Native food/host plants		
Foraging Plant Food – Scientific Name/ Category	Foraging Plant Food – Laymen Name	Plant Status
Asteraceae	Isobels Lily, Morices Astelia, Morices Kakaha	Not Threatened
Fabaceae	Unknown	Exotic
Hemerocallidaceae	Daylily– Orange Day Lilly	Exotic
Laxmanniaceae	Unknown	
Loranthaceae	Yellow Mistletoe, Pirita, Piriraki	At Risk - Declining
Myrtaceae	Agonis, peppermint tree, peppermint myrtle, river	Exotic
Pennantiaceae	Three Kings Kaikomako	Threatened - Nationally Critical
Plantaginaceae	Unknown	At Risk - Naturally Uncommon
Polygonaceae	Creeping Pohuehue, Creeping Muehlenbeckia	Not Threatened
Rousseaceae - <i>Carpodetus serratus</i>	Putaputaweta, Marbleleaf	

(Leioproctus) Waipounamu - Associative Native food/host plants		
Foraging Plant Food – Scientific Name/ Category	Foraging Plant Food – Laymen Name	Plant Status
Asteraceae - <i>Olearia virgata</i> - <i>Ozothamnus leptophyllus</i>	Twiggy Tree Daisy Tauhinu	Not Threatened Not Threatened
<i>Hemerocallidaceae</i>	Daylily– Orange Day Lilly	Exotic
Xanthorrhoeaceae - <i>Phormium tenax</i>	Flax, Harakeke, Korari (Maori name for inflorescence).	Not Threatened
Myrtaceae - <i>Kunzea ericoides</i> - <i>Leptospermum scoparium</i>	Kanuka Manuka, kahikatoa	Threatened - Nationally Vulnerable
Plantaginaceae - <i>Hebe brachysiphon</i> - <i>Hebe odora</i> - <i>Hebe salicifolia</i> - <i>Hebe stricta</i> - <i>Hebe subalpina</i> - <i>Hebe traversii</i>	Hebe Hebe Hebe Koromiko Hebe Hebe	Not Threatened Not Threatened Not Threatened At Risk - Naturally Uncommon Not Threatened Not Threatened
Phrymaceae - <i>Mimulus repens</i>	Native Musk, Maori Musk, Native Monkey Flower	At Risk - Naturally Uncommon

(Leioproctus) Imitates (Smith) - Associative Native food/host plants		
Foraging Plant Food – Scientific Name/Category	Foraging Plant Food – Laymen Name	Plant Status
Epacridaceae - <i>Dracophyllum filifolium</i>	Unknown	Not Threatened
Hemerocallidaceae - <i>Phormium tenax</i>	Flax, Harakeke, Korari (maori name for inflorescence)	Not Threatened
Myrtaceae - <i>Kunzea ericoides</i> - <i>Leptospermum scoparium</i> - <i>Kunzea/Leptospermum</i> - <i>Lophomyrtus</i> - <i>Metrosideros excels</i>	Kanuka Manuka, kahikatoa Ramarama White Flowering Rata, Akatea Pohutukawa	Threatened - Nationally Critical At Risk – Declining Threatened - Nationally Critical Threatened - Nationally Vulnerable Threatened - Nationally Vulnerable
Plantaginaceae - <i>Hebe sp.</i>	Hebe	Not Threatened
Polygonaceae - <i>Muehlenbeckia australis</i> - <i>Muehlenbeckia complexa</i>	Pohuehue, Large-leaved Muehlenbeckia Small-leaved Pohuehue, Scrub Pohuehue, Wire Vine	Not Threatened Not Threatened

(Leioproctus) Kanapuu - Associative Native food/host plants		
Foraging Plant Food – Scientific Name/Cate-gory	Foraging Plant Food – Laymen Name	Plant Status
Myrtaceae - Kunzea eri-coides - Leptospermum scoparium - Kunzea/Leptospermum -Metrosideros excelsa	Kanuka Manuka, kahika-toa Ramarama Pohutukawa	Threatened - Nationally Critical At Risk – Declining Threatened - Nationally Critical Threatened - Nationally Vulnerable Threatened - Nationally Vulnerable
Introduced Pants		
Actinidiaceae - Actinidia deliciosa	Kiwifruit (exotic)	Exotic
Apiaceae - Daucus carota	Wild Carrot	Exotic
Boraginaceae - Echium vulgare	Viper’s bugloss	Exotic
Fagaceae - Castanea sativa	Sweet Chetsnut	Exotic

Note: The Kanapuu bee is an exception to the chosen bees for the site, seeing as how it has a fairly limited native plant diet. It is important to observe such bees (to understand whether they may need exotic plants as part of their diet or if native plants are enough) for the sake of research and better preservation techniques.

