Growing for the Future: UBC Botanical Garden Redevelopment

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Growing for the Future

UBC Botanical Garden Redevelopment

For UBC CIVL 445

ubcbotanicalgarden
& centre for plant research

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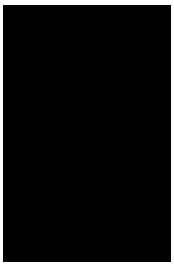

Executive Summary

Group Twelve Consulting was tasked with creating a conceptual redevelopment plan for the UBC Botanical Garden. Design concepts were developed with the objective of improving the visibility and presence of UBC Botanical Garden on UBC campus and within the surrounding communities; improving accessibility to the Garden; increasing the academic, research and recreational potential of the Garden and enhancing the overall visitor experience through carefully considered and evaluated developments.

The conceptual redevelopment design proposed by Group Twelve Consulting Ltd. consists of multiple stand-alone elements. The primary element is a new two floor administrative building to be constructed in the location of the current administrative building and gift shop. This proposed building will provide the botanical garden with an attractive multi-functioning space and café, making it a desirable destination on campus and thus attract a broader demographic of visitors. This design incorporates a covered bicycle parking and storage area to improve accessibility of the garden. The secondary element is a timber tree house building that will be located adjacent to the existing food garden. This building is intended to provide a unique aesthetic to draw visitors into the garden, and to provide additional indoor space to accommodate future events in the planned cooking demonstration area. Tertiary elements consist of a pedestrian overpass across SW Marine Drive at the main entrance, and an expansion of the existing parking lot. The pedestrian overpass will improve the safety of the street crossing, loop visitor flow, and serve as advertisement space for the garden. The parking lot expansion will increase the overall parking capacity to accommodate special events and future increases in garden visitors.

Due to funding constraints, a staged project implementation plan is proposed. It is recommended that redevelopment begin with the tree house, followed by either the parking lot expansion or pedestrian overpass. The new administration building should be implemented last.

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Introduction

Established in 1916, the University of British Columbia Botanical Gardens (UBCBG) have undergone many incarnations, moving to its current location on the south side of the UBC Point Grey Campus in the 1940s. Currently the research collection consists of over 8000 species of plants from temperate regions around the world. The Botanical Garden is divided into a number of smaller garden areas including the Alpine Garden displaying plants native to the high-altitude regions of the world, Asian Garden, Carolinian Forest showcasing the woodland flora of eastern North America, Food Garden, the Native Garden showcasing the plants of British Columbia and the Physic Garden. (Lewis, 2013)

A part of the Department of Land and Food systems, the UBC Botanical garden is the oldest continuously operating botanical garden on a university campus in Canada and has the only internationally significant research collection in Canada. Incorporating the Centre for Plant Research, the mandate of the Garden is to provide a world class research facility, facilitate post-secondary and vocational learning in the areas of horticulture and botany and provide a restful space for the wider public to experience and learn about diverse international and local flora. (Lewis, 2013)(Justice, 2013)

Problem Definition

The UBC Botanical Garden is a hidden gem of tranquility on the UBC Point Grey Campus, in addition to being a valuable academic resource. However the gardens are facing a number of challenges. Chief among them:

- The UBCBG is largely unknown and underutilized by the public, with a somewhat narrow demographic appeal. The predominant visitors to the garden are retirees.
- Access to the site is challenging, with limited transit access, bicycle storage and pedestrian access. On-site parking capacity for patrons is insufficient for special events and a limiting factor in increased visitor capacity.

- Major infrastructure at the garden, such as the admissions building, gift shop and the tunnel joining the north and south gardens, is outdated and does not provide optimal functionality to users and staff of the garden facilities.
- There is an unsustainable use of potable water at the garden, particularly in the areas of irrigation and aesthetic water features.
- Funding for new projects is restricted due to the botanical garden's limited operating budget.
- Redevelopment must not compromise the research collection or negatively impact visitor experience.

(Lewis, P., 2013) (Justice, D., 2013)

Design Objectives

With these specific challenges in mind, the design team assembled at Group Twelve Consulting Ltd. endeavored to improve the visibility and presence of UBC Botanical Garden on UBC campus and within the surrounding communities, improve accessibility to the Garden, increase the academic, research and recreational potential of the Garden and enhance the overall visitor experience through carefully considered and evaluated developments; the conceptual design for which are presented here.

Technical Approach

A wide range of preliminary design concepts were developed by the design team based on constraint and objective information provided by administrators of the UBC Botanical Garden, primarily Patrick Lewis, the garden's Director; and Douglas Justice, the associate director and curator of collections; through presentations, correspondence and a tour of the garden facilities.

Design concepts were evaluated by team members based on how well they met the design objectives specified previously, and ultimately, how they integrated to form a single, comprehensive, development plan.

Design Description

Administrative Building

The ultimate goal of the administrative building is to provide the botanical garden with an attractive multi-functioning space and bring a larger population to the garden, especially during the winter months. The building will include features that will not only benefit garden visitors but will attract a broader range of UBC students by making the Botanical Garden a desirable destination on campus.

The building is approximately 13250 ft^2 and is located in the current location of the garden's gift shop and admissions booth (Refer to site map in Appendix A). It consists of two floors, featuring a large central atrium and a covered outdoor patio. The first floor is 9900 ft^2 comprising a coffee shop, a gift store, admissions and visitor information desk, restrooms, an interpretive area and the central atrium. The open floor design of the main floor facilitates flow from one area to the next, while providing sufficient barriers to excessive sound. The interpretive area will be used to provide information about the garden's varied history and showcase its continuing research and role in cultivating and preserving international plant specimens. In this way visitors to the garden can develop an understanding of the garden as not just a beautiful natural space, but the important academic role it has within the University. The central atrium will provide a versatile space for the gardens, on a typical day providing an inspiring space to relax or study, as well as being a visually striking space to use for corporate or academic events.

The second floor is 3350 ft^2 and consists of a balcony overlooking the first floor atrium, administration offices and an additional multi-use area. This multi-use area can be developed in the future as an integrated research/teaching space, or continue to be used as a flexible space for studies, teaching and third party rentals. The conceptual floor plan of the proposed administration building is presented in Figure 1.