(Hylaeus) (Prosopisteron) Agilis (Smith) - Associative Native food/host plants		
Foraging Plant Food – Scientific Name/Category	Foraging Plant Food – Laymen Name	Plant Status
Araliaceae - Pseudopanax sp.	Fivefinger, Whau-whaupaku	Not Threat-ened
Asteraceae - Brachyglottis sp. - Olearia angustifolia	None Known Teteaweka	Not Threat-ened At Risk - Naturally Uncommon
Fabaceae - Carmichaelia	Pink Broom	Nationally threatened
Hemerocallidaceae - Phormium tenax	Flax, Harakeke, Korari (maori name for inflo-rescence)	Not Threat-ened
Loranthaceae - Peraxilla colensoi - Peraxilla tetra-petala	Scarlet mistletoe, Korukoru, Pirita, Roeroe Red mistletoe, Pikirangi, Pirita, Roeroe, Pirinoa	At Risk – Declining At Risk - De-clining
Myrtaceae - Leptospermum scoparium - Leptospermum scopariu - Metrosideros excelsa	Kanuka Manuka, kahika-toa Ramarama Pohutukawa	Threatened - Nationally Critical At Risk – Declining Threatened - Nationally Critical Threatened - Nationally Vulnerable Threatened - Nationally Vulnerable

(Leioproctus) Waipounamu - Associative Native food/host plants		
Foraging Plant Food – Scientific Name/Category	Foraging Plant Food – Lay-men Name	Plant Status
Asteraceae - Olearia virgata - Ozothamnus leptophyllus	Twiggy Tree Daisy Tauhinu	Not Threat-ened Not Threat-ened
Hemerocallidaceae	Daylily– Or-ange Day Lilly	Exotic
Xanthorrhoeaceae - Phormium tenax	Flax, Harakeke, Korari (Maori name for inflo-rescence).	Not Threat-ened
Myrtaceae - Kunzea ericoides - Leptospermum scoparium	Kanuka Manuka, kahikatoa	Threatened - Nationally Vulnerable
Plantaginaceae - Hebe brachysiphon - Hebe odora - Hebe salicifolia - Hebe stricta - Hebe subalpina - Hebe traversii	Hebe Hebe Hebe Koromico Hebe Hebe	Not Threat-ened Not Threat-ened Not Threat-ened Not Threat-ened At Risk - Naturally Uncommon Not Threat-ened Not Threat-ened
Phrymaceae - Mimulus repens	Native Musk, Maori Musk, Native Monkey Flower	At Risk - Naturally Uncommon

(Leioproctus) Imitates (Smith) - Associative Native food/host plants		
Foraging Plant Food – Scien-tific Name/Category	Foraging Plant Food – Laymen Name	Plant Status
Epacridaceae - Dracophyllum filifolium	Unknown	Not Threatened
Hemerocallida-ceae - Phormium tenax	Flax, Harakeke, Korari (maori name for inflo-rescence)	Not Threatened
Myrtaceae - Kunzea eri-coides - Leptospermum scopar-ium - Kunzea/Leptospermum - Lophomyrtus -Metrosideros excels	Kanuka Manuka, kahika-toa Ramarama White Flowering Rata, Akatea Pohutukawa	Threatened - Na-tionally Critical At Risk – De-clining Threatened - Na-tionally Critical Threatened - Nationally Vulnerable Threatened - Nationally Vulnerable
Plantaginaceae - Hebe sp.	Hebe	Not Threatened
Polygonaceae - Muehlenbeck-ia australis - Muehlenbeckia complexa	Pohuehue, Large-leaved Muehlenbeckia Small-leaved Pohuehue, Scrub Pohuehue, Wire Vine	Not Threatened Not Threatened