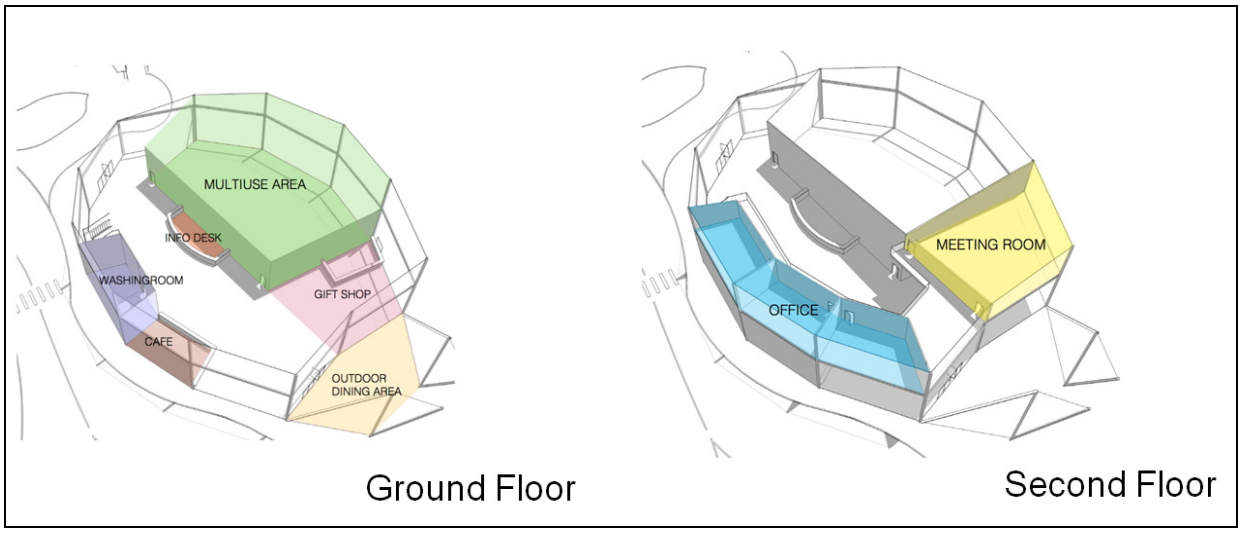

Figure 1 – Conceptual Administration Building Floor Plan

The exterior of the building, with its growing wall and green roof is beautiful, unique and representative of the UBCBG's and UBC's commitments to sustainability in learning, in botany and in daily living. A conceptual rendering of the administration building exterior is presented in Figure 2.

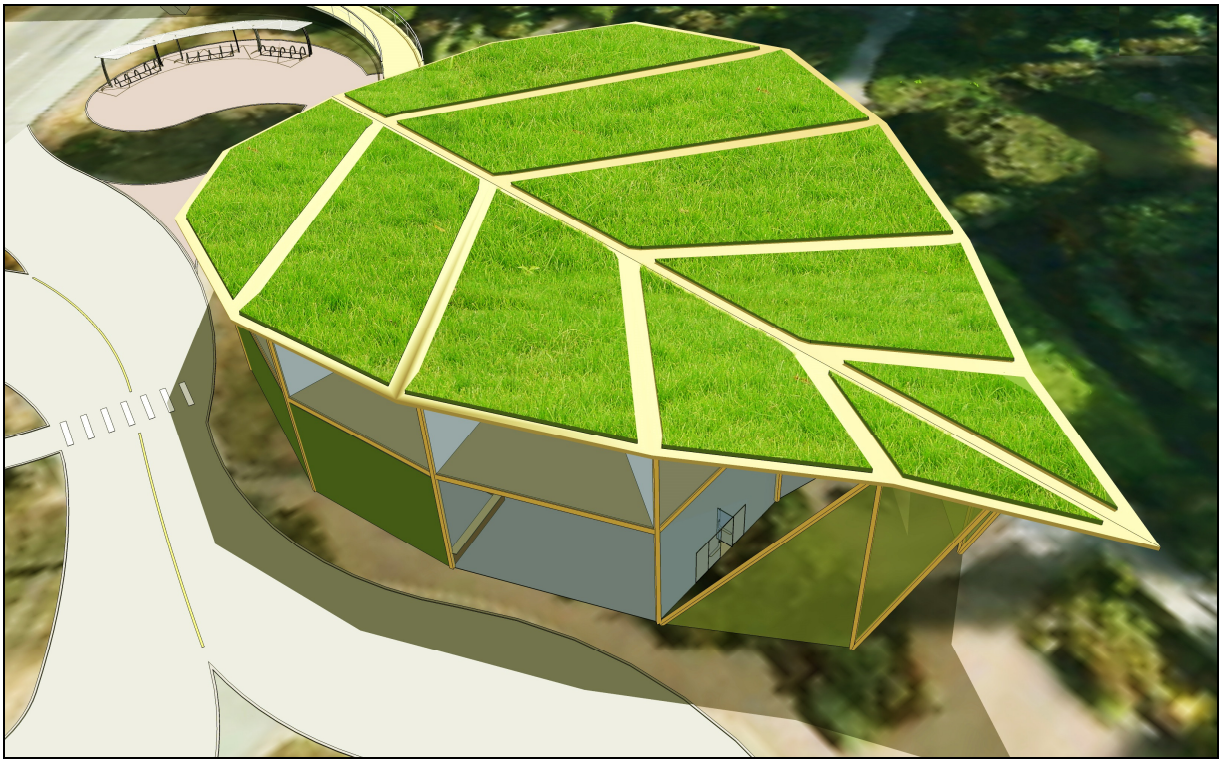

Figure 2 - Conceptual Administration Building Exterior

Specifications

The administrative building's design consists of a post and beam timber frame structure with predominantly glazed exterior walls and a green roof in the shape of a leaf. The roof cantilevers out over the outdoor patio and is supported by two vertical columns and braced by four diagonal members. The building contains three interior columns and eleven outer columns that resist the dead and live vertical loads within the building. The columns are made of large rectangular glulam members, which provide sufficient compression strength while maintaining an attractive aesthetic. These loads will be distributed to the columns by glulam beams throughout the building. Concrete shear walls with heavy reinforcement are located behind the reception desk and encasing the restrooms to resist lateral and earthquake loading. The estimated cost for this administration building design is $2,487,500.

Sustainable Design

The administrative building will have a unique and innovative aesthetic among the academic buildings on UBC's Point Grey campus and be a leader of building sustainability at the University of British Columbia. The new administrative building will achieve a minimum Gold performance rating under the United States Green Building Council LEED requirements as adopted in Canada or equivalent performance. It will meet requirements in each LEED category including site development, water efficiency, energy efficiency, material selection, indoor environmental quality, innovative design, and regional priority. This is in accordance with the Province of British Columbia's 2006 provision that all new institutional buildings and renovations exceeding 600 m^2 shall achieve the minimum requirements of LEED Gold, as well as UBC's commitments to sustainable development. Further, it is recommended that a building life cycle assessment (LCA) be performed, encompassing the construction and operation phases of the building, for full building credits under LEED. This will integrate with UBC SEEDS projects in the area of life cycle assessment and the development of LCA databases on UBC's academic buildings (Sianchuk, R., Personal communication). This would also further UBC's goals of developing the Point Grey campus and its facilities as a living laboratory for sustainability.

Where possible the construction of the building will utilize recyclable and environmentally conscious materials contributing to the goal to being a completely green building. Using wood as the major construction material has many environmental advantages as well as its obvious advantages of aesthetics. Compared to other building materials timber construction has less waste and a lower production of carbon dioxide, while at the same time absorbing carbon dioxide from the atmosphere. Timber also generally has a faster construction time than concrete or steel due to the prefabrication of members, allowing for an economical and sustainable construction period.

The administration building's green roof will consist of mainly native grass plantings with the capacity to nourish flowers or vegetables. The green roof allows water to be absorbed by plants rather than contributing to storm water runoff. A filter fabric layer beneath the vegetation surface will allow for drainage of excess water that is not absorbed. The roof is sloped toward the middle of the building, which will facilitate the collection of excess water. The runoff will be stored on site, and allowed for use in toilets. The administrative building will also have a green wall on the north side of the building. The green wall will consist of vines and other plants providing appealing aesthetics to the exterior of the building. Further, the inclusion of additional living plants into the exterior of the building contributes to the carbon sequestered by the building and has the long term effect of reducing carbon dioxide in the atmosphere, in adherence with UBC's Climate Action Plan and their commitments to reducing green-house gas emissions.

Electrical lighting in the building will be minimal due to the extensive amount of natural light provided by the extensive fenestration and the north-south orientation of the building. The building's large atrium will benefit from the large glass exterior walls and will efficiently light the majority of the building. Lighting fixtures will be placed where necessary and use energy efficient LED light bulbs. Having motion censored lighting and adjustable brightness level will allow for a reduction in energy usage. This will allow the administrative building to use minimal energy and save expenses for UBC.

The administrative building's design focuses mainly on visual appeal and sustainability in construction and operation. This design allows the building to be

an eye-catching and in-demand location on UBC campus for studying, integrated horticultural learning and hosting special events. The multi-use space will allow the botanical gardens to host more events in an effort to draw more visitors and allow the space to be rented out to third parties.

Covered Bicycle Parking and Secure Storage

Currently the majority of visitors to the garden arrive in private vehicles, but as the UBC Botanical Garden develops into more of a scenic and sustainable anchor attraction at UBC, there will likely be an increased demand to commute to the garden by cycling. There is a large cycling population on the university campus as well as in the adjacent neighbourhood of Kitsilano. Currently there are a few bicycle storage racks in front of the gift shop and admissions buildings and no covered or long term bike storage. Additionally, bicycles are not permitted inside the garden. This is restrictive to the visitors to the garden who would wish to cycle there. By increasing the bicycle storage capacity, the design team hopes to encourage a wider demographic of recreational visitors to the Botanical Garden. The Garden may even choose to create bicycle paths through the facility to add further recreational value. The proposed plan is to add covered bicycle parking as well as secure storage in part of the administration building. A general layout of the proposed covered bicycle storage area is presented in Figure 3.

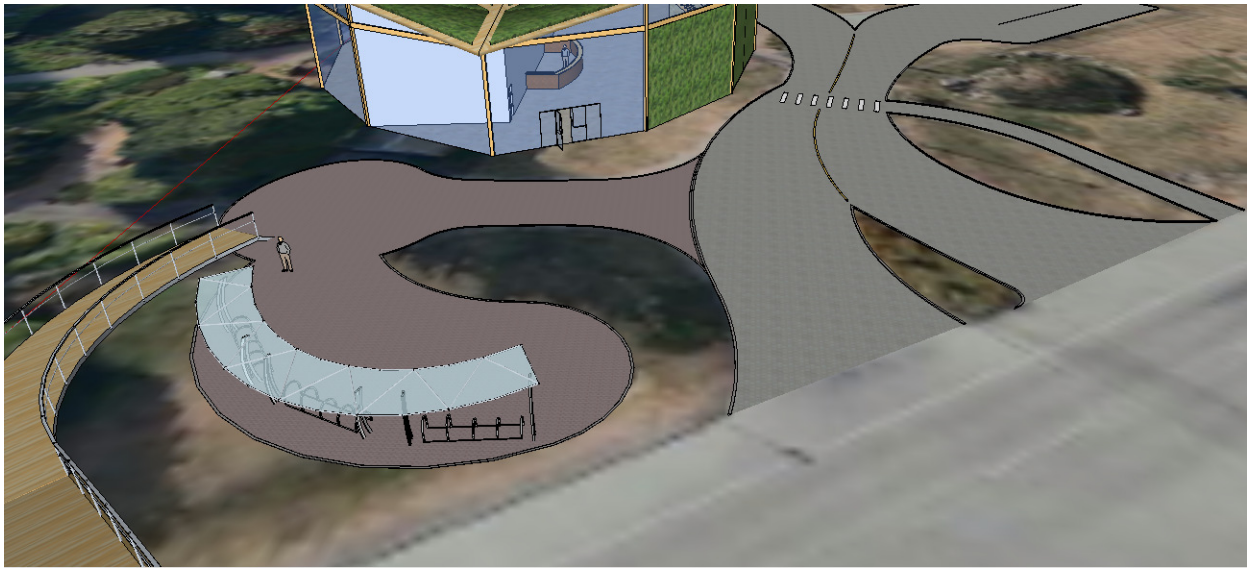

Figure 3: General view of the proposed covered bicycled parking

Encouraging active transportation aligns with UBC's Sustainability Plan and the inclusion of both covered and secure bicycle storage in the new administration building design is in concurrence with UBC's policies for infrastructure development.

Specifications

The current bicycle storage capacity is short-term parking for 12 bicycles in the form of bicycle racks. The covered bicycle parking which would replace it would be composed of racks oriented in a curved line as seen below in Figure 4. It would be installed along the side of the paved courtyard in front of the new administration building and beside entrance of the proposed pedestrian overpass. The new racks are able to accommodate a parking capacity of 30 bicycles. The rack loops are modelled as per the design standards for the Inverted U Shape type specified by UBC Infrastructure Planning (Urban Racks Bicycle Parking Systems, 2013).