(Leioproctus) Kanapuu - Associative Native food/host plants		
Foraging Plant Food – Scientific Name/Category	Foraging Plant Food – Laymen Name	Plant Status
Myrtaceae - Kunzea eri-coides - Leptospermum scoparium - Kunzea/Leptospermum -Metrosideros excelsa	 Kanuka Manuka, kahikatoa Ramarama Pohutukawa	 Threatened - Nationally Critical At Risk – Declining Threatened - Nationally Critical Threatened - Nationally Vulnerable Threatened - Nationally Vulnerable
Introduced Pants		
Actinidiaceae - Actinidia deliciosa	 Kiwifruit (exotic)	 Exotic
Apiaceae - Daucus carota	 Wild Carrot	 Exotic
Boraginaceae - Echium vulgare	 Viper’s bugloss	 Exotic
Fagaceae - Castanea sativa	 Sweet Chetsnut	 Exotic

Note: The Kanapuu bee is an exception to the chosen bees for the site, seeing as how it has a fairly limited native plant diet. It is important to observe such bees (to understand whether they may need exotic plants as part of their diet or if native plants are enough) for the sake of research and better preservation techniques.

(Hylaeus) (Prosopisteron) Agilis (Smith) - Associative Native food/host plants		
Foraging Plant Food – Scientific Name/Category	Foraging Plant Food – Laymen Name	Plant Status
Araliaceae - Pseudopanax sp.	 Fivefinger, Whau-whaupaku	 Not Threatened
Asteraceae - Brachyglottis sp. - Olearia angustifolia	 None Known Teteaweka	 Not Threatened At Risk - Naturally Uncommon
Fabaceae - Carmichaelia	 Pink Broom	 Nationally threatened
Hemerocallidaceae - Phormium tenax	 Flax, Harakeke, Korari (maori name for inflorescence)	 Not Threatened
Loranthaceae - Peraxilla colensoi - Peraxilla tetrapetala	 Scarlet mistletoe, Korukoru, Pirita, Roeroe Red mistletoe, Pikirangi, Pirita, Roeroe, Pirinoa	 At Risk – Declining At Risk - Declining

Myrtaceae - Leptospermum scoparium - Leptospermum scopariu - Metrosideros excelsa	 Kanuka Manuka, kahikatoa Ramarama Pohutukawa	 Threatened - Nationally Critical At Risk – Declining Threatened - Nationally Critical Threatened - Nationally Vulnerable Threatened - Nationally Vulnerable
Pennantiaceae - Pennantia corymbosa	 Kaikomako	 Not Threatened
Plantaginaceae - Hebe salicifolia - Hebe sp.	 Hebe Hebe	 Not Threatened Not Threatened

(Hylaeus) Matamoko- Associative Native food/host plants		
Foraging Plant Food – Scientific Name/Category	Foraging Plant Food – Laymen Name	Plant Status
Boraginaceae Myosotis sp.	 Unknown Kopakopa, Chatham Island Forget-me-not, Kopukapuka	 At Risk - Naturally Uncommon Threatened - Nationally Vulnerable
Onagraceae Epilobium sp.	 Creeping willowherb	 Not Threatened
Plantaginaceae Hebe sp.	 Hebe	 Not Threatened

(Hylaeus) Perhumilis (Cockerell)- Associative Native food/host plants		
Foraging Plant Food – Scientific Name/Category	Foraging Plant Food – Laymen Name	Plant Status
Boraginaceae Myosotis sp.	 Unknown Kopakopa, Chatham Island Forget-me-not, Kopukapuka	 At Risk - Naturally Uncommon Threatened - Nationally Vulnerable
Onagraceae Epilobium sp.	 Creeping willowherb	 Not Threatened
Plantaginaceae Hebe sp.	 Hebe	 Not Threatened

Genus Hyleoides Smith- Associative Native food/host plant		
Foraging Plant Food – Scientific Name/Category	Foraging Plant Food – Laymen Name	Plant Status
Apocynaceae - Nerium ole- ander	Oleander	Exotic
Asteraceae - Tanacetum parthenium	Feverfew	Exotic
Bignoniaceae - Campsis sp. - Tecoma sp.	Campsis Yellow bells, Yellow elder	Exotic Exotic
Laxmanniaceae - Cordylina australis	Cabbage Tree, Ti Kouka, Palm Lilly	Not Threatened
Myrtaceae - Kunzea ericoides - Leptosper- mum scoparium - Kunzea Lep- tospermum - Lophomyrtus obcordata - Metrosideros excels - Rata	Kanuka Manuka, Kahikatoa Kānuka, White Tea-Tree or Burgan Rohutu Pohutukawa Rata	Nationally Threatened At National Risk Threatened - Nationally Vulnerable Threatened-Na- tionally Critical Threatened – Nationally Vulnerable At Risk - Naturally Uncommon