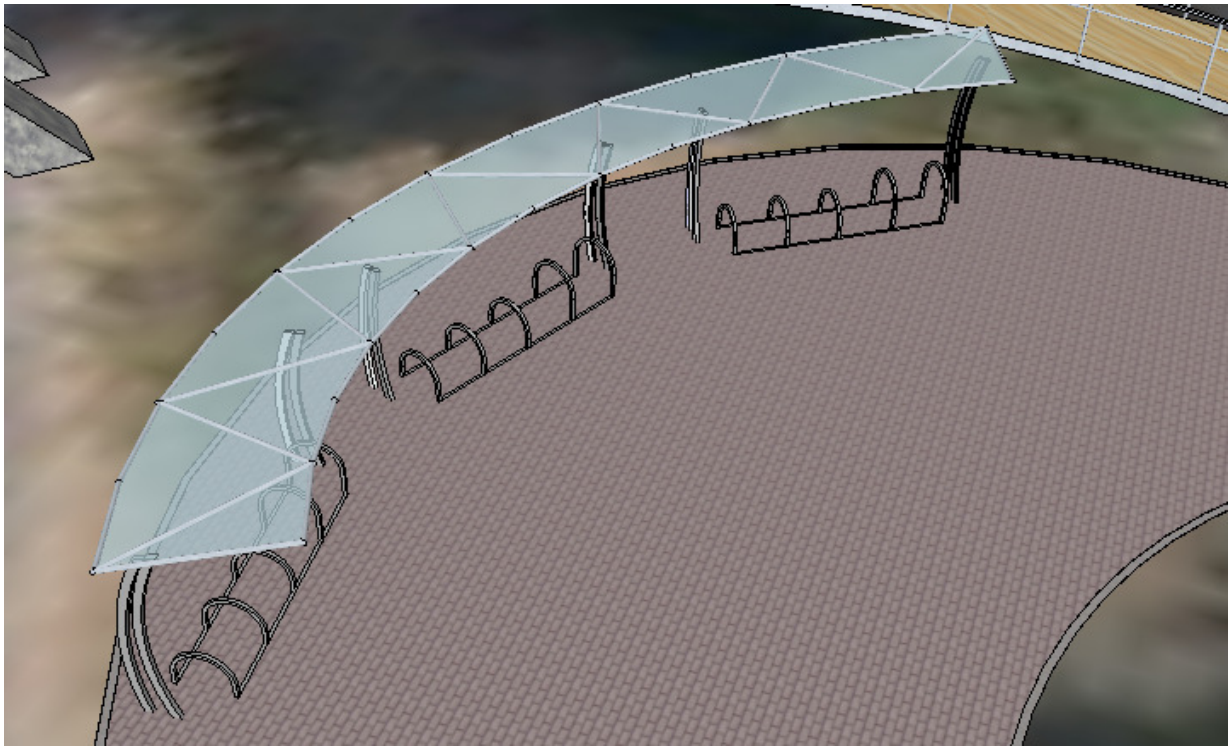

Figure 4: Proposed Short-Term Bicycle Parking Expansion

The secure long-term bicycle parking will take up an area in the room just behind the information desk in the lobby of the administration building. Patrons wishing to use to the secure parking would bring their bicycle to the staff at the information desk who would then give them a numbered key or item. The staff then takes the bicycle into the secure room where there will be several aisles of vertical braces. The bicycles can be attached upwards with the front wheel clipped to the top and the back wheel on the ground. This technique of storing bicycles is space efficient and can also be less physically demanding for staff, depending on the bracing system used, as some are partially automated or employ levers for aid. The owner of the bicycle would then retrieve their bicycle with their number in a manner similar to a coat check. The daily capacity in the secure storage area may vary, from 20 bicycles and higher depending on how many braces are purchased and if adequate space given. The space dedicated to long-term bicycle storage can be flexible depending on how much of the multi-use space can be spared. More area will not necessarily be required during special events and can actually be reduced as the Garden already employs a Bicycle Valet organization to provide those services.

Tree House

The proposed tree house is a 900ft^2 timber building that is elevated above the ground surface and built around three fully grown, living trees. The elevated floor of the building will be accessed through a stairway, with ramp access provided in the rear of the building for mobility impaired visitors. The tree house is to be located in the Alpine Garden, on the south-east side of the north portion of the garden adjacent to the fence bordering 16th Avenue (Refer to site map in Appendix A). This particular location was chosen by the design team for a number of reasons. A stand of native trees provides an optimal space for integration of the tree house into the existing landscape. Since the building will be visible from 16th Avenue, the design team believes that its unique aesthetic will draw visitors into the garden. Finally, this location provides proximity to the planned cooking demonstration area at the food garden, and will provide an additional space for preparation and storage, as well as an indoor demonstration space for use during inclement weather. Should garden administrators choose to include washroom facilities in the tree house, this will complement the existing facilities in the tea

house. If the inclusion of extensive plumbing in the tree house is undesirable, any activities taking place there are within reasonable proximity to the tea house for access to the existing facilities there. A conceptual design of the tree house is presented in Figure 5.

Figure 5 - Conceptual Design of Tree House

It is expected that the innovative design of the tree house will be an attraction to the garden, such that it would serve to draw visitors to the far north end of the garden. Additionally, the elevated nature of the building in tandem with its location will allow the development to be constructed and used with minimal impacts to the research collections housed at the facility.

The tree house will provide a unique and innovative space for interactive and interpretive displays showcasing the UBC Botanical Gardens, particularly the Alpine Garden where the tree house is located; scholastic and summer day camp activities, additional flexible classroom space for vocational programs provided by the garden and a lounge for garden visitors. It is the design team's intent that

the tree house will provide a unique, vibrant and sustainable space to bring together UBC and Botanical Garden faculty and staff, students, visitors and community residents to engage in plant conservation. The interior layout of the tree house is presented in Figure 6.

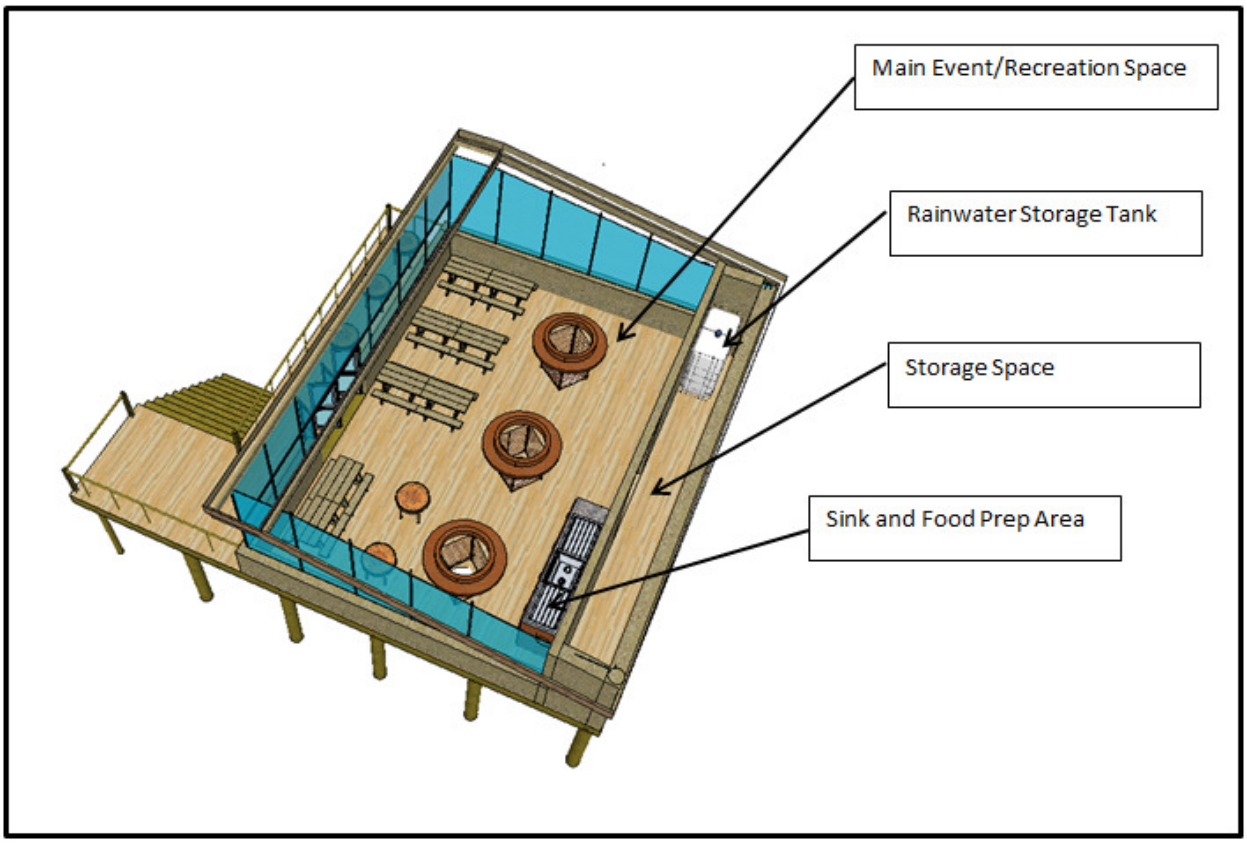

Figure 6 - Conceptual Interior Layout of Tree House Building

The development of the tree house is aligned with several major goals in UBC's strategic plan. Although the building's footprint area is under the 600 m^2 such that it is exempt from requiring LEED Gold certification, it is the intention of the design team that the building will be a model for sustainable practices on a small scale, with the inclusion of the aforementioned environmental design elements, in addition to utilizing best practices in sustainable design and construction to minimize impacts to the surrounding areas of the garden.

Specifications

The tree house will have the unique feature of being constructed around large living trees. However, this is primarily for aesthetic purposes and the trees are not intended to bear loads of any significance. The timber platform that serves as the floor of the tree house shall be raised off the ground surface and supported by timber columns. The number and spacing of columns is contingent on loading conditions and shall be defined in subsequent detailed design. With respect to water management, the roof of the tree house will be sloped in a single direction in order to efficiently collect and redirect storm runoff for irrigation use. The estimated cost for the conceptual tree house is $71,370

Sustainable Design

Environmentally Conscious Construction

In the event that the proposed administrative building is approved for construction, the necessary dismantling of the existing garden administration building would provide recycled materials for use in building the tree house. By utilizing recycled material such as windows, cladding and timber, the cost of the tree house would be reduced and less waste would be generated from the overall redevelopment project.

Rainwater Management

The conceptual design of the tree house incorporates a storm water collection and storage system that can be utilized for irrigation of the Food Garden. This system is anticipated to reduce the garden's potable water consumption. Storm runoff from the roof will be diverted to a storage tank located on the elevated floor of the building. Utilizing the gravity head of the elevated storage tank, the storm water will be fed into a low pressure micro-irrigation system for the nearby Food Garden.

Pedestrian Bridge

The addition of a pedestrian bridge crossing SW Marine Drive will improve the safety of pedestrians, principally visitors wishing to visit the garden, as the

current transit stop is located opposite the main entrance across a four lane road. Furthermore, the inclusion of the pedestrian bridge will facilitate the flow of visitor traffic through the garden, establishing a looping route in conjunction with the existing tunnel passing beneath SW Marine Drive.

The design of the bridge will incorporate an innovative living railing which will absorb runoff from the bridge deck, reducing the transference of sediments and pollutants from the bridge and roadway into the waterways of the garden. Furthermore, the use of living elements in the bridge will have a unique visual impact, providing an additional identifier for the garden from the roadway. The conceptual design of the proposed pedestrian overpass is presented in Figure 7.