Plantaginaceae - Hebe traversii	Hebe	Not Threatened
Polygonaceae - Muehlenbeckia complexa	Small-leaved Pohuehue, Scrub Pohue- hue, Wire Vine	Not threatened
Thymelaeaceae - Pimelea tra- versii	Boreus	Threatened Nationally Vul- nerable

(Lasioglossum) Austrevylaeus Mataroa		
Foraging Plant Food – Scien- tific Name/ Category	Foraging Plant Food – Laymen Name	Plant Status
Asphodelaceae - Bulbinella sp.	Gibs	Not Threatened
Asteraceae - Raoulia australis - Raoulia parkii - Raoulia sp. - Taraxacum magellanicum	Mat Daisy Celadon mat daisy None Known New Zealand dandelion, native dandelion	Not Threatened Not Threatened Not Threatened Not Threatened
Campanulaceae - Wahlenbergia sp.	Wahlenbergia sp	Not Threatened
Laxmanniaceae - Cordylina australis	Cabbage Tree, Ti Kouka, Palm Lilly	Not Threatened
Myrtaceae - Kunzea eri- coides	Kanuka	Nationally threatened
Polygonaceae - Chionohebe pulvinaris	Veronica	Not threatened
Rhamnaceae - Discaria tou- matou	Matagouri	At Risk - De- clining

(Lasioglossum) Austrevylaeus Maunga		
Foraging Plant Food – Scien- tific Name/ Category	Foraging Plant Food – Laymen Name	Plant Status
Myrtaceae - Kunzea ericoides - Metrosideros sp.	Kanuka White flowering Rata, Akatea	Nationally threatened Threatened, Nationally Vul- nerable
Asteraceae - Brachyglottis bellidi- oides - Brachyscome sinclairii - Celmisia discolor - Celmisia gracilentia - Celmisia spectabilis - Celmisia verbascifolia - Helichrysum bellidi- oides - Leucogenes grandiceps - Olearia avicenniifolia - Olearia virgata	None Known Lees Valley Daisy None Known Common Mountain Daisy, Pekapeka Cotton Daisy None Known Hells Bells South Island Edel- weiss Mountain Akeake Twiggy tree daisy	Not Threatened Threatened, Nationally Vul- nerable Not Not Threatened Not Threatened At Risk - Natural- ly Uncommon Not Threatened Not Threatened Not Threatened Not Threatened Not Threatened
Campanulaceae - Wahlenbergia sp.	Wahlenbergia sp	Not Threatened
Ericaceae - Dracophyllum sp. - Gaultheria crassa	None Known None Known	Not Threatened Not Threatened

Gentianaceae		
- Gentiana bellidifolia	Gentian	Not Threatened
- Gentiana corymbifera	Grassland Gen- tian, Tall Gentian	Not Threatened
- Gentiana townsonii	Unknown	Not Threatened
Malvaceae		
- Hoheria populnea	Lacebark, Houhere, Ribbon- wood	Not Threatened
Myrtaceae		
- Kunzea ericoides	Kanuka	Nationally threatened
Plantaginaceae		
- Hebe sp.	Hebe	Not threatened
- Ourisia caespitosa	Creeping Moun- tain Fox Glove	Not threatened
- Ourisia macrocarpa	Snowy Mountain Foxglove, Moun- tain Ourisia	Not threatened
Ranunculaceae		
- Ranunculus lyallii	Giant, Great Mountain or Mt Cook Buttercup	Not Threatened
Rhamnaceae		
- Discaria toumatou	Matagouri	At Risk - De- clining
Thymelaeaceae		
- Pimelea prostrata	Pinatoro, New Zealand daphne, Strathmore weed	Not Threatened
- Pimelea traversii	Travers Pimelea	Not Threatened