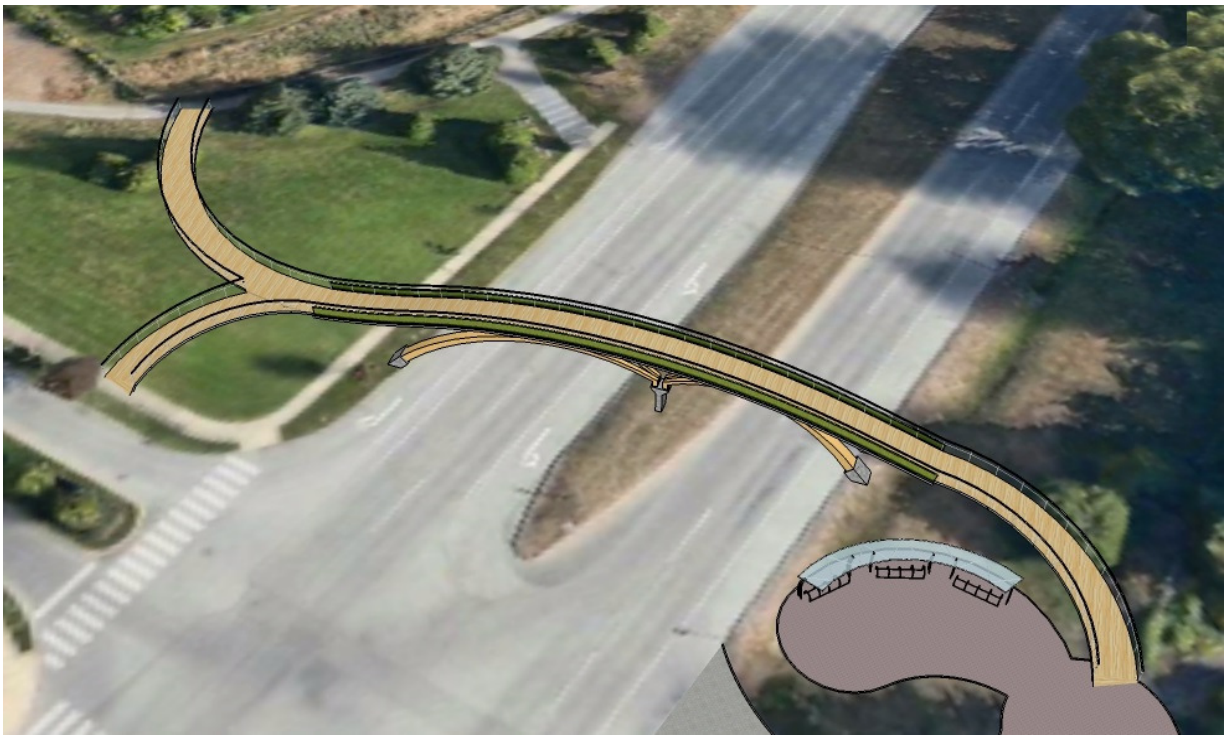

Figure 7 - Conceptual Model of Proposed Pedestrian Overpass

Specifications

The pedestrian bridge features a double arch system, with each arch spanning half of SW Marine Drive from the shoulder to the median. Each span is composed of a pair of arches, constructed using large weather resistant glulam sections and shall be mounted on concrete piers with steel fastening plates. The

walking surface of the bridge will be composed of concrete with wood details and aluminum railings. The eaves along the sides of the bridge will be constructed out of steel and filled with a light-weight growing medium. Plantings will be primarily of short local grasses, which are amenable to seasonal fluctuations in rainfall and require minimal maintenance.

Pedestrians will access the bridge on either side by ramps. On the south-west side, a ramp will join directly to the bicycle storage courtyard of the new administrative building. On the north-east side, two ramps will descend from the walkway, one joining the existing sidewalk along Stadium Road and the other providing access to the north side of the Botanical Garden in the Carolinian Forest area near the great lawn. The estimated cost for this design is $700,000

It should be noted that a particular challenge of implementing this design will be in the permitting required for construction. As SW Marine Drive is classed as a provincial highway, it is administrated by the British Columbia Ministry of Transportation (BC MOT). Consequently, additional consideration of sightlines will be required in the detailed design of the pedestrian bridge. (Doyle, 2013)

Parking Expansion

The UBC Botanical Garden is seeking to draw more visitors to their facility during non-peak seasons. During certain times of the year, for example the Apple Festival in mid-October, the garden is overflowing with visitors. Currently the garden's parking capacity is insufficient to accommodate these peak demands. This results in nearby streets being filled with cars, nearby parking facilities becoming saturated and the necessity of hiring traffic control personnel. If the botanical garden is to develop into a major anchor point on the university campus, it will need to consider how it can handle the potential growing demand for parking. Due to its isolated location, most patrons will likely need to drive until more convenient public transportation routes are organised.

To handle the growing demand for parking, Group Twelve Consulting is proposing a parking expansion that will find more utility for the existing space currently dedicated to parking. This would also involve improving the operation of the roundabouts and paving over new space to create a more efficient shape.

Figure 8 below presents the conceptual design of the proposed parking lot expansion.

Figure 8: Proposed Parking Lot Expansion

Specifications

The soil and terrain in the vicinity of the Garden is mostly Ice Age upland sediments (Potter, 2013), which were deposited by retreating glaciers. These sediments consist of stiff and compact tills in a layer that is less than 15m thick, and is underlain by tough bedrock (Provincial Government of British Columbia, 2013). Since the bedrock is fairly close to the surface and is topped by firm soils, the ground is very geologically stable. A stable ground allows for significantly less effort to build a durable pavement.

The roadway entry into the property and parking lot from SW Marine Drive experiences some large grade changes, which will require some leveling to create a flat parking surface. This would also allow for better driver sightlines and increase pedestrian safety. Grades throughout the existing parking lot footprint

may undergo minor adjustments. Drainage off the grade will also be monitored to ensure that precipitation does not pool or accumulate on any paved areas.

The roundabouts and medians will be rebuilt with new curbs where required. The design of the parking lot expansion will maximize parking area while still providing a proper turning radius for vehicles navigating through the loop. Vehicles that only wish to make a drop off are not forced to go through the whole loop but can choose to use the break in the median to turn around. The break in the loop will also be sufficiently large for shuttle and public transit buses to navigate through. Arrow symbols will be painted directly onto the pavement to ensure there is no misunderstanding of the traffic flow expectations.

The existing parking facility would increase its paved area by 768m^2 as seen below in Figure 9. This would increase capacity from 80 car stalls to 124 car stalls with an additional 2 parking stalls for busses. Paving this new area connects previously paved areas in a space efficient manner, without taking away useful space in front of the entrance and still provides a drop off point near the administration building. With this added capacity, the garden can accommodate more visitors on a daily basis as well as prepare for the opportunities of joining partnerships with public transit and tourism shuttle services.

Figure 9: Recommended areas to expand paving facilities

There are various paving options recommended for the parking lot expansion. Asphalt patching is a short term but the most cost effective option, as it would not require the parking lot to be repaved entirely. Instead, the expanded portions will be paved and patched smoothly to connect to the existing pavement. As an alternative to conventional asphalt paving, permeable pavements should be considered for improved storm water management and control. Permeable pavements permit the infiltration of rainwater such that less surface runoff is generated, this in turn would also allow a reduction in concrete curbs needed for runoff containment. However, curbs are still recommended around the island medians for vehicle safety. A permeable pavement would additionally enable the filtration of possible pollutants from surface runoff before the water percolates into the groundwater table. Utilizing permeable paving for the parking lot expansion would result in greater cost, and would require the entire lot to be repaved. Approximate costs for various pavement options are presented in Table 1.

Paving Method	Estimate Total Cost of Parking Lot Expansion
Standard Asphalt Patching + New Areas	$88,812
Permeable/Recycled Asphalt Pavement	$355,421
Plastic Grid Paving	$300,331
Bound Recycled Glass Porous Pavement	$365,180

Table 1: Class D Cost Estimate for Each Paving Method

Pavement Options

Standard Asphalt Patching + New Areas

A minimum of 100mm for the layer of 15mm crushed gravel base is sufficient due to ideal geological conditions. The asphalt will be paved with two lifts, 50mm each due to the nature of the parking lot's use as noted in a typical road construction cross-section in Figure 10.

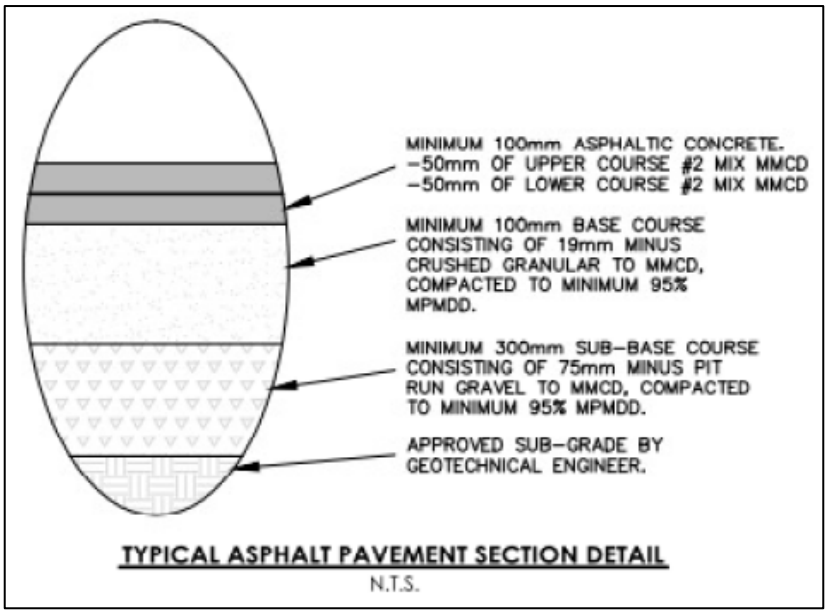

Figure 10: Standard Asphalt Road Construction (Core Concept Consulting Ltd, 2013)

This treatment would be applied to areas that are newly constructed and will be connected smoothly to the existing, unchanged portions with asphalt. A groove will be milled into the edges of the existing pavement and filled with the new asphalt to allow for a better bond. This option outlines typical parking lot pavement which is generally cost efficient, but is considered as more of a temporary solution since alternative options are generally more effective and have a longer lifespan. In order to create a more sustainable parking lot, recycled aggregate can be used for the gravel base.

Permeable/Recycled Asphalt Pavement

Special asphalt mixes can be created to fit the specific criteria requested by the UBC Botanical Garden. The underlying gravel base for these asphalt mixes would be identical to that of the standard asphalt road (i.e. 100mm for the layer of 15mm crushed gravel base).

- Recycled material may be requested in the mix
- Permeable properties may be requested
- More expensive than standard paving

Plastic Grid Paving

This methodology of paving is growing in popularity and is used extensively in European countries. It consists of a structure similar to geo-grid, and is composed of a plastic grid or net with deep but narrow walls creating a honeycomb pattern. The cavities are then filled with gravel and soil (TrueGrid, 2013).

- Plastic used is made of 100% recycled and recyclable material
- Permeable pavement, eliminating need for expensive curbs and improved surface water runoff
- More expensive than standard paving
- Provides a more natural and aesthetic quality to the parking lot to make it appealing and fits the theme of the garden more effectively
- Reduces the heat island effect, due to its low heat absorbency
- Prevents erosion

Bound Recycled Glass Porous Pavement

This paving form is a type of pervious pavement that utilizes a high amount of post-consumer glass products. Construction and manufacturing costs are extremely high and the pavement is not suitable for high traffic areas. For these reasons it is recommended by the supplier that this particular medium is utilized only for the parking stalls, with a harder and more standard medium such as asphalt to compose the driving lanes. It is currently trademarked by FilterPave Products LLC.

- Composed of over 96% recycled materials
- Permeable pavement, eliminating need for expensive curbs and improved surface water runoff
- More expensive than standard paving
- Reduces the heat island effect, due to its high reflectivity
- Looks similar to a standard asphalt parking lot
- Comes with a selection of available coloured tints

(FilterPave Products LLC, 2013)

Proposed Implementation

Given a qualitative understanding of the UBC Botanical Gardens somewhat restrictive budget constraint (Justice, 2013), Group Twelve Consulting Ltd. recommends an incremental approach to the development strategies proposed in this report.

Using a multi-criteria decision making matrix (refer to Appendix E), each of the aforementioned design components were evaluated on their contributions to the design goals of sustainability, accessibility, commercial viability of the garden, visibility, engagement with the community and cost. In each category, each design component was ranked on a scale from 0 to 5, with 0 indicating that this element does not contribute to the goal area, and 5 meaning that the element makes a substantial contribution. Rankings based on cost differ somewhat, with the designs being ranked from 1 to 4, with 4 being the least expensive and 1 being the most. Rankings are then summed across the categories to yield a single score for each design element.

Based on this process, it is recommended that redevelopment begin with the tree house, followed by either the parking lot expansion or pedestrian overpass. The new administration building should be implemented last.

Conclusion

Through consultation with the administration of the UBC Botanical Garden to best understand constraints and goals, the design team at Group Twelve Consulting Ltd. developed a number of objectives to guide and evaluate design choices.

A number of preliminary designs were proposed, and through careful deliberation and evaluation utilizing a multi-criteria decision making process, it is recommended that a multi-use tree house building, parking lot expansion, pedestrian bridge, and new administration building be constructed. The design team considers these projects to best meet the needs of the garden in the areas of improved accessibility, visibility, sustainability in construction and operation and enhanced visitor experience.

The entire project will have a cost ranging from approximately $3,348,000 to $3,624,000. However, as the design team is aware of the garden's budget constraint, a staged process of development is recommended. The order of implementation should begin with the tree house, followed by the pedestrian bridge or parking lot expansion, and concluding with the new administrative building.

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Appendix A - Location Map

1 – Administration Building

2 – Pedestrian Overpass

3 – Parking Lot Expansion

4 – Tree House

Appendix B – Photographs of Existing Redevelopment Site

Photo B1 – Site of Proposed New Administration Building

Photo B2 – Site of Proposed Parking Lot Expansion

Photo B3 – Site of Proposed Pedestrian Bridge

Photo B4 – Site of Proposed Tree House

Appendix C –Conceptual Model of Redeveloped Entrance Area

Appendix D - Class D Cost Estimate and Assumptions

Cost Estimation of Proposed Buildings by RS-Means Method

An initial cost estimate for the conceptual designs of the Administration Building and Treehouse was prepared using methods prescribed in the RS-Means Cost Data Handbook. The components of each building were grouped together under three different classifications, as deemed most suitable by the designers. Unit costs for each classification were adjusted for size with respect to their corresponding components. Modification factors were applied to final cost to adjust for the location of the project and inflation compared to those set-out in the handbook.

Final designs of the structures are required to develop more accurate cost estimates. For the Treehouse, recycled materials may be utilized for the dismantling of existing buildings. Additionally, it may also be possible to retrofit existing foundations to support the new multipurpose building.

Conceptual Design	Classification	Components	Square Feet	Cost
Administration Building & TreeHouse	Classroom and Administration ($103.00/ft^2)	Lecture Hall	3497	$1,824,921
		Front Desk	271	
		Atrium Space	4076	
		Second Floor	3368	
	Restaurant ($111.00/ft^2)	Café	384	$91,987
		Washrooms	445	
	Retail ($52.00/ft^2)	Gift Shop	1233	$64,105
		Tree House	900	$46,800
		TOTAL COST (Adjusted for inflation and cost)	Administration Building	$2,487,548
			Treehouse	$71,370

Parking Expansion Cost Estimate

Conventional Asphalt Patching + New Areas
Approximate square metres of paving area added/modified: 2243 m^2
Estimated paving unit rate per square meter: $32 (Lafarge, 2013)
Total paving: $71,760
New curbs unit cost per linear metre: $60 (R. Rayner, personal communication, October 10, 2013)
Approximate linear metres of new curb: 284 m^2
Total curbing amount: $17,052
TOTAL: $88,812

Permeable Asphalt paving

Approximate square metres of paving needed: 5287 m^2
Permeable paving unit rate: $64
Total paving amount: $338,369
New curbs unit cost per linear metre: $60
Approximate linear metres of new curb: 284 m^2
Total curbing amount: $17,052
TOTAL: $355,421

Plastic Grid Paving
Approximate square metres of paving needed: 5287 m^2
Permeable paving unit rate: $55 (Kedel Limited, 2013) to help with estimate)
Total paving amount: $290,785
New curbs unit cost per linear metre: $60
Approximate linear metres of new (median) curb: 159 m
Total curbing amount: $9,546
TOTAL: $300,331

Bound Recycled Glass Porous Paving (See following page for calculation diagram)
Approximate square metres of asphalt paving needed (driving lanes): 5287 – 1650 = 3637 m^2
Standard asphalt paving unit rate: $32
Approximate square metres of permeable paving needed (parking stalls): 1650 m^2
Permeable paving unit rate: $115+30 (L. Ralph of FilterPave, personal communication, November 13, 2013)
Total paving amount: $355,634
New curbs unit cost per linear metre: $60
Approximate linear metres of new (median) curb: 159 m
Total curbing amount: $9,546
TOTAL: $365,180

Figure 11: FilterPave applied areas of parking lot expansion

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Pedestrian Bridge Cost Estimate

An approximate conceptual cost estimate for the pedestrian bridge was based off the da Vinci Bridge built just south of Oslo, Norway. The da Vinci Bridge consisting of 3 large glulam arches spanning a 40-meter roadway has a similar design to the proposed pedestrian bridge for the botanical garden. A unit cost per length of glulam, based off of the da Vinci Bridge project cost, was applied to the Botanical Garden's pedestrian bridge. In addition to the cost of glulam arches, pricing was added for the decking and green medium on the bridge. Discrepancy between designs will contribute to a very approximate cost estimate. Further detailed design specifications are required to develop a more accurate cost estimate.

Reference Bridge	Total Cost ($)	Glulam Cost ($)	Span (m)	Unit Cost ($/m)
Da Vinci Bridge	2,025,000	675,000	40	16,875

Conceptual Design	Unit Cost ($/m)	Span (m)	Glulam Cost ($)	Additional Costs	Total Cost ($)
Botanical Garden Bridge	16,875	36	607,500	92,500	700,000

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Appendix E – Multi Criteria Decision Making Matrix

Design Concept	Sustainability		Accessibility		Commercial		Visibility		Cost		Community		Score
Parking lot expansion and covered bike racks	• Encourage cycling • Improved rainwater management over current paved space • Decreased impermeable area • Recycled materials used in the various paving options	3	• Increased customer convenience • Improved bicycle storage (secure as well as outdoor) capacity and shelter from rainwater	4	• Increase parking capacity for events • Potential for revenue from paid parking	4	• Additional capacity during non-peak times made available for on-campus parking brings more awareness to the garden	3	$88,812 - $365,180	4	• Provides additional on-campus parking • Engages the need for increased storm and rainwater management best practice along SW Marine Dr.	1	19
Pedestrian Bridge	• Green medium reducing runoff • Sequestered carbon in living railing	3	• Improved safety crossing marine drive • Improved flow for visitors to the garden	4	• Improved access between north and south gardens	2	• Innovative, tasteful design integrating living elements visible from Marine Drive	5	$700,000	3	• Improves safety crossing marine drive for non-visitors • Provides a looping route through the garden	2	19
Tree House	• Recycled materials • Stormwater capture and storage system	5	• N/A	0	• Innovative multi-use space for educational programs and small events • Provide an anchor on the north side of the garden	3	• Building is visible from 16th Avenue, drawing interest to the garden. • Locally unique design serves as an attraction	4	$71,370	4	• Unique space for school programs and summer camps • Showcase the UBCBG as part of the UBC Living Lab	4	20
Administration Building	• Rainwater capture and temperature moderation through green roof • Sequestered carbon in living walls • LEED Gold Standard	5	• N/A	0	• Inclusion of café and expanded gift shop • Increase traffic to the gardens	4	• Interactive, informative visitor space detailing the history of the garden and its current research role	4	$2,487,500	1	• Engage with the student community through provision of unique and tranquil study space • Showcase the UBCBG as part of the UBC Living Lab • Additional research and integrated teaching space	4	18

Score from 0 – 5, 0 - Does not contribute to this area of development, 5 – Exemplary contribution to development